

Prostate Cancer: Patterns of Occurrence, Major Risk Factors, and Diagnostic Methods

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ABSTRACT

The incidence of prostate cancer (PCa) varies significantly, making it a chief international health issue. This article examines the current maximum studies on prostate cancer primary hazard factors, epidemiology, and both established and growing diagnostic strategies. Epidemiological information advocates that high-income nations have historically reported the highest incidence, and rates are increasingly rising in Africa, Asia, and Latin America/Caribbean, indicating a shifting worldwide burden. The most significant non-modifiable risk variables are age, race (with men of African origin at the highest risk), and a family history of the disease. Potentially modifiable factors, such as smoking, sexually transmitted diseases, sexual activity, statins, obesity, and food, offer opportunities for primary prevention. More precise methods, such as multiparametric Magnetic Resonance Prostate-Specific Membrane Antigen Positron and Imaging (mp-MRI). PET scanning, Emission Tomography scanning, is being used as a replacement for the traditional Prostate-Specific Antigen testing and systematic biopsy in the diagnosis of cancer. These cutting-edge methods lessen the adverse effects of overdiagnosis and facilitate precise risk classification. Addressing the global differences in PCa outcomes requires a coordinated effort to enhance awareness, establish personalized screening methods, and ensure fair access to sophisticated diagnostic and treatment interventions.

Keywords: Prostate Cancer, Epidemiology, Incidence, Mortality, Risk Factors, Diagnostic Methods

INTRODUCTION

The male secondary reproductive organ, the prostate, lies beneath the bladder. Its primary purpose is to maintain the viability of the sperm by enriching the requisite secretions in semen. Central, transitional, and peripheral areas make up the adult human prostate [1]. Prostate cancer (PCa) is a critical health concern worldwide, being one of the most prevalent. Men across the globe are diagnosed with malignancies [2]. It starts in the prostate gland, which is a small gland in males that is positioned under the bladder and is responsible for the production of seminal fluid [3]. Prostate cancer is the most common type of urological carcinoma and the second deadliest type of cancer among males in other countries. Its incidence is increasing; it is ranked as the sixth leading cancer-related mortality among males [4]. Cancer of the prostate is acutely genetically inherited and polygenic, and develops as the outcome of complex interactions between an individual's gene profile and their environment. It is also one of the most genetically inheritable diseases [5]. The aggregation of genetic variation, particularly in the DNA of prostate cells, that upsets the proper stability between cell division and programmed cell death (apoptosis), is the primary cause of PCa [3]. This leads to the uncontrolled multiplication of malignant cells and the tumor formation [6]. While the particular origin of these genetic changes is typically unknown, the process requires the transformation of benign epithelial cells into an aggressive form [7].

While frequently slow-growing and restricted to the prostate gland, PCa can be aggressive and metastasize to other zones of the body, particularly the bones and lymph nodes [3]. Taking into account the prevalence of PCa worldwide, it is crucial to regularly monitor the disease's epidemiological trends, underlying risk factors, and the effectiveness of available diagnostic techniques. The paper is intended to offer a thorough literature review of the existing work on the subject. To examine the global trends in the incidence of PCa, to identify key non-modifiable and modifiable risk determinants associated with its emergence and progression, and to evaluate both established and new diagnostic strategies.

Patterns of Occurrence (Epidemiology)

Prostate cancer (PCa) is the second most common cancer after non-melanoma skin cancer in the world. Worldwide, 1,414,249 new cases were identified in the year 2020, and the disease is responsible for 375,000 fatalities per year [9]. In 2020, it was accountable for more than 10 million deaths, or about one out of every six fatalities [10,11,12,13]. Global estimates from 2020 indicated that over 1.4 million new PCa cases were determined, with a crude incidence rate of 36.0 per 100,000 males [8]. Recent data from the United States, a high-income country with comprehensive reporting, estimates 313,780 new cases and 35,770 deaths in 2025 [14]. Asian men residing in Asia exhibit a comparatively lower susceptibility to developing prostate cancer. However, the probability was higher among Asian immigrants [15]. Globally, incidence rates of prostate cancer (PCa) and fatality in 2022 ranged from around 13 to 9.5 times. The highest death rate was found in Southern Africa (29.7 per 100,000

men), whereas among all the regions, Northern Europe reported the greatest rate of incidence, with 82.8 cases per 100,000 men. Several Caribbean, Brazilian, New Zealand, and the United States, Australian, and Northern European nations had the highest level of incidence, while mortality was less prevalent across Asia and highest in sub-Saharan African nations, including Barbados, Jamaica, and Chad [16, 17].

With 5,198 newly diagnosed cases recorded annually, it is categorized as the 12th most widespread disease in Pakistan, making it a serious health concern. The overall prevalence, with geographical variations, was 5.20% including Sindh 3.30%, Punjab 8.09%, and Khyber Pakhtunkhwa (KP) 8.29% according to a 2023 meta-analysis of 11 studies with 184,384 participants. The incidence increased from 3.88% between 2000 and 2010 to 5.80% between 2011 and 2023, according to the data [9,18]. Recent data from the United States, a high-income country with comprehensive reporting, estimates 313,780 new cases and 35,770 deaths in 2025 [19]. Cancer of the prostate has a high degree of geographical and temporal trends in incidence and mortality over time. Western European countries, North American countries, the Oceania countries, and high-income countries, in particular, have traditionally recorded the highest rate of incidence, mostly due to the prevalence of the Prostate-Specific Antigen (PSA) test and the identification of the asymptomatic cases [19]. While incidence rates have historically stabilized or declined in some high income regions, recent analysis indicate a concerning reversal in this trend, with US incidence rates increasing by 3.0% annually between 2014 and 2021 [19].

Globally, incidence rates continue to show significant increases in countries located in Africa, Asia, and Latin America/Caribbean [20, 21]. This rise in incidence in developing nations is often linked to demographic shifts, such as aging populations and the adoption of Western lifestyles, alongside improvements in cancer registration and diagnostic capabilities [20].

Despite its high incidence, PCa is not the foremost contributor to cancer-related fatalities across all nations, highlighting the disparity between diagnosis and fatal outcomes [21]. Mortality rates are generally highest in regions with lower incidence, such as parts of Africa, suggesting that factors like late-stage diagnosis, limited access to advanced treatment, and more aggressive tumor phenotype in certain populations may contribute to poorer survival outcomes [21].

Major Risk Factors

Age

The pathogenesis of PCa is multifaceted, comprising a complicated association between non-modifiable and potentially modifiable risk factors [23].

It is known that aggressive PCa is linked to the incidence of prostate cancer, as it increases with age [24]. The median age at diagnosis has declined, and studies have demonstrated a greater reduction in prostate cancer-specific mortality.

Testing starts earlier in life (for example, before the age of fifty-five rather than after) [25]. Furthermore, humans with positive family records, who are stimulated at a younger age, have a greater burden [25,26]. In postmortem investigations, most men will have PCa by means of a hundred years age of; but, localized PCa may additionally stay asymptomatic earlier than evolving to a clinically significant disorder [27].

Genetics

The etiology of PCa is not known; inheritance plays a vital role. It is known that prostate cancer vulnerability is dependent on race, heredity, and genetic background [28]. Generally, males who develop genetic or hereditary prostate cancer are likely to develop it. They get their tumors at an earlier age, develop faster, and are more recurrent after surgery [29]. Among common malignancies in men, hereditary prostate cancer demonstrates the greatest genetic heritability [30]. Men whose first-degree relatives (father or brother) have had prostate cancer have double the chance of getting prostate cancer [31].

A brother's illness increases the danger compared to a father's illness [32]. If the first-degree relative experienced an illness with an early onset (before the age of 55), the risk would be considerably higher. The risk is five times higher for men who have two afflicted first-degree relatives. Individuals who have a high family history of prostate cancer are more likely to develop the disease at a younger age (2.9 years) and with more advanced local disease [33].

Modifiable risk factors:

Smoking

At least 70 carcinogens are detected in burning cigarettes, and smoking is a recognized risk factor for several malignancies, including genitourinary cancers such as kidney and bladder cancer. A prior meta-analysis demonstrated an enhanced risk of PCa among past smokers but not among current smokers [34]. Nevertheless, its link with PCa is still controversial. Furthermore, two recent meta-analyses produced comparable results, suggesting a negative connection with PCa incidence and an elevated risk of PCa death [35]. The results of both investigations were connected to smokers' low adherence with PCa screening.

Sexually transmitted disease

Sexually transmitted infections (STDs) are also linked to prostate cancer.

According to a recent large population-based study, the vulnerability of prostate cancer is roughly two to three times higher when STDs, particularly gonorrhea and syphilis infections, are present. Human papillomavirus (HPV) types 16, 18, and 33 diagnoses have also been associated with an elevated chance of prostate cancer (PCa) by other studies. On the side, the length of HIV infection was related to a greater chance of prostate cancer, according to an analysis based on the human immunodeficiency virus (HIV) infected population.

A current meta-analysis of 17 studies demonstrated that a greater proportion of sexual partners is related to a higher PCa chance, mainly through the more activity of infections transmitted through sexual contact [36].

Sexual activity

Frequent ejaculation more than 20 times a month (20 or more) would help prevent PCa, which is associated with a reduction of carcinogenic secretions in prostatics [37]. A possible risk to be modified is sexual behavior.

Statins

Statins, as lipid-lowering agents, can reduce triglycerides, low-density lipoprotein, and total cholesterol levels. Since cholesterol is the primary substrate for androgen

formation, it may modulate androgen-related signalling pathways [38]. It is unknown how statin use influences PCa risk; however, studies have connected raised cholesterol to a higher prevalence of high-risk PCa.

Diagnostic methods

Diagnosis of PCa is normally a multi-step procedure and is initiated by screening and proceeding to definitive diagnostic measures. The second most common is prostate cancer (PCa), the most frequent malignancy in men, all over the world, is estimated 1.4 million new cases diagnosed annually. [39]. Early detection is crucial, as localized PCa has a 5-year survival rate exceeding 99%, while metastatic disease drops to about 30% [40]

Several steps are usually included in the diagnosis process: screening, confirming testing, and staging to determine the severity of the disease. This highlights significant diagnostic approaches, supported by evidence from clinical trials, meta-analyses, and guidelines, stressing their accuracy, limitations, and therapeutic value.

Screening and Initial Detection

The main approaches for screening prostate cancer in asymptomatic men include physical examination and blood-based testing. The primary goal of screening is the identification of cancer; overdiagnosis and overtreatment remain significant concerns, as up to 50% of tumors detected through screening may be indolent[41].

Prostate-Specific Antigen (PSA) Blood Test:

PSA is an example of a blood test used in the early diagnosis and treatment of prostate cancer. Measures the protein levels in the bloodstream that are released through the prostate gland, which is characterized by a biomarker. Even with limitations in specificity, PSA testing is advantageous for routine prostate cancer screening, even though expanded PSA levels may also suggest other prostate problems like BPH or prostatitis, complicating the diagnostic method. [42]. The sensitivity of PSA checking out levels ranges from seventy-eight percent to one hundred percent, while its specificity varies broadly between studies, between 6% and 66% [43]. Despite being enormously cheaper and readily available, the confined specificity of PSA testing raises the chance of false positives and pointless biopsies, leading to extended expenses.

As a result, many attempts have been made to improve diagnostic accuracy by means of substituting or combining PSA with alternative assays. To detect prostate cancer, cutting-edge requirements additionally advocate combining PSA and DRE [42]. Other biomarkers, along with loose PSA (fPSA) and PSA density (PSAD), have evolved to get around PSA's limitations in terms of diagnostic accuracy. Risk for prostate cancer is calculated the use of the ratio of fPSA to overall PSA. However, owing to its decreased accuracy, there was a drop in its usage. [44].

MRI

MRI is an enormous approach for determining prostate cancer risk, staging, and remedy planning [45]. MRI permits a high-resolution assessment of the tumor's area, length, and extent; for this reason, it boosts diagnostic accuracy and reduces invasive

methods [45]. It decreases the need for pointless biopsies and stops overdiagnosis of clinically unimportant prostate cancer [45]. Several studies have indicated that integrating MRI with PSA and DRE testing will increase the accuracy of prostate cancer diagnoses [45,46]. According to the PI-RADS version 2.1, it has a sensitivity of 90, a specificity of 62, a positive predictive value (PPV) of 53, and a negative predictive value (NPV) of ninety-three percent.[45,47].

PSMA-PET

The scientific significance of prostate-specific membrane antigen needs to be discussed.

It has not been approved yet for screening of prostate cancer (PCa) in Korea. A new diagnostic method for prostate cancer, PSMA-PET's characteristic, continues to be determined. It is mostly utilized for sufferers with high-risk prostate cancer or the ones who've biochemical recurrence following localized prostate cancer remedy [48]. This imaging modality is provided by focusing on the PSMA. Significantly in the identification of low residual contamination and chronic malignancy.[48].

New diagnostic technologies:

The fast development of AI and genetic technologies has facilitated the improvement of modern screening procedures. AI has been increasingly employed to improve the interpretive precision of imaging and genetic data sets, especially through device mastering and deep learning algorithms [49]. Despite these advances, the performance of AI-based models remains restrained by challenges such as variability across fashions, regularly imbalanced datasets that characterise tons of clinical research. Genomic techniques attention on figuring out genetic alterations associated with prostate cancer through the evaluation of human tissue samples. Although the proper molecular pathways continue to be incompletely understood, researchers have identified numerous genes that preserve diagnostic cost. These genomic procedures are specifically beneficial for people with their own family records of prostate cancer, as they support genetic counselling and facilitate customized treatment planning [50]. Nevertheless, the excessive economic charges associated with genetic testing currently limit its feasibility as a routine screening.

Prostate Biopsy Techniques

Transrectal Ultrasound-Guided Systematic Biopsy (TRUS-Bx) includes 10–12 cores are still often used but are being replaced. MRI-Targeted Biopsy (Cognitive, Fusion, or In-Bore) detects 30% more PCa and 20–30% fewer insignificant tumors compared with systematic biopsy alone. Transperineal Biopsy is a preferred method in many places (reduced infection rate <0.1% vs. 2–6% transrectal [51,52].

USPSTF recommends that men aged fifty-five to sixty-nine make a carefully informed choice concerning prostate-specific antigen (PSA) screening, considering personal risk factors, including family history, ethnic background, and relevant comorbidities. For individuals elderly 70 years and above, recurring PSA screening is normally discouraged. By comparison, the European Association of Urology supports advanced screening initiation, advising PSA checking out at round 50 years for guys at common risk, at forty-five years for those with a circle of relatives records of

prostate cancer or of African descent, and at forty years for carriers of BRCA2 mutations. In alignment with this, the European Society of Medical Oncology recommends initiating PSA screening at age 50 in the general population, at 45 in men with increased familial or ethnic risk, and at 40 in individuals who carry BRCA1/2 gene mutations.

Primary prevention of most prostate cancers centres on promoting wholesome lifestyle behaviours. This includes adherence to a nutrient-rich eating regimen incorporating polyunsaturated fat, culmination, and veggies that supply antioxidants and other shielding micronutrients, inclusive of selenium, nutrients D and E, and beta-carotene. Additionally, ordinary physical exercise and the reduction of prolonged sedentary durations appear as important components of effective preventive health strategies [53].

DISCUSSION:

Global epidemiological trends emphasize the continuing and shifting challenges associated with prostate cancer. The rising incidence in developing nations suggests a need for proactive public health strategies in these regions, focusing on awareness, early detection, and the establishment of robust cancer registries [54]. The established non-modifiable risk determinants are age, race, and family history; they remain the cornerstones of risk stratification [55]. The significant racial gap, particularly the unevenly high burden on men of African descent, demands further research into the underlying genetic and socio-environmental determinants to develop targeted screening and intervention programs [56]. The recent increase in incidence in high-income countries further emphasizes the need to re-evaluate current screening guidelines and public health campaigns [57]. The role of modifiable risk factors, such as smoking, diet, and obesity, presents an opportunity for primary prevention [58]. While the evidence for specific dietary components is often inconsistent, the promotion of a healthy lifestyle, including maintaining a healthy weight and a balanced diet, aligns with general cancer prevention guidelines and may offer a protective effect against aggressive PCa [59].

The evolution of diagnostic methods reflects a move towards more precise and risk-stratified detection. The controversy surrounding PSA screening, primarily due to overdiagnosis, is being mitigated by the integration of advanced imaging [60]. Multiparametric MRI and targeted biopsy techniques are instrumental in distinguishing between indolent and clinically significant disease, thereby reducing unnecessary treatment and its associated morbidity [61]. Furthermore, the advent of PSMA PET scanning has revolutionized the staging and restaging of high-risk and recurrent disease, allowing for more accurate treatment planning. [62] Future research should focus on refining risk prediction models that integrate genetic, clinical, and imaging data to optimize screening protocols and minimize the harms of overdiagnosis [63].

Conclusion

Prostate cancer is still a significant worldwide health concern with complicated epidemiological patterns that are influenced by both changing demographics and differing screening program penetration. Non-modifiable characteristics, particularly

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age and race, are the most powerful predictors of risk, while the potential influence of modifiable factors underscores the necessity of lifestyle interventions. With MP-magnetic resonance imaging and PSMA PET providing more advanced techniques for precise identification, risk stratification, and staging, the diagnostic picture is changing quickly. Through customized screening, early diagnosis, and fair access to cutting-edge treatment modalities, a coordinated worldwide effort is needed to address the rising prevalence in emerging nations and reduce the notable racial disparities in PCa outcomes.

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