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PIONEERING PROSTATE CANCER DIAGNOSIS: EVALUATING AI AGAINST TRADITIONAL METHODS - A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Prostate cancer is one of the most common forms of men's cancer in the world and the understanding of its epidemiology is crucial to effective prevention, early detection and management strategies. This systematic review highlights the potential of artificial intelligence-based diagnostic methods to revolutionize the early diagnosis of prostate cancer. A comprehensive literature search was carried out using databases such as PubMed, Google Scholar and Scopus. After removing duplicates, titles and abstracts were examined in 279 studies and the following full texts were examined in 128 studies. We have ten studies to review in total. Therefore, we chose to review data for all 10 identified studies that applied AI techniques to detect ca prostate. The Paige Prostate Alpha AI system significantly enhances pathologists' diagnostic capabilities, leading to more accurate and effective prostate cancer detection. These limitations indicate that further research is required to address these issues and validate the results in a more diverse and controlled environment. AI-based diagnostic methods have shown significant promise in enhancing the early detection of prostate cancer. As technology continues to advance, integrating AI with traditional diagnostic approaches could lead to more effective, efficient, and accurate prostate cancer screening and diagnosis. Future studies should focus on large-scale clinical trials and real-world applications to validate these findings and facilitate the adoption of AI in clinical settings.

Keywords: Prostate Cancer, Artificial Intelligent, Deep Machine Learning, MRI

INTRODUCTION

Prostate cancer is one of the most prevalent forms of cancer affecting men worldwide, and understanding its epidemiology is crucial for effective prevention, early detection, and management strategies. According to the GLOBOCAN 2018 report, prostate cancer is the second most common cancer in men and the fifth leading cause of cancer-related deaths globally. The incidence of prostate cancer varies significantly across different regions, with the highest rates observed in Northern and Western Europe, the Caribbean, Australia, New Zealand, North America, and Southern Africa, while the lowest rates are reported in Asia and Northern Africa. (Yang et al., 2022; Youssef et al., 2022; Zhang, Liu, et al., 2023)

The reasons for the increasing incidence of prostate cancer in

recent years are multifaceted and not entirely clear. However, factors such as the widespread adoption of prostate-specific antigen testing, the increased use of transurethral resections, and the rapid aging of the population are believed to play important roles (Yang et al., 2022). Interestingly, the mortality rates of prostate cancer have been declining or stabilizing in many high-income countries, while continuously rising in China. (Youssef et al., 2022)

Prostate cancer is a highly heterogeneous disease, with approximately 20-30% of patients with limited prostate cancer experiencing recurrence after treatment, and a 5-year survival rate of only 30% when metastases occur. This heterogeneity highlights the importance of accurate risk stratification and the inclusion of prognostic and predictive biomarkers to guide treatment decisions and improve patient outcomes. (Zhang, Liu, et al., 2023)

The early and accurate detection of prostate cancer is crucial for effective treatment and patient outcomes. Traditionally, prostate cancer diagnosis has relied on a combination of digital rectal examination, prostate-specific antigen testing, and histopathological analysis of tissue samples obtained through biopsies. However, these traditional methods have limitations, including the potential for underdiagnosis of high-grade lesions and overdiagnosis of low-grade tumors. (Catalona et al., 2017)

In recent years, the emergence of artificial intelligence algorithms has shown promise in improving the accuracy and efficiency of prostate cancer detection. These AI-based algorithms have been developed to analyze digital pathology slides and provide automated detection of cancerous tissue. Previous studies have demonstrated the potential of these AI systems to enhance the performance of pathologists in identifying prostate cancer, particularly for small or subtle lesions that may be overlooked. (da Silva et al., 2021)

One study found that a AI-based prostate cancer detection algorithm was able to accurately identify cancer in 509 out of 11,429 H&E-stained slides, with a subset of these alerts leading to additional diagnostic tests and the detection of a cancer case that was initially missed by the pathologist. Another study reported on the independent real-world application of a clinical-grade AI system for prostate cancer detection, demonstrating strong diagnostic accuracy in a setting outside of the original development and validation of the system. (da Silva et al., 2021).

OVERVIEW

Prostate cases generally occur in adult men up to old age, this case is in the form of hyperplasia where this disease is an increase in the number of abnormal cells, when abnormal genetic mutations occur, this disease will become a malignant tumor which can develop in the male prostate and causes prostate cancer. This cancer can spread to other body organs, especially the bones and hip lymph nodes. Classification Classification of prostate cancer according to Smart in 2014 (Miyahira, 2022):

a. Stage A: a lump in the prostate gland that cannot be felt on physical examination, and is usually discovered accidentally after prostate problems due to other diseases.
b. B. Stage B: it is known that there is a lump or tumor in the prostate that can be felt or by physical examination or by the

Prostate Specific Antigen (PSA) test.

c. C. Stage C: the tumor has spread outside the prostate capsule, but is still not too serious and has not spread to the lymph nodes.
d. D. Stage D: at this stage, cancer is very dangerous because prostate cancer has spread (metastasized) to regional lymph nodes and other parts of the body (bones, lungs, etc.).

Prostate cancer usually has no signs of symptoms indicating the presence of cancer. Sometimes, signs and symptoms resemble Benign Prostate Hyperplasia (BPH), namely difficulty urinating or frequent urination. Cancer can also cause the urinary tract to turn red or cause the urinary tract to be suddenly removed. Usually prostate cancer is detected after the cancer has metastasized. Prostate cancer can also cause pain in the bones, and the bones become brittle so they can easily fracture. Apart from that, prostate cancer can also cause anemia, nervous or mental symptoms (Teng, 2021).

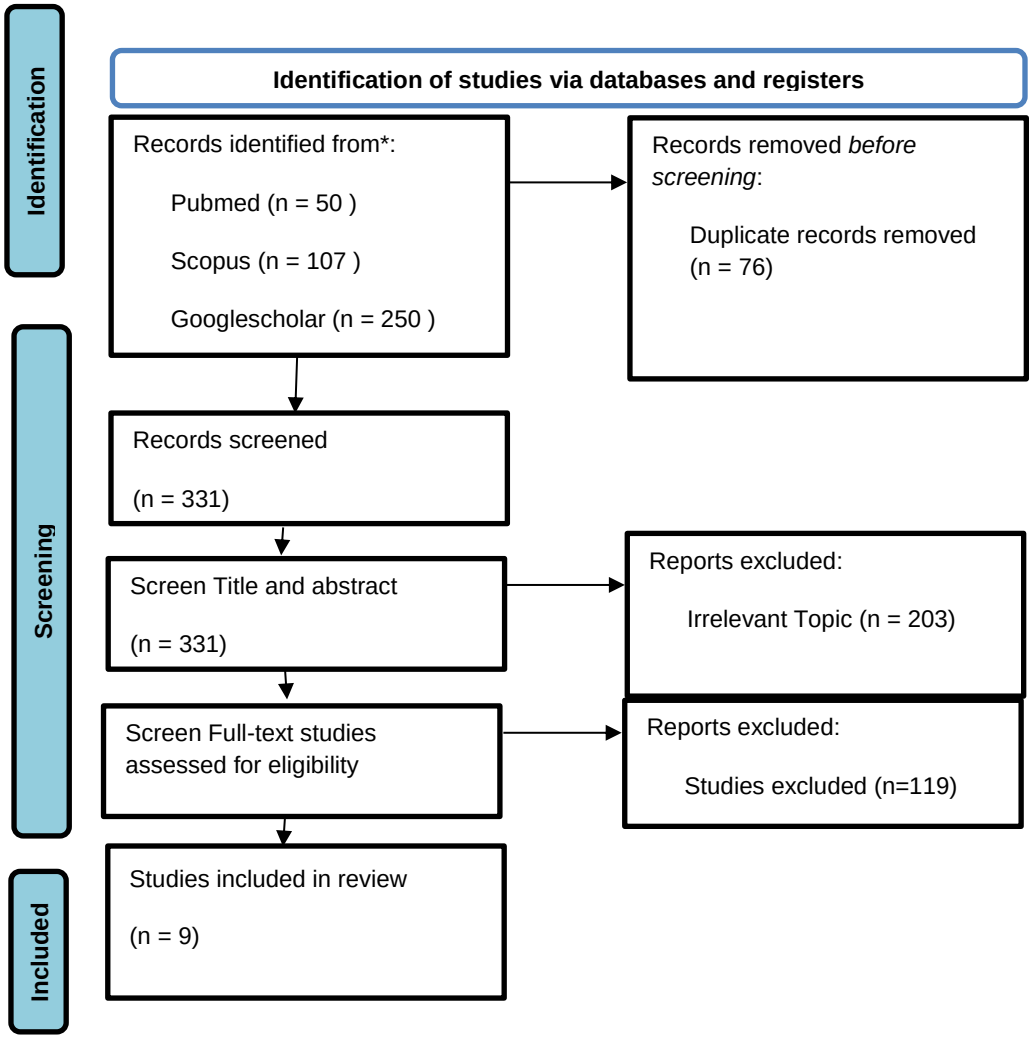
RESEARCH METHODS

Search Strategy

We searched from January 2019 up to January 2024. All the refrences of included manuscripts and previous reviews were also screned. This systematic review was reported in compliance to the Preferred Reporting Items for Systematic Reviews with PRISMA protocol. (fig 1)

A comprehensive literature search was conducted using databases such as PubMed, Google Scholar, and Scopus. The search strategy employed Boolean operators to combine keywords related to AI, traditional diagnostic methods, and prostate cancer. The search terms included “Artificial Intelligence" OR "Machine Learning" AND "Prostate Cancer" AND "Early Detection" Traditional Diagnostic Methods" AND "Prostate Cancer" AND "Early Detection" "AI-based Diagnostics" AND "Prostate Cancer" “PSA Testing" AND "AI" AND "Prostate Cancer".

We have recorded from pubmed, googlescholar and scopus. In each of these searches we found pubmed (n=50), googlescholar (n=250) and scopus (n=107) from each of these we screened for duplication and found 76 duplicated study. In short, after screening the title, abstract and overall, we finally got 9 studies that we will review next.



Eligible Criteria

After identifying the initial set of studies, a reviewer undertook the removal of duplicate entries. Subsequently, two reviewers assessed independently all the titles and abstracts (and full text, in need of further clarification) for relevance. The eligibility of studies and data extraction were performed with a comprehensive full-text review conducted by two reviewers.

The population, intervention, comparator, outcome and study (PICOS) approach was used to define the research question and study eligibility as follows: Men at risk for or suspected of having prostate cancer (P), Artificial intelligence (AI)-based diagnostic methods (e.g., machine learning algorithms, AI-enhanced imaging techniques) (I), Traditional diagnostic methods (e.g., PSA testing, digital rectal examination (DRE), standard imaging techniques such as MRI or ultrasound, and biopsy) (C), Diagnostic accuracy (sensitivity, specificity), early detection rates, false positive and false negative rates, Time to diagnosis (O), Cohort studies, cross-sectional studies, randomized controlled trials (RCTs) (S).

Inclusion Criteria

Studies involving men at risk for or suspected of having prostate

cancer and participants of varying ages, particularly those over 50, with risk factors such as family history, elevated PSA levels, or abnormal DRE findings. Studies evaluating AI-based diagnostic methods, including Machine learning algorithms for analyzing PSA levels, imaging results, or other biomarkers, AI-enhanced imaging techniques such as AI-assisted MRI or ultrasound, AI-based pathology analysis for biopsy samples. Studies reporting on primary outcomes such as diagnostic accuracy (sensitivity, specificity), early detection rates, false positive and false negative rates. Studies reporting on secondary outcomes such as time to diagnosis, patient outcomes (e.g., survival rates, progression-free survival), cost-effectiveness, and patient satisfaction. Study Design has Randomized controlled trials (RCTs), Cohort studies, Case-control studies, Diagnostic accuracy studies. Language and Publication Date must be in English and published within the last 5 years to ensure contemporary relevance, given the rapid advancements in AI technology.

Exclusion Criteria

Studies involving men with a prior diagnosis of prostate cancer including participants with severe comorbidities that preclude screening or follow-up. we do not includes involving men already undergoing treatment for prostate cancer. Studies focusing solely on non-diagnostic aspects of AI (e.g., AI for treatment planning or monitoring). Studies not reporting relevant primary or secondary outcomes. Case reports, letters, editorials, and review articles without original data must be exluded.

RESULTS

Study Selection

The searches identified 407 studies, After removing duplicates, the titles and abstracts were screened for 279 studies, with subsequent full-text screening of 128 studies. We have ten studies to review in total. Therefore, we chose to review data for all 10 identified studies that applied AI techniques to detect ca prostate.

DISCUSSION

The findings of this systematic review highlight the potential of AI-based diagnostic methods to revolutionize early detection of prostate cancer. several studies show AI techniques offer superior accuracy and early detection capabilities compared to traditional methods, which can lead to improved patient outcomes and cost savings. However, further research and clinical validation are necessary to integrate AI into routine clinical practice fully.

Each of the ten studies we selected has results and characters that we will explain based on the following table 1. each study showed an advantage in using artificial intelligence to detect prostate cancer. Some studies explain with the help of artificial intelligence can increase the accuracy in detecting prostate cancer. The study conducted by Rui Uo et al in Hubei, China in 150 patients found 137 patients with prostate Ca and this used Artificial Intelligence Algorithm-Based MRI in the form of RLRE algorithm (low-rank matrix restoration algorithm) where the sensitivity of DCE (97.08%) was higher than DWI (91.97%) and plain scan (86.13%). The specificity of DCE

(92.31%) was also higher than DWI (76.92%) and plain scan (69.23%)(Bao et al., 2022). David et al's study on 49 biopsied patients and subsequent detection using Deep Learning and Biparametric Imaging showed a sensitivity of 87% (33 out of 38 clinically significant lesions detected) and a specificity of 50% (5 out of 10 non-cancerous cases correctly identified). (Winkel, Wetterauer, et al., 2020)

The studies we extracted showed significant advantages in selecting for prostate cancer in the suspected population. The significant increase in sensitivity and specificity compared to diagnostic tools without the help of artificial intelligence is evidence that the development of diagnostic diseases, especially prostate cancer is very good. In a study conducted by Huiyo Zang et al conducted on 4747 participants in 2023 in China showed The main finding of the study is that the Prostate Cancer Artificial Intelligence Diagnostic System (PCAIDS), developed using automated machine learning (AutoML), significantly improves the detection of clinically significant prostate cancer (csPCa) compared to traditional diagnostic methods. This advancement is crucial for early detection and improved patient outcomes in prostate cancer management. (Zhang, Ji, et al., 2023)

The studies conducted have some limitations, namely the lack of a research sample that can represent general feasibility (Sun et al., 2023). However, while the sample size may not be large enough to represent a large population, the use of artificial intelligence makes it possible to detect patients suspected of having prostate cancer with low PSA levels. This was proven and explained in a study conducted by Xiaobin Deng et al. The study involved a total of 146 patients from the First Affiliated Hospital of Guangxi Medical University and the main finding of the study was the development of a machine learning (ML) model that effectively predicted prostate cancer (PCa) in patients with low prostate-specific antigen (PSA) levels (≤20 ng/mL). The conclusion of this study emphasized the successful development of a machine learning (ML) model that demonstrated strong predictive accuracy for diagnosing prostate cancer (PCa) in patients with low prostate-specific antigen (PSA) levels (Deng et al., 2022). Other studies have also shown improved detection of ca prostate with the help of artificial intelligence. (Cosma et al., 2021; Morote et al., 2022; Raciti et al., 2020; Winkel, Breit, et al., 2020).

CONCLUSION

AI-based diagnostic methods have shown significant promise in enhancing the early detection of prostate cancer. As technology continues to advance, integrating AI with traditional diagnostic approaches could lead to more effective, efficient, and accurate prostate cancer screening and diagnosis. Future studies should focus on large-scale clinical trials and real-world applications to validate these findings and facilitate the adoption of AI in clinical settings.

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