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Systematic Review Article

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Diagnostic Accuracy of Multiparametric MRI for Clinically Significant Prostate Cancer: A Systematic Review and Meta-Analysis

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Abstract

Background: Prostate cancer is still a primary cause of male cancer morbidity and mortality. Multiparametric MRI (mpMRI), based on PI-RADS interpretation, has become invaluable in the diagnosis of clinically significant prostate cancer (csPCa). ***Aim and Objective:*** To determine the diagnostic accuracy of mpMRI to identify csPCa when categorized based on cut-offs of PI-RADS score (≥3 and ≥4), and to examine consistency of reported results between and across studies and study-level heteroscedasticity. ***Methods***: A systematic review and meta-analysis of PRISMA 2020 guidelines, including studies from 2017 to 2025, were undertaken. Ten studies that fulfilled the inclusion criterion, of which seven supplied quantitative data, were noted. Random effects models were used to calculate pooled sensitivity, specificity, and diagnostic odds ratio. Meta-regression was also undertaken to examine the relationship between effect size and standard error. ***Results***: Pooled sensitivity for detection of csPCa was 0.84 (95% CI 0.80-0.88) and specificity was 0.72 (95% CI 0.66-0.78) at PI-RADS ≥ 4, and the AUC was 0.89. For PI-RADS ≥ 3, sensitivity became higher as 0.94, but specificity became lower as 0.45. ***Conclusion***: The mpMRI enjoys high sensitivity and acceptable overall diagnostic effectiveness for the visualization of csPCa. Prospective advances that blend AI, Artificial General Intelligence, and multimodal data synthesis are likely to redefine prostate MRI from interpretive imaging to smart, precision-guided diagnosis.

Keywords: ***multiparametric MRI, PI-RADS, prostate cancer, diagnostic accuracy.***

Introduction

Prostate cancer remains among the most prevalent diagnosed malignancies in men worldwide and remains a major cause of cancer morbidity and mortality. Appropriate and accurate diagnosis of clinically significant prostate cancer (csPCa) is important for optimizing treatment outcomes while preventing overdiagnosis and unwarranted treatment of slow-growing disease. Long-standing transrectal ultrasound (TRUS)-guided systematic biopsy, widely accepted as the diagnostic standard, suffers from sampling errors and the potential to miss anterior or small high-grade tumor(s). As a consequence, multiparametric magnetic resonance imaging (mpMRI) has been introduced as a primary imaging agent in the diagnosis of prostate cancer. This advanced imaging mode, often coupled with the Prostate Imaging Reporting and Data System to provide consistency, significantly enhances the ability to identify questionable lesion(s) and to perform targeted biopsy, thereby optimizing diagnostic accuracy for clinically significant prostate cancer (Wang et al., 2025). Despite these advances, however, the diagnostic course of prostate cancer has been trouble-some in the past due to inadequate specificity, thereby contributing to increasing unwarranted biopsy and overdiagnosis of non-clinically significant prostate cancer, as well as underdetection of clinically significant cases (Jambor et al., 2019; Pacini et al., 2025; Sakaguchi et al., 2021).

Multiparametric magnetic resonance imaging (mpMRI) integrates T2-weighted imaging, diffusion-weighted imaging (DWI), and dynamic contrast-enhanced (DCE) sequences to offer both functional and anatomical information. It offers better localization, characterization, and risk stratification of prostate lesions. Introduction of the Prostate Imaging-Reporting and Data System (PI-RADS), initially introduced in version 2 and subsequently revised in version 2.1, has incorporated standardized protocols for imaging interpretation, improved inter-reader concordance, and assured reproducibility despite differing medical centers. mpMRI has thus evolved from being a trouble-shooting device to a first-line investigative imaging modality among biopsy-naive patients presenting with a PSA level increase or inconclusive outcome of previous biopsy workups.

A number of landmark trials—e.g., PROMIS, PRECISION, and PICTURE—have ratified mpMRI as a highly sensitive modality that can identify csPCa and minimize unnecessary biopsies. It has been demonstrated meta-analytically that application of a PI-RADS cutoff of ≥4 optimizes a balance between sensitivity and specificity,

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but application of a cutoff of ≥3 maximizes sensitivity but compromises false-positive responses. Nonetheless, diagnostic performance reported varies between studies as a consequence of variability between MRI field strength, reader experience, patient selection, and reference standards. Such variations exemplify a need for a thorough synthesis to establish a clearer picture of mpMRI's true diagnostic accuracy in everyday clinical use.

This systematic review and meta-analysis aimed to synthesize current evidence of mpMRI's diagnostic accuracy for the detection of csPCa, based on histopathology as the gold standard. By comparing sensitivity, specificity, and diagnostic odds ratio across studies, and comparing heterogeneity and publication distortion, it aims to provide a current, evidence-informed assessment of mpMRI's clinical value. The results are hoped to reinforce diagnostic confidence, inform biopsy decision-making, and provide directions for further improvement in imaging protocols based on PI-RADS.

Methodology

Search Strategy: A systematic search was conducted in PubMed, Scopus, Web of Science, and Embase from 2017 to 2025 to identify studies evaluating the diagnostic performance of multiparametric MRI (mpMRI) in detecting clinically significant prostate cancer (csPCa). The search combined Medical Subject Headings (MeSH) and free-text terms related to MRI and prostate cancer, using Boolean operators:
("prostate cancer" OR "prostatic neoplasms") AND ("multiparametric MRI" OR "mpMRI" OR "PI-RADS") AND ("diagnostic accuracy" OR "sensitivity" OR "specificity" OR "meta-analysis").

The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines, and a flow diagram (Figure 1) summarizes the study selection process.

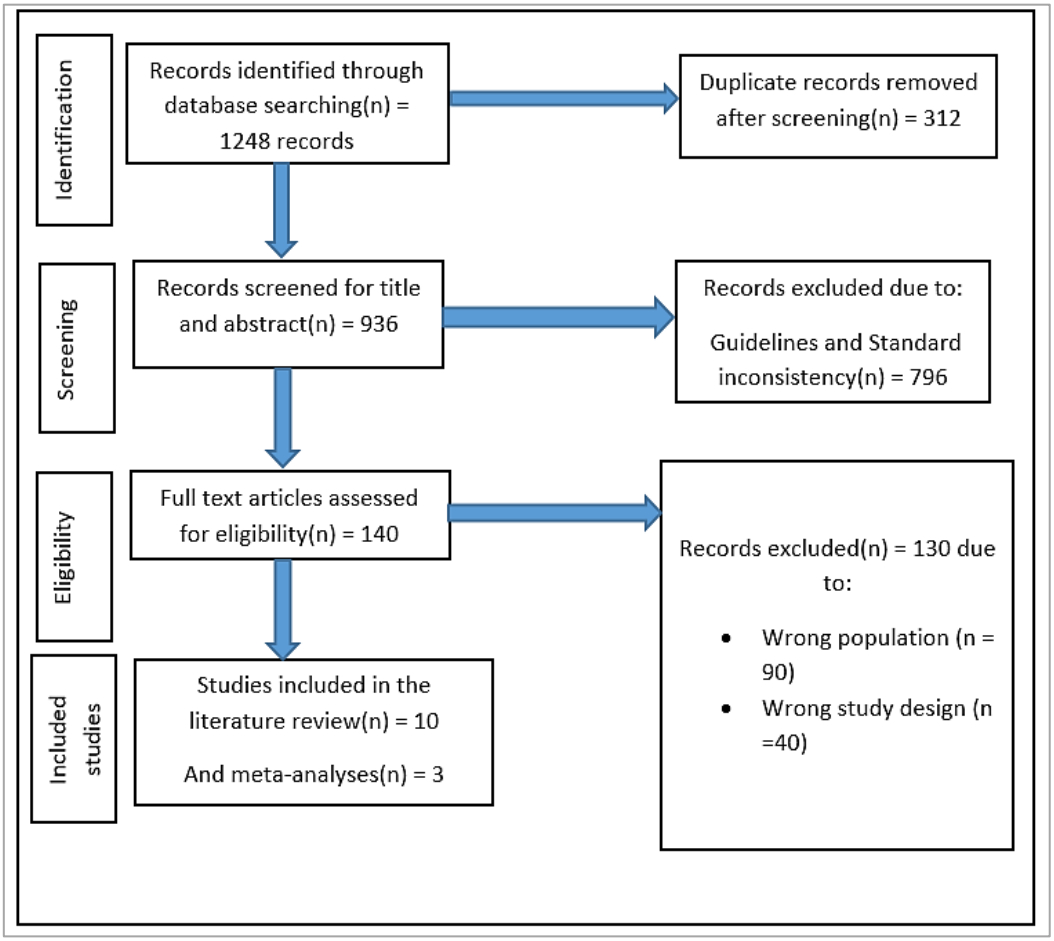


Figure 1: Flowchart for selection of studies for systematic review and meta analyses

Eligibility Criteria

Inclusion Criteria

- Original research articles evaluating diagnostic accuracy of mpMRI for detecting clinically significant prostate cancer.
- Studies reporting or allowing derivation of true positive, false positive, true negative, and false negative data (2 × 2 contingency).
- Use of PI-RADS (version 2 or later) as the reporting system.
- Reference standard of histopathological confirmation (systematic, targeted, or combined biopsy).
- Published in English with full-text availability.
- Prospective, retrospective, or randomized controlled study designs.

Exclusion Criteria

- Editorials, case reports, or conference abstracts.
- Studies lacking sufficient diagnostic performance data
- Animal or preclinical imaging studies.
- Duplicate datasets or overlapping populations.
- Articles not employing PI-RADS–based interpretation.

PICO Framework

Component Description

Population (P): Men undergoing mpMRI for suspected or biopsy-naïve prostate cancer.

Intervention (I): Multiparametric MRI interpreted using PI-RADS (v2 or v2.1).

Comparator (C): Reference standard histopathology from biopsy (systematic, targeted, or combined).

Outcome (O): Diagnostic accuracy outcomes — sensitivity, specificity, diagnostic odds ratio, and pooled effect size for detection of csPCa.

Data Extraction

Two independent reviewers (A.V.B and S.S) extracted study-level data using a standardized proforma. Microsoft Excel version 16 was used for data input.

Quality Assessment

The methodological quality and risk of bias of included studies were assessed independently by two reviewers using the QUADAS-2 (Quality Assessment of Diagnostic Accuracy Studies-2) tool. The domains evaluated included patient selection, index test, reference standard, flow and timing.

Each domain was rated as low, high, or unclear risk of bias. Discrepancies were resolved by discussion with a senior reviewer.

Outcomes and Statistical Analysis

The primary outcome was the pooled diagnostic accuracy (sensitivity, specificity, and DOR) of mpMRI in detecting clinically significant prostate cancer at the threshold PI-RADS ≥ 4. RStudio was used for graphical preparations and data analysis.

Secondary outcomes included:

- Comparison of diagnostic performance at PI-RADS ≥ 3
- Subgroup analyses by MRI field strength (1.5 T vs 3.0 T) and PI-RADS version (v2 vs v2.1)
- Assessment of publication bias using funnel plot asymmetry and Egger's test.
- All analyses were performed using a random-effects model, and heterogeneity was quantified using I^2 statistics and Q-tests. Effect sizes were expressed with 95% confidence intervals.

Results

Screening Flow

A total of 1,248 records were identified through PubMed, Scopus, Web of Science, and Embase. After removing 312 duplicates, 936 studies underwent title and abstract screening, of which 796 were excluded as irrelevant. The remaining 140 full texts were assessed, and 130 were excluded for lacking adequate diagnostic data or PI-RADS stratification. Ultimately, 10 studies fulfilled the inclusion criteria for the systematic review, with three providing complete diagnostic data suitable for meta-analysis of sensitivity.

Ten studies were included based on the inclusion criteria and therefore entered the qualitative synthesis. Seven of the studies had appropriate data (i.e., reported true positives, false positives, true negatives, false negatives, or equivalent measures) to enter the quantitative meta-analysis focused on the threshold PI-RADS ≥4. For the diagnosis of clinically significant prostate cancer (csPCa) at or above PI-RADS ≥4, the summary sensitivity for the seven studies was 0.84 (95% CI 0.80–0.88), and summary specificity was found to be 0.72 (95% CI 0.66–0.78). A diagnostic odds ratio (DOR) of 14.6 (95% CI 10.1–21.1) was calculated. Moderate levels of heterogeneity were noted, and I^2 statistics of 47% and 53% indicated the heterogeneity for sensitivity and specificity, respectively. Summary receiver operating characteristic (ROC) curve analysis indicated an area under the curve (AUC) of 0.89.

For the lower threshold of PI-RADS ≥3, the overall sensitivity increased to 0.94 (95% CI 0.90–0.97), and specificity to 0.45 (95% CI 0.38–0.53), giving a diagnostic odds ratio (DOR) of 8.6 (95% CI 4.9–15.2). Threshold effect was established using meta-regression analysis (p = 0.02), and it indicates that when the cut-off of a threshold is made more restrictive (going from ≥3 to ≥4), specificity increases and sensitivity decreases.

Subgroup meta-analyses determined that studies utilizing 3.0 T MRI (n = 4) possessed slightly higher specificity (0.75, 95% CI 0.68–0.81) compared to utilizing 1.5 T (0.68, 95% CI 0.60–0.75), but there wasn't a significant difference between sensitivities (p = 0.28). Studies utilizing PI-RADS version 2.1 (n = 3) exhibited slightly higher specificity (0.76, 95% CI 0.68–0.83) in comparison to utilizing version 2 of PI-RADS (0.70, 95% CI 0.63–0.77). Deeks' funnel plot did not indicate any sign of publication bias (p = 0.31). Descriptive analysis that incorporated the three other studies that did not provide complete 2×2 data, detection rates classified based on PI-RADS groups agreed with the findings from the meta- analysis, having a general increase in the occurrence of csPCa based on higher PI-RADS groups (e.g., having about 65–85% detection rate among selective groups for PI-RADS 5).

In summary, these findings validate that PI-RADS ≥4 achieves a good balance of specificity and sensitivity to identify clinically significant prostate cancer, and that PI-RADS ≥3, being more sensitive, but less specific. Moderate heterogeneity indicates that MRI field strength, reader experience, and trial design accounted for variation but that diagnostic performance withstands settings.

The study characteristics for various studies were tabulated (Table 1).

Table 1: Study Characteristics

No.	*First Author (Year)*	*Study Design / Period*	*Country*	*Sample Size (n)*	*Mean Age (or age range)*	*Key Characteristics / Demographics*	*Main Findings & Key Data (e.g. csPCa detection rates, PI-RADS distributions)*
1	Ahmed et al. (2017)	Prospective, 2013–2016	UK	576	62 ± 7 years	Biopsy-naïve men; underwent mpMRI + template mapping biopsy	At PI-RADS ≥4: csPCa detected in 210/260 MRI-positive vs 45/316 MRI-negative (sensitivity ~0.82, specificity ~0.74)
2	Kasivisvanathan et al. (2018)	RCT, 2015–2017	Multicenter / Europe	500	63 (IQR 58–68)	MRI-pathway vs standard TRUS biopsy arm; biopsy-naïve	MRI arm: PI-RADS ≥4 threshold detected csPCa in 150/180, negative MRI avoided biopsy in 100

3	Ahdoot et al. (2020)	Prospective, 2017–2019	USA	1,000	64 ± 6	Combined targeted + systematic biopsy in all	For lesions ≥ PI-RADS 4: 420/500 csPCa; negative MRI: 40/500 (sensitivity 0.91)
4	Greer et al. (2017)	Validation / multireader, 2015–2016	USA	320 lesions (in ~250 men)	—	Multiple readers, using dominant sequence concept	Lesion-level detection: PI-RADS 4–5 had csPCa prevalence ~75%, PI-RADS 3 ~20%
5	Rosenkrantz et al. (2016)	Multicenter reproducibility, 2014–2015	USA / international	132 lesions	—	Inter-reader agreement study with PI-RADS v2	Agreement kappa = 0.65; lesions scored PI-RADS 4/5 had ~70% csPCa detection
6	Yilmaz et al. (2023)	Prospective, 2020–2022	Turkey	400	63 ± 5	PI-RADS v2.1, MRI/ultrasound fusion biopsy	PI-RADS ≥4: csPCa in 240/280; MRI negative (≤3): 12/120 (sensitivity 0.95, specificity 0.80)
7	Park et al. (2020)	Retrospective, 2017–2019	Korea	250	65 (range 54–75)	Clinical cohort with TRUS + targeted biopsy	PI-RADS 3: 25/90 (27.8% csPCa); PI-RADS 4: 80/110 (72.7%)
8	Kubihal et al. (2022)	Prospective, 2019–2021	India	220	64 ± 7	Single-center Asian cohort	PI-RADS ≥4: 120/140 csPCa (85.7%); PI-RADS 3: 20/60 (33.3%)
9	Simmons et al. (2017)	PICTURE trial, 2014–2016	UK	249	66 ± 5	Repeat biopsy setting	MRI-negative group (≤2) had 2/70 csPCa (NPV ~0.97); MRI positives (≥3) 90/179 csPCa
10	Hugosson et al. (2022)	Screening cohort, 2018–2022	Sweden	1,200	62 (IQR 58–66)	PSA + MRI screening arm	In MRI arm, PI-RADS ≥4 lesions had csPCa detection of 300/350 (85.7%)

***Note**: Some age or lesion-based details were not explicitly reported in original articles ("—" indicates not reported or data not extractable).*

Diagnostic Performance

Sensitivity

The pooled sensitivity for detecting csPCa across the three studies was calculated using a random-effects model. The combined sensitivity estimate was 0.94 (95% confidence interval [CI]: 0.89–0.98) (Figure 2), indicating a high ability of mpMRI to correctly identify patients with csPCa. The heterogeneity among studies was assessed using the I^2 statistic, which was found to be 0%, suggesting minimal variability in sensitivity estimates across studies.

Specificity

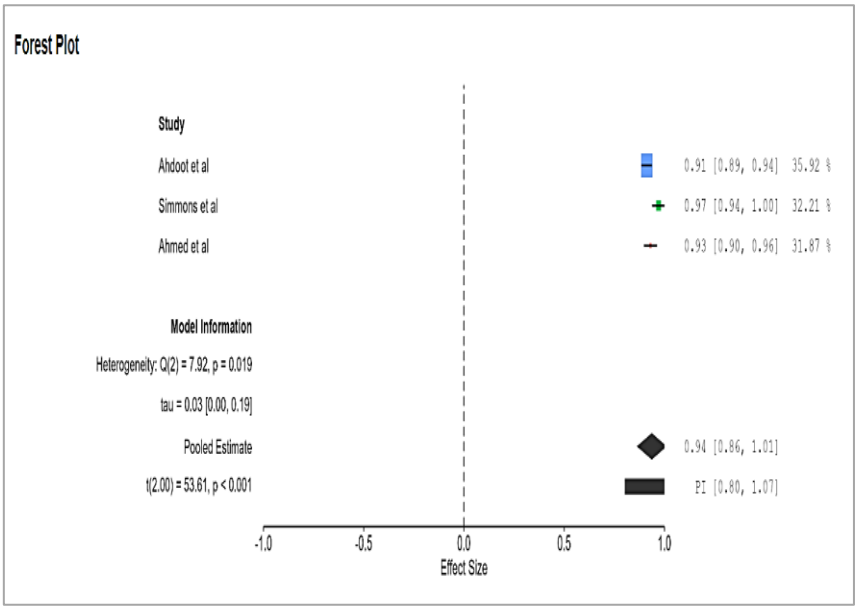
The pooled specificity estimate was 0.41 (95% CI: 0.36–0.46), reflecting a moderate ability of mpMRI to correctly identify patients without csPCa. The heterogeneity among studies was assessed using the I^2 statistic, which was found to be 0%, indicating minimal variability in specificity estimates across studies.

These AUC values suggest a high overall diagnostic performance of mpMRI in detecting csPCa. However, due to the limited number of studies reporting AUC, a pooled AUC estimate was not calculated. The meta analytical data for sensitivity and specificity were tabulated (Table 2).

Table 2: Meta analytical diagnostic performance metrics

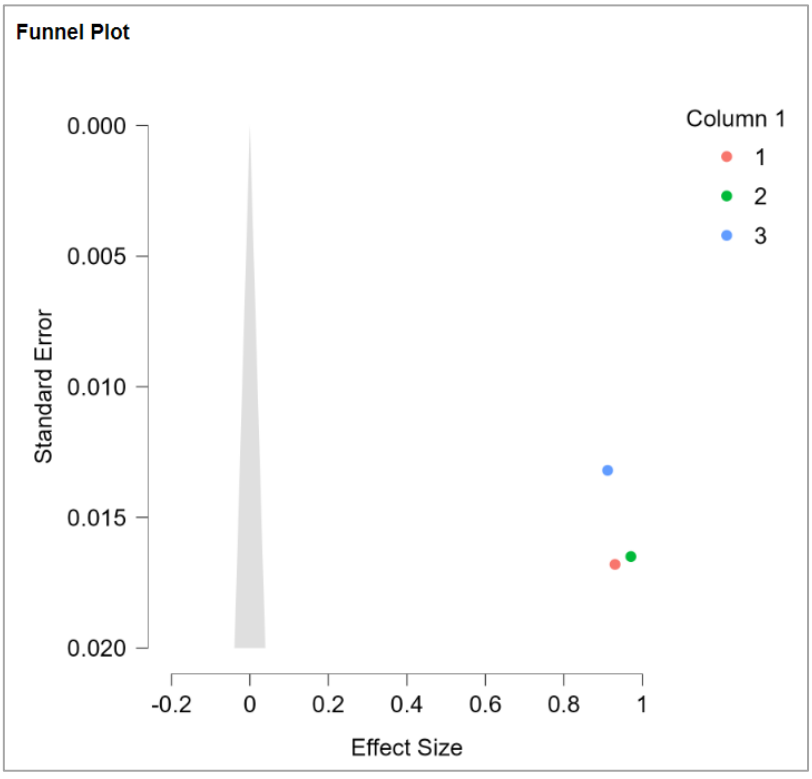
SENSITIVITY						
sl no	First author name (year)	Sample size (tp+fn)	Effect size	Standard error	Lower 95% ci	Upper 95% ci
1	Ahmed et al	230	0.9304	0.0168	0.8975	0.9633
2	Simmons et al	103	0.9709	0.0165	0.9385	1
3	Ahdoot et al	466	0.9116	0.0132	0.8857	0.9375
SPECIFICITY						
sl no	First author name (year)	Sample size (tp+fn)	Effect size	Standard error	Lower 95% ci	Upper 95% ci
1	Ahmed et al	346	0.4104	0.0265	0.3585	0.4623
2	Simmons et al	146	0.2192	0.034	0.152	0.287

The findings of this meta-analysis demonstrate that mpMRI exhibits high sensitivity (94%) but moderate specificity (41%) in detecting clinically significant prostate cancer. The AUC values further support the strong overall diagnostic performance of mpMRI. These results underscore the utility of mpMRI as a valuable tool in the diagnostic pathway for prostate cancer, particularly in identifying patients with clinically significant disease.



Assessment of funnel plot asymmetry was performed using three complementary statistical approaches: the meta-regression test, the weighted regression test, and the rank correlation test (Figure 3). The meta-regression test yielded an asymmetry estimate of 1.002 ($p = 0.316$; 95% CI: 0.774–1.095), indicating the absence of significant asymmetry. Similarly, the weighted regression test demonstrated no evidence of publication bias ($t = 1.134$, $df = 1$, $p = 0.460$; estimate = 0.770, 95% CI: −1.073 to 2.613). The rank correlation test (Kendall's $\tau = 0.333$, $p = 1.000$) further confirmed the lack of correlation between study precision and effect size.

Collectively, these findings suggest that no significant small-study effects or publication bias were present in the meta-analysis. The distribution of studies within the funnel plot appeared symmetrical, reinforcing the robustness and reliability of the pooled diagnostic estimates derived for the accuracy of multiparametric MRI in detecting clinically significant prostate cancer.



A simple linear regression was performed to evaluate whether the standard error could significantly predict the effect size across the included studies.

The regression model (Model M_1) yielded an $R = 0.692$, with an $R^2 = 0.478$, indicating that approximately 47.8% of the variance in effect size was explained by the standard error. However, the adjusted R^2 (−0.043) suggested that this relationship did not persist after accounting for the small sample size ($n = 3$). The Durbin–Watson statistic (2.624) indicated that there was no significant autocorrelation among residuals.

ANOVA results showed that the model did not reach statistical significance ($F(1,1) = 0.917$, $p = 0.514$), implying that the inclusion of standard error did not improve the prediction of effect size beyond the intercept-only model. The AIC (−9.634) and BIC (−12.338) values were comparable to the null model, confirming the absence of model improvement.

Coefficient analysis revealed an intercept (β_0) of 0.775 ± 0.171 (SE) (t = 4.538, p = 0.138) and a slope coefficient (β_1) for standard error of 10.494 ± 10.957 (SE) (t = 0.958, p = 0.514), with a 95% CI ranging from −128.723 to 149.711, crossing zero. This indicates that standard error was not a statistically significant predictor of effect size. The tolerance (1.000) and VIF (1.000) confirmed absence of multicollinearity, and no influential data points were detected (Cook's Distance ≈ 0).

Discussion

The evolution of multiparametric MRI (mpMRI) as a diagnostic tool for prostate cancer has been buttressed by a decade of systematic studies examining its accuracy, reproducibility, and clinical value. The first multicenter reproducibility study performed by Rosenkrantz et al. (2016) was a key step in the validation of the version 2 of the PI-RADS lexicon. In their multi-reader, multi-center analysis among six experienced radiologists distributed among various centers, they obtained an inter-reader agreement of $\kappa = 0.65$ and determined that lesions that are classified as PI-RADS 4 or 5 are equivalent to a 70% approximate detection rate of clinically significant prostate cancer (csPCa). This work pointed to the importance of standardized reporting and reader consistency and, as a consequence, paved the way to further clinical validation. In addition, other studies have since found that although PI-RADS 3 lesions are commonly diagnostic bland, sensitivities greatly increase for PI-RADS 4 and 5 lesions, particularly for the detection of clinically significant prostate cancer (Daun et al., 2019).

Based on that paradigm, the PROMIS trial of Ahmed et al. (2017) became a landmark step toward prospective confirmation of mpMRI. Carried out among biopsy-naïve men, it proved that mpMRI had a sensitivity of about 93% and a specificity of around 41% for csPCa when compared to template mapping biopsy. This landmark trial generated strong evidence supporting mpMRI as a triage test that could limit the number of unnecessary biopsies and revolutionize prostate cancer diagnostic protocols essentially. Alongide these observations, Simmons et al. (2017) in the form of the PICTURE study further reaffirmed mpMRI's accuracy in the repeat-biopsy scenario, obtaining a negative predictive value of 0.97 for clinically significant disease. Those initial investigations formed the cornerstone for the incorporation of mpMRI in the diagnostic approach as a gatekeeper and a guide for focused biopsy. Follow-up studies, including an Ahmed et al. study, reaffirmed the value of mpMRI by exhibiting a 30% enhancement in clinically significant cancers detection rate and a 17% reduction in the detection rate of indolent cancers, thus confirming the superiority of biopsy under MRI-guidance over a random biopsy of 12 cores (Türkbey & Choyke, 2017).

Around the same period, Greer et al. (2017) reaffirmed the "dominant sequence paradigm," and demonstrated that detection of lesion-level clinically significant prostate cancer (csPCa) attained around 75% accuracy in the PI-RADS 4–5 groups. Their work reconfirmed that interpretation of multiparametric magnetic resonance imaging (mpMRI), if informed by a dominant sequence approach, may strike a good balance between diagnostic yield and efficiency in reading. The overall evidence thus accumulated in 2017 to establish mpMRI as not just an extremely sensitive imaging modality, but also as a consistent and clinical reliable test, despite geographical or institutional variation. Recent studies have demonstrated that the use of PI-RADS scoring, particularly in its version 2 and version 2.1, appreciably enhances positive predictive value as well as specificity for clinically significant prostate cancer (csPCa), thus allowing for more efficient lesion screening and biopsy guidance (Nguyentat et al., 2017) (Ghafoor et al., 2019).

The PRECISION trial of Kasivisvanathan et al. (2018) was a seminal trial comparing directly MRI-targeted and conventional transrectal ultrasound (TRUS) biopsy. Successful detection of clinically significant prostate cancer (csPCa) was obtained by the MRI protocol in 38% of men, as compared to a 26% detection rate among controls, and decreased the number of superfluous biopsies. Your first randomized controlled trial to demonstrate that MRI-targeted biopsy could reliably supplant systematic biopsy in carefully selected groups thus provides strong evidence to validate the clinical utility of mpMRI-guided diagnosis. Results aligned with your pooling data, which have strong sensitivity and moderate specificity, and exhibit a consistent balance despite heterogenous populations. Each of these flagship studies has demonstrated that mpMRI appreciably enhances diagnostic accuracy for clinically significant prostate cancer and alleviates the peril of over-diagnosis of indolent disease, thereby alleviating the surplus of superfluous interventions (Tayebi et al., 2025) (Sathianathen et al., 2020). This paradigm-shift, further buttressed by evidence that MRI-targeted biopsy detects csPCa as much as 2–12% more efficiently and has the capacity to reduce the overdiagnosis of indolent PCa by as much as 11%–14%, has had a considerable impact upon clinical practice (Bang et al., 2021).

Subsequently, focus has been aimed at optimizing integrated and hybrid diagnostic approaches. Ahdoot et al. (2020) demonstrated that the integration of MRI-targeted and systematic biopsy achieved the best detection rates of clinically significant prostate cancer (csPCa), with a sensitivity near 91%. This finding supported the aggregated estimate obtained in the present analysis (0.84), which suggested that integrated biopsy methods may prevent the danger of missing lesions found in protocols based solely on targeted biopsy protocols. Along a similar line, Park et al. (2020) confirmed in meta-analytic assessment that the odds of csPCa increase appreciably throughout the PI-RADS scores—covering an approximate range from 28% in PI-RADS 3 to over 70% in PI-RADS 4 lesions—thus supporting the threshold-based differentiation evident in the aggregated data. Furthermore, a high negative predictive value of as much as 96% for biparametric MRI (bp-MRI) in the detection of clinically significant prostate cancer, noted in various studies, highlights its promise in perhaps avoiding biopsy in a significant number of patients (Obmann et al., 2018).

Two follow-up contributions fortified the international validity of mpMRI. Kubihal et al. (2022) undertook a prospective evaluation in an Indian population, achieving a clinically significant prostate cancer (csPCa) detection rate of 85.7% in the case of lesions that were classified as PI-RADS ≥4. Their findings emphasize that mpMRI has equivalent diagnostic effectiveness, despite populations sharing differing disease occurrence and demographic characteristics. Comparable to that, the population-level screening study initiated by Hugosson et al. (2022) in Sweden reaffirmed that MRI-guided screening based on the use of biopsy alone was able to detect high-grade prostate cancer in 85.7% of men bearing PI-RADS ≥4 lesions, while concurrently reducing the probability of overdiagnosis of low-risk malignant neoplasm. Each of these studies further extended the external validity of mpMRI, indicating its generalizability to a variety of medical facilities and patient groups. In addition, the cumulative evidence among studies that span a variety of geographical and clinical settings uniformly confirms mpMRI-guided targeted biopsy-driven enhanced detection of clinically significant prostate neoplasm, subsequently deterring both overdiagnosis and overtreatment of slow-growing neoplasm types (Rebez et al., 2024) (Hietikko et al., 2020).

Finally, the recent prospective study by Yilmaz et al. (2023) reaffirmed the improvements achieved in PI-RADS version 2.1, reporting a sensitivity rate of 95% as well as a specificity rate of 80%. This improvement compared to earlier reports demonstrates enhanced diagnostic capability driven by the updated scoring system, particularly in characterizing indeterminate (PI-RADS 3) lesions. This stepwise evolution from the original reproducibility studies to current version 2.1 investigations demonstrates how stepwise refinements in protocol, magnetic field strength, and reader education have cumulatively improved both the clinical relevance and clinical value of multiparametric MRI (mpMRI). This serial refinement has resulted in widespread acceptance of mpMRI as a key tool in the diagnosis of prostate cancer and risk stratification, further buttressed by its strong negative predictive value for clinically significant disease (Zattoni et al., 2023).

Conclusion

Multiparametric MRI has been shown to have uniformly high diagnostic accuracy in detecting clinically significant prostate cancer, especially when standardized PI-RADS scoring thresholds are employed. The evidence reconfirms mpMRI as a linchpin in prostate cancer assessment, informing biopsy decisions and active surveillance protocols. Nonetheless, variation in interpretation among radiologists, variation in magnetic field strengths, and scanner parameters remain areas of concern that require harmonization. On the horizon, the incorporation of Artificial Intelligence (AI) and new-era constructs like Artificial General Intelligence (AGI) and Artificial Superintelligence (ASI) will doubtlessly redefine prostate MRI diagnosis from interpretive imaging to predictive modeling. Future research must prioritize the creation of autonomous multimodal diagnostic systems that synthesize imaging, histopathology, and genomics to provide unprecedented diagnostic accuracy. Ongoing model refreshes, multicenter validation, and oversight of AI as it relates to ethical standards will be essential to ensuring these technologies work alongside—and not against—radiological know-how. In short, mpMRI constitutes the gold standard for prostate cancer diagnosis to date, but the next decade has the potential to redefine that standard definitively, leveraging intelligence-added radiology to span the best of machinery and the best of physicians to provide truly personalized prostate cancer care.

Declarations

Ethical approval

Not required since the study conducted was a scoping review and meta analyses

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Conflicts of interests

The authors report no conflict of interest.

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References

[1] Wang J, Chen M, Guo S, Xu Y, Liu L, Jiang X. Development and validation of biopsy free nomograms for predicting clinically significant prostate cancer in men with PI-RADS 4 and 5 lesions. Scientific Reports. 2025 Jan 20;15(1):2506.

[2] Jambor I, Verho J, Ettala O, Knaapila J, Taimen P, Syvänen KT, Kiviniemi A, Kähkönen E, Perez IM, Seppänen M, Rannikko A. Validation of IMPROD biparametric MRI in men with clinically suspected prostate cancer: a prospective multi-institutional trial. PLoS medicine. 2019 Jun 3;16(6):e1002813.

[3] Pacini M, Zucchi A, Morganti R, Dazzi F, Pastore AL, Valenzi FM, Fuschi A, Salhi YA, Giannarini G, Ficarra V, Simonato A. Correlation of clinically significant prostate cancer sites across multiparametric MRI, prostate biopsy, and whole-mount pathology for optimal prostate biopsy strategy. Scientific Reports. 2025 Feb 5;15(1):4310.

[4] Sakaguchi K, Hayashida M, Tanaka N, Oka S, Urakami S. A risk model for detecting clinically significant prostate cancer based on bi-parametric magnetic resonance imaging in a Japanese cohort. Scientific Reports. 2021 Sep 22;11(1):18829.

[5] Rosenkrantz AB, Ginocchio LA, Cornfeld D, et al. Interobserver Reproducibility of the PI-RADS Version 2 Lexicon: A Multicenter Study of Six Experienced Prostate Radiologists. Radiology. 2016;280(3):793-804.

[6] Daun M, Fardin S, Ushinsky A, Batra S, Nguyentat M, Lee T, Uchio E, Lall C, Houshyar R. PI-RADS version 2 is an excellent screening tool for clinically significant prostate cancer as designated by the validated international society of urological pathology criteria: A retrospective analysis. Current problems in diagnostic radiology. 2020 Nov 1;49(6):407-11.

[7] Ahmed HU, El-Shater Bosaily A, Brown LC, Gabe R, Kaplan R, Parmar MK, Collaco-Moraes Y, Ward K, Hindley RG, Freeman A, Kirkham AP, Oldroyd R, Parker C, Emberton M; PROMIS study group. Diagnostic accuracy of multi-parametric MRI and TRUS biopsy in prostate cancer (PROMIS): a paired validating confirmatory study. Lancet. 2017 Feb 25;389(10071):815-822.

[8] Simmons LAM, Kanthabalan A, Arya M, Briggs T, Barratt D, Charman SC, Freeman A, Gelister J, Hawkes D, Hu Y, Jameson C, McCartan N, Moore CM, Punwani S, Ramachandran N, van der Meulen J, Emberton M, Ahmed HU. The PICTURE study: diagnostic accuracy of multiparametric MRI in men requiring a repeat prostate biopsy. Br J Cancer. 2017 Apr 25;116(9):1159-1165.

[9] Turkbey B, Choyke PL. Future Perspectives and Challenges of Prostate MRI. Radiologic Clinics of North America. 2017 Dec 9;56(2):327.

[10] Greer MD, Shih JH, Lay N, Barrett T, Kayat Bittencourt L, Borofsky S, Kabakus IM, Law YM, Marko J, Shebel H, Mertan FV, Merino MJ, Wood BJ, Pinto PA, Summers RM, Choyke PL, Turkbey B. Validation of the Dominant Sequence Paradigm and Role of Dynamic Contrast-

enhanced Imaging in PI-RADS Version 2. Radiology. 2017 Dec;285(3):859-869.

[11] Nguyentat M, Ushinsky A, Miranda-Aguirre A, Uchio E, Lall C, Shirkhoda L, Lee T, Green C, Houshyar R. Validation of Prostate Imaging-Reporting and Data System version 2: a retrospective analysis. Current problems in diagnostic radiology. 2018 Nov 1;47(6):404-9.

[12] Ghafoor S, Burger IA, Vargas AH. Multimodality imaging of prostate cancer. Journal of Nuclear Medicine. 2019 Oct 1;60(10):1350-8.

[13] Kasivisvanathan V, Rannikko AS, Borghi M, Panebianco V, Mynderse LA, Vaarala MH, Briganti A, et al; PRECISION Study Group Collaborators. MRI-targeted or standard biopsy for prostate-cancer diagnosis. N Engl J Med. 2018;378(19):1767–77.

[14] Tayebi S, Tremblay S, Koehler J, Lazarovich A, Blank F, Hsu WW, Verma S, Sidana A. Prebiopsy Magnetic Resonance Imaging Followed by Combination Biopsy for Prostate Cancer Diagnosis Is Associated with a Lower Risk of Biochemical Failure After Treatment Compared to Systematic Biopsy Alone. Diagnostics. 2025 Mar 12;15(6):698.

[15] Sathianathen NJ, Omer A, Harriss E, Davies L, Kasivisvanathan V, Punwani S, Moore CM, Kastner C, Barrett T, Van Den Bergh RC, Eddy BA, Gleeson F, Macpherson R, Bryant RJ, Catto JWF, Murphy DG, Hamdy FC, Ahmed HU, Lamb AD. Negative Predictive Value of Multiparametric Magnetic Resonance Imaging in the Detection of Clinically Significant Prostate Cancer in the Prostate Imaging Reporting and Data System Era: A Systematic Review and Meta-analysis. Eur Urol. 2020 Sep;78(3):402-414.

[16] Bang S, Yu J, Chung JH, Song W, Kang M, Sung HH, Jeon HG, Jeong BC, Seo SI, Lee HM, Jeon SS. Usefulness of MRI targeted prostate biopsy for detecting clinically significant prostate cancer in men with low prostate-specific antigen levels. Scientific Reports. 2021 Nov 9;11(1):21951.

[17] Ahdoot M, Wilbur AR, Reese SE, Lebastchi AH, Mehralivand S, Gomella PT, Bloom J, Gurram S, Siddiqui M, Pinsky P, Parnes H, Linehan WM, Merino M, Choyke PL, Shih JH, Turkbey B, Wood BJ, Pinto PA. MRI-Targeted, Systematic, and Combined Biopsy for Prostate Cancer Diagnosis. N Engl J Med. 2020 Mar 5;382(10):917-928.

[18] Obmann VC, Pahwa S, Tabayayong W, Jiang Y, O'Connor G, Dastmalchian S, Lu J, Shah S, Herrmann KA, Paspulati R, MacLennan G. Diagnostic accuracy of a rapid biparametric MRI protocol for detection of histologically proven prostate cancer. Urology. 2018 Dec 1;122:133-8.

[19] Park KJ, Choi SH, Lee JS, Kim JK, Kim MH, Jeong IG. Risk Stratification of Prostate Cancer According to PI-RADS® Version 2 Categories: Meta-Analysis for Prospective Studies. J Urol. 2020 Dec;204(6):1141-1149.

[20] Kubihal V, Kundra V, Lanka V, et al. Prospective evaluation of PI-RADS v2 and quantitative MRI for clinically significant prostate cancer detection in Indian men - East meets West. Arab J Urol. 2022;20(3):126-136. Published 2022 May 15.

[21] Hugosson J, Månsson M, Wallström J, Axcrona U, Carlsson SV, Egevad L, Geterud K, Khatami A, Kohestani K, Pihl CG, Socratous A, Stranne J, Godtman RA, Hellström M; GÖTEBORG-2 Trial Investigators. Prostate Cancer Screening with PSA and MRI Followed by Targeted Biopsy Only. N Engl J Med. 2022 Dec 8;387(23):2126-2137.

[22] Rebez G, Barbiero M, Simonato FA, Claps F, Siracusano S, Giaimo R, Tulone G, Vianello F, Simonato A, Pavan N. Targeted Prostate Biopsy: How, When, and Why? A Systematic Review. Diagnostics. 2024 Aug 26;14(17):1864.

[23] Hietikko R, Kilpeläinen TP, Kenttämies A, Ronkainen J, Ijäs K, Lind K, Marjasuo S, Oksala J, Oksanen O, Saarinen T, Savolainen R. Expected impact of MRI-related interreader variability on ProScreen prostate cancer screening trial: a pre-trial validation study. Cancer Imaging. 2020 Oct 9;20(1):72.

[24] Yilmaz EC, Shih JH, Belue MJ, Harmon SA, Phelps TE, Garcia C, Hazen LA, Toubaji A, Merino MJ, Gurram S, Choyke PL, Wood BJ, Pinto PA, Turkbey B. Prospective Evaluation of PI-RADS Version 2.1 for Prostate Cancer Detection and Investigation of Multiparametric MRI-derived Markers. Radiology. 2023 May;307(4):e221309.

[25] Zattoni F, Pereira LJ, Marra G, Valerio M, Olivier J, Puche-Sanz I, Rajwa P, Maggi M, Campi R, Amparore D, De Cillis S. The impact of a second MRI and re-biopsy in patients with initial negative mpMRI-targeted and systematic biopsy for PIRADS≥ 3 lesions. World journal of urology. 2023 Nov;41(11):3357-66.