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Original Article

Artificial Intelligence-assisted Versus Conventional Colonoscopy for Adenoma and Polyp Detection Rates: A Meta-analysis of Recent Randomized and Quasi-randomized Trials

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Abstract

Background and objectives: Artificial intelligence (AI)-based computer-aided detection (CADe) has been associated with improved adenoma detection during colonoscopy. However, prior meta-analyses synthesized earlier trials, and whether the benefit remains consistent in recent contemporary trials is uncertain. This meta-analysis aimed to estimate the effects of current-generation AI-assisted colonoscopy on adenoma detection rate (ADR) as the primary outcome and polyp detection rate (PDR) as the secondary outcome in randomized and quasi-randomized trials published from August 1, 2024, to August 18, 2026, without re-pooling trials included in earlier comprehensive meta-analyses.

Methods: MEDLINE/PubMed, Embase, CENTRAL, Scopus, and Google Scholar were searched for peer-reviewed parallel-group randomized and quasi-randomized trials enrolling adults undergoing screening, surveillance, or diagnostic colonoscopy and comparing real-time AI-based CADe-assisted with conventional high-definition white-light colonoscopy. Tandem designs were excluded. The primary and secondary outcomes were ADR and PDR, respectively. Random-effects risk ratios with 95% confidence intervals (CIs) were calculated; heterogeneity and leave-one-out sensitivity were assessed.

Results: Seventeen trials comprising 15,242 patients were included for ADR; 12 trials comprising 8,665 patients reported extractable PDR data. The pooled risk ratio was 1.14 (95% CI 1.09–1.20; I^2 = 53.8%) for ADR and 1.13 (95% CI 1.07–1.20; I^2 = 63.4%) for PDR.

Conclusions: This meta-analysis supports an average improvement in adenoma and polyp detection with AI-assisted colonoscopy; however, moderate-to-substantial heterogeneity and variability across settings and platforms warrant cautious interpretation rather than an unqualified recommendation for routine adoption.

Introduction

Colorectal cancer (CRC) is a common malignancy, with most cases arising from precancerous adenomatous and serrated polyps,[1] and it represents one of the leading causes of cancer-related death worldwide.[2] Established risk factors for conventional adenomas and CRC include age, male sex, family history, obesity, physical inactivity, and red meat intake,[1] as well as cigarette smoking, which has been consistently associated with an increased risk of colorectal adenomas and cancer.[3] Serrated polyps can additionally progress to CRC through a pathway distinct from the conventional adenoma–carcinoma sequence.[4] Colonoscopy is widely used as a primary or follow-up screening test for CRC and has been shown to reduce cancer incidence and mortality through the detection of tumors at an earlier, more treatable stage and through removal of precancerous adenomas.[5,6]

The effectiveness of colonoscopy in preventing CRC is closely linked to the quality of the examination, and the adenoma detection rate (ADR) has been established as one of the main quality

Keywords: Adenoma detection rate; Computer-aided detection; Colonoscopy; Artificial intelligence; Meta-analysis; Colorectal cancer screening.
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indicators of screening colonoscopy.[7] A large population-based study demonstrated that ADR is inversely associated with the risk of interval CRC, advanced-stage interval cancer, and cancer-related death, with each 1% increase in ADR corresponding to an approximate 3% reduction in interval CRC risk.[6] Despite its clinical relevance, ADR shows substantial variability across endoscopists and countries, with reported rates ranging from 8% to 35%,[7] and polyp miss rates as high as 27% have been described, largely attributable to both lesion- and operator-related factors.[8] Consistently, quality-adjusted back-to-back colonoscopy studies have reported adenoma miss rates of approximately 17%, even under optimal examination conditions.[9] These persistent miss rates highlight the need for more consistent and reliable detection strategies.

In recent years, artificial intelligence (AI)-based computer-aided detection (CADe) systems have been proposed as a tool to reduce operator-dependent variability and improve the diagnostic performance of colonoscopy, providing real-time alerts for suspicious lesions during the withdrawal phase of the procedure.[10,11]

The evidence base surrounding CADe-assisted colonoscopy has continued to expand, with newer randomized and quasi-randomized trials evaluating increasingly diverse patient populations, clinical settings, and AI platforms. Previous systematic reviews and meta-analyses have already established a beneficial association between CADe and adenoma detection, predominantly on the basis of trials conducted during the earlier phases of AI-assisted colonoscopy. Consequently, repeated re-pooling of the same historical trials may provide limited additional information regarding the performance of newer CADe technologies.

A clinically relevant question is therefore whether the beneficial effect observed in earlier studies remains consistent in the more recent generation of randomized and quasi-randomized trials conducted with contemporary CADe systems and current colonoscopy practice. Evaluating this more recent evidence separately may also reduce the potential for historical technology, operator experience, and early implementation effects to influence the estimated magnitude of benefit.

Accordingly, the present meta-analysis was designed to evaluate randomized and quasi-randomized trials published between August 1, 2024, and August 18, 2026, following the search period of the most recent comprehensive systematic review used as the reference evidence synthesis. By focusing specifically on this contemporary evidence base, the study aimed to estimate the effect of current-generation CADe-assisted colonoscopy on ADR as the primary outcome and polyp detection rate (PDR) as the secondary outcome, without re-pooling trials already synthesized in earlier comprehensive meta-analyses.

Materials and methods

Study design and rationale

This study was designed as a meta-analysis of recently published randomized and quasi-randomized trials evaluating the effect of contemporary CADe systems on adenoma and polyp detection during colonoscopy. The study deliberately adopted a temporally restricted evidence framework rather than re-pooling the full historical CADe literature.

This approach was chosen because the effectiveness of CADe-assisted colonoscopy has already been evaluated in several comprehensive systematic reviews and meta-analyses, including large syntheses incorporating trials from the earlier phases of AI-assisted colonoscopy, including Makar *et al.*[12] (k = 28), Soleymanjahi *et al.*[13] (k = 44), Eman *et al.*[14] (k = 48), and Tan *et al.*[15] (k = 64). Repeating a pooled analysis of the same historical trials would provide limited incremental information. At the same time, a substantial number of randomized and quasi-randomized trials evaluating newer CADe systems and contemporary clinical practice have been published subsequently.

Accordingly, a prespecified publication date window from August 1, 2024 through August 18, 2026 was applied. This temporal restriction was adopted to define a contemporary evidence window, minimize overlap with previously synthesized trials, and specifically capture randomized and quasi-randomized studies evaluating more recent generations of CADe systems and their implementation in current colonoscopy practice (see Section 2.3, publication-date handling).

The objective of this analysis was not to provide a new estimate based on the entire historical evidence base, but rather to determine whether the beneficial effect of CADe on adenoma and polyp detection remains consistent in the most recent generation of randomized and quasi-randomized clinical studies.

The study was reported in accordance with the PRISMA 2020 statement. The protocol was prospectively registered on PROSPERO (registration number: CRD420261446631).

Eligibility criteria (PICOS)

- Population (P): Adult patients (≥18 years) undergoing colonoscopy for screening, surveillance, or diagnostic indications.
- Intervention (I): Colonoscopy performed with real-time CADe using any commercially available or investigational AI system.
- Comparator (C): Conventional high-definition white-light colonoscopy without AI assistance, with or without adjunctive non-AI techniques, provided these were not differentially restricted between arms.
- Outcomes (O):

- Primary outcome: ADR — proportion of colonoscopies with ≥1 histologically confirmed adenoma.

- Secondary outcome: Polyp Detection Rate (PDR) — proportion of colonoscopies with ≥1 detected polyp, regardless of histology.

Study design (S): Parallel-group randomized controlled trials (RCTs) and quasi-randomized trials. Tandem (back-to-back) designs were excluded from the primary parallel-arm ADR/PDR pooling, given the differing unit of comparison (within-patient sequential passes vs. between-patient independent groups).

Publication date and search window

The publication date and search windows were prespecified and covered the period from August 1, 2024 through August 18, 2026. Publication date was defined as the date of final journal-issue assignment; where a trial had not yet been assigned to a final issue at the time of the search, the online-ahead-of-print publication date was used instead. The search was performed to identify randomized and quasi-randomized trials published within this predefined period evaluating real-time CADe-assisted colonoscopy compared

with conventional colonoscopy.

Studies published before August 1, 2024 or after August 18, 2026 were considered outside the prespecified evidence window and were therefore excluded from the present quantitative synthesis on temporal grounds.

Information sources and search strategy

MEDLINE/PubMed, Embase, CENTRAL, Scopus, and Google Scholar were searched for eligible studies, applying the same date restriction uniformly across all five databases. No language restriction was applied. Only peer-reviewed publications were eligible; conference abstracts, trial registry entries, preprints, and other grey literature were not searched or included. Reference lists of relevant systematic reviews and meta-analyses were reviewed to cross-check the completeness of study identification from the database searches; potentially eligible primary studies were assessed against the same eligibility criteria.

Search terms combined four concept blocks joined with AND: (1) colonoscopy; (2) artificial intelligence / computer-aided detection; (3) adenoma or polyp detection outcomes, further restricted to randomized or quasi-randomized trial designs. The following terms were used, combined with OR within each block and AND across blocks:

- Block 1 (colonoscopy): colonoscopy
- Block 2 (AI/CADe): artificial intelligence, computer-aided detection, CADe
- Block 3 (outcome): adenoma detection rate, ADR, polyp detection rate, PDR, polyp
- Block 4 (design): randomized, randomized, randomized controlled trial, quasi-randomized, trial

The same conceptual search strategy was applied across all five databases, with database-specific adaptations of controlled vocabulary, field codes, Boolean syntax, and publication-date filters. The complete database-specific search strategies are provided in Supplementary Table. 1. All databases were last searched on August 18, 2026.

Study selection process

Two reviewers (G.A. and V.M.) independently screened all records after Ryyan-based deduplication and independently performed full-text review of potentially eligible articles; disagreements at both stages were resolved through discussion and consensus between the two reviewers, following the PRISMA 2020 flow diagram.

Data extraction

Two independent reviewers (G.A. and V.M.) screened titles and abstracts, followed by a full-text review of potentially eligible articles. Disagreements were resolved through discussion and consensus. Data were extracted independently by both reviewers using a standardized form. The following information was extracted from each trial:

- Study characteristics: first author, publication year, trial name, study design;
- Population characteristics: sample size;
- Intervention details: colonoscopy performed with real-time CADe using any commercially available or investigational AI system;
- Outcomes:
- Primary outcome: ADR — proportion of colonoscopies with ≥1 histologically confirmed adenoma.
- Secondary outcome: Polyp Detection Rate (PDR) — proportion of colonoscopies with ≥1 detected polyp, regardless of histology.

This resulted in a final analytic dataset of k = 17 studies for ADR and k = 12 studies for PDR.

Risk of bias assessment

Risk of bias for each included randomized controlled trial was assessed independently by two reviewers using the Cochrane Risk of Bias 2 (RoB 2) tool. The assessment covered five domains:

- Bias arising from the randomization process;
- Bias due to deviations from intended interventions;
- Bias due to missing outcome data;
- Bias in the measurement of outcomes;
- Bias in the selection of the reported result.

Each domain was rated as "low risk," "some concerns," or "high risk." Each study's risk of bias was evaluated.

Because Lagström *et al.*[21] used a quasi-randomized, center-level allocation based on alternating 2-week periods of CADe and control rather than true randomization, this study was assessed separately using the Risk Of Bias in Non-randomized Studies – of Interventions (ROBINS-I) tool. The assessment covered seven domains:

- Bias due to confounding;
- Bias in selection of participants into the study;
- Bias in classification of interventions;
- Bias due to deviations from intended interventions;
- Bias due to missing data;
- Bias in measurement of outcomes;
- Bias in selection of the reported result.

Each ROBINS-I domain was rated as "low," "moderate," "serious," or "critical" risk of bias, with an additional "no information" category where applicable. An overall risk-of-bias judgment was then assigned according to the ROBINS-I framework.

Effect measures and data synthesis

Risk ratios (RRs) with 95% confidence intervals (CIs) were used as the effect measure for both outcomes, calculated using a random-effects model with restricted maximum likelihood (REML) estimation in `metafor`,[16] given the a priori expectation of clinical and methodological heterogeneity across CADe systems, populations, and settings — a modeling choice made independent of, and prior to, observation of the actual heterogeneity in the data.

Analyses were cross-validated in Python (PyMARE package, REML estimator), consistent with the metafor implementation. Confidence intervals used the standard Wald method, with a Knapp-Hartung adjustment computed as a sensitivity analysis given the moderate number of studies.[17] Prediction intervals were calculated following Higgins *et al.*[18] Study weights shown in Tables 1 and 2 are random-effects (REML-based) weights rather than fixed-effect weights,[19-35] which would understate the influence of heterogeneity, particularly for PDR. Statistical heterogeneity was assessed using Cochran's Q, I^2, and τ^2.

Small-study effects and potential publication bias were assessed for both outcomes using Egger's regression test, in which the

Table 1. Adenoma detection rate (ADR): study-level and pooled results (k = 17)

Study	CADe (n/N)	Control (n/N)	RR	95% CI	Weight (RE)
Park 2024[19]	153/437	103/368	1.25	1.02-1.54	4%
Alali 2025[20]	24/51	19/51	1.26	0.80-2.00	1.1%
Lagström 2025[21]	236/399	184/395	1.27	1.11-1.45	6.5%
Schauer 2026[22]	243/383	225/393	1.11	0.99-1.24	7.3%
Seager 2024 (COLO-DETECT)[23]	555/980	477/986	1.17	1.08-1.27	8.7%
EAGLE 2025[24]	180/417	152/424	1.20	1.02-1.42	5.2%
Hsu 2026[25]	395/675	363/681	1.10	1.00-1.21	8.3%
Thiruvengadam 2024[26]	234/550	189/550	1.24	1.06-1.44	5.8%
Maas 2024 (DISCOVERY)[27]	96/250	93/247	1.02	0.81-1.28	3.6%
Spada 2025 (ACCENDO-Colo)[28]	290/578	235/580	1.24	1.09-1.41	6.7%
Yabuuchi 2025[29]	254/501	271/497	0.93	0.83-1.05	7.2%
Xu 2025[30]	78/195	77/195	1.01	0.79-1.29	3.2%
Jeon 2026[31]	260/497	181/501	1.45	1.25-1.67	6.1%
Dos Santos 2025[32]	180/354	164/357	1.11	0.95-1.29	5.8%
Spada 2026 (FIT-AI)[33]	342/506	301/503	1.13	1.03-1.24	8.3%
Lux 2026 (EndoMind)[34]	156/452	152/462	1.05	0.87-1.26	4.7%
Davila-Piñón 2026 (PolyDeep Advance 3)[35]	250/411	240/416	1.05	0.94-1.18	7.4%
Pooled (random-effects)			1.14	1.09–1.20	100%

CADe, computer-aided detection; CI, confidence interval; RE, random-effects; RR, risk ratio (inverse-variance weights based on REML τ^2; see Effect measures and data synthesis). Heterogeneity: Cochran's Q = 34.65, df = 16, P = 0.0044; I^2 = 53.8%, τ^2 = 0.0061 (REML). Knapp-Hartung-adjusted 95% CI: 1.08–1.21. REML, restricted maximum likelihood.

Table 2. Polyp detection rate (PDR): study-level and pooled results (k = 12)

Study	CADe (n/N)	Control (n/N)	RR	95% CI	Weight (RE)
Park 2024[19]	271/437	191/368	1.19	1.06-1.35	8.1%
Alali 2025[20]	40/51	29/51	1.38	1.04-1.82	3.0%
Lagström 2025[21]	279/400	222/395	1.24	1.11-1.38	9.0%
Schauer 2026[22]	298/383	286/393	1.07	0.99-1.16	10.7%
EAGLE 2025[24]	251/417	225/424	1.13	1.01-1.28	8.4%
Maas 2024 (DISCOVERY)[27]	138/250	127/247	1.07	0.91-1.27	6.1%
Xu 2025[30]	131/195	111/195	1.18	1.01-1.38	6.4%
Jeon 2026[31]	359/497	273/501	1.33	1.20-1.46	9.7%
Dos Santos 2025[32]	240/354	225/357	1.08	0.97-1.20	9.1%
Spada 2026 (FIT-AI)[33]	401/506	350/503	1.14	1.06-1.23	11.2%
Lux 2026 (EndoMind)[34]	243/452	252/462	0.99	0.87-1.11	8.3%
Davila-Piñón 2026 (PolyDeep Advance 3)[35]	286/411	286/416	1.01	0.92-1.11	10.0%
Pooled (random-effects)			1.13	1.07–1.20	100%

CADe, computer-aided detection; CI, confidence interval; RE, random-effects; RR, risk ratio (inverse-variance weights based on REML τ^2; see Section 2.8). Heterogeneity: Cochran's Q = 30.04, df = 11, P = 0.0016; I^2 = 63.4%, τ^2 = 0.0054 (REML). Knapp-Hartung-adjusted 95% CI: 1.07–1.20. REML, restricted maximum likelihood.

standardized effect size (log RR divided by its standard error (SE)) was regressed on precision (the inverse of the SE); a regression intercept significantly different from zero was taken as evidence of funnel plot asymmetry.

Sensitivity analyses — leave-one-out

A leave-one-out sensitivity analysis was prespecified for both ADR and PDR. Each study was sequentially excluded, and the pooled random-effects RR, 95% CI, and I^2 were recalculated to assess the influence of individual studies on the magnitude and statistical significance of the overall effect estimate and on between-study heterogeneity.

In addition to the pre-specified leave-one-out analysis, a post-hoc exploratory sensitivity analysis was conducted following completion of the risk-of-bias assessment, in response to the quasi-randomized, cluster-based allocation design identified in Lagström et al., in which randomization occurred at the center level using alternating 2-week blocks rather than individual patient-level allocation. Because Lagström et al. did not report an intracluster correlation coefficient (ICC) for either outcome, a principled, trial-specific design-effect calculation was not possible a priori. As a conservative bounding approach, the reported variance of this trial's effect estimate was doubled and both pooled models were re-estimated.

Patient and public involvement

No patients or members of the public were involved in the design, conduct, reporting, or dissemination of this research. It represents a secondary analysis of publicly available data from previously published randomized and quasi-randomized controlled trials.

Results

Study selection

The initial search identified 185 potentially relevant articles. After removal of duplicates (n = 10), 175 records remained for title and abstract screening. Of these, 14 articles were excluded because they involved populations other than adults undergoing screening, surveillance, or diagnostic colonoscopy. 161 full-text articles were assessed for eligibility. Of these, 101 were excluded because they did not use a randomized or quasi-randomized comparative study setting and 39 because outcome data were missing. Ultimately, 21 randomized and quasi-randomized controlled trials met all inclusion criteria and were included in the review, and 17 of these were included in the quantitative synthesis (Fig. 1).

Characteristics of included studies

Seventeen studies met inclusion criteria for the ADR outcome, collectively enrolling 15,242 patients.[19-35] Twelve of these studies reported extractable PDR data suitable for pooling (Table 3).[19-35] The included trials were published between 2024 and 2026, comprising four studies from 2024, seven from 2025, and six from 2026, reflecting the temporally restricted evidence base defined a priori for this synthesis. Study designs were predominantly parallel-group randomized controlled trials, with one quasi-randomized cluster design (Lagström 2025).[21]

Risk-of-bias assessment using the Cochrane RoB 2 tool classified nine randomized trials as low risk and seven as raising some concerns; the quasi-randomized Lagström study was judged to have serious overall risk of bias using ROBINS-I. Among the randomized trials, concerns were most commonly attributable to the randomization process domain (Park 2024, Xu 2025, and Spada 2026b) or to deviations from intended interventions and missing outcome data (EAGLE 2025, Hsu 2026, Spada 2025/ACCENDO-Colo, Lux 2026/EndoMind). Several trials exhibited notable methodological features warranting mention: Lagström 2025 employed a cluster-randomized quasi-experimental design with an associated denominator imbalance between arms; Park 2024 showed an unequal arm-size allocation; Xu 2025 reported multiple baseline imbalances between groups; Dos Santos 2025 was conducted by a single endoscopist, limiting generalizability; Schauer 2026 was funded by the device manufacturer (Olympus America), which also provided the CADe equipment free of charge; ; and Spada 2026b (FIT-AI) reported comparatively weak allocation concealment. Two studies, Lux 2026 (EndoMind) and Davila-Piñón 2026 (PolyDeep Advance 3), evaluated not-for-profit CADe systems, distinguishing them from the predominantly commercially developed platforms assessed elsewhere in the pool.

Four studies retained for qualitative synthesis only (Codesido-Prado 2026,[36] Chang 2026,[37] Leggett 2026/DEEP2,[38] Robles de la Osa 2026[39]) were excluded from the quantitative synthesis because raw counts were unextractable or outcome-reporting formats were incompatible.

Risk-of-bias assessment

Risk of bias was assessed using the RoB 2 tool across five domains[40]: bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in measurement of the outcome, and bias in selection of the reported result. Judgments were made at the outcome level and categorized as low risk, some concerns, or high risk of bias according to the RoB 2 framework (Table 4).[19,20,22-35]

Overall, the methodological quality of the included trials was considered acceptable. No trial was judged to be at overall high risk of bias based on the available information. However, several studies raised specific methodological concerns, principally related to post-randomization exclusions, quasi-randomized allocation, baseline imbalance, or allocation concealment.

Park *et al.*[19] was judged to have some concerns, primarily because of post-randomization imbalance between study arms associated with differential withdrawal, particularly in the control group. Differential post-randomization withdrawals between study arms raised some concerns in the domain of missing outcome data, as the extent and imbalance of exclusions could potentially be related to the outcome.

Funding and manufacturer involvement were also considered as potential sources of bias. For Schauer *et al.*,[22] the reported industry involvement was evaluated in relation to the RoB 2 domains, particularly the selection of the reported result and other aspects of trial conduct and reporting. No evidence was identified that industry involvement influenced the randomization process, deviations from intended interventions, outcome assessment, or selective reporting; therefore, industry sponsorship alone did not warrant upgrading the RoB 2 judgment.

Because Lagström *et al.*[21] used quasi-randomized allocation based on alternating 2-week intervention periods rather than individual randomization, risk of bias for this study was assessed separately using the ROBINS-I tool (Table 5). For ADR, the study

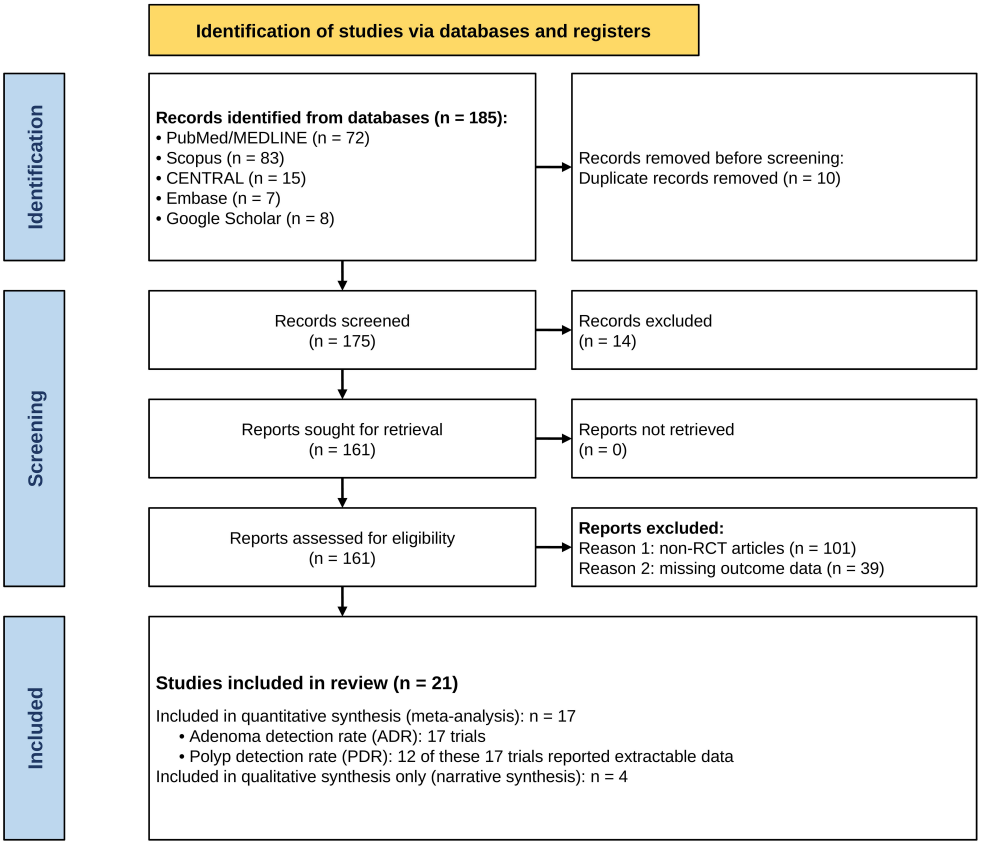

Fig. 1. PRISMA flow diagram for the selection of randomized and quasi-randomized trials included in this review. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; RCT, randomized controlled trial.

was judged to have serious overall risk of bias, primarily because the time-block allocation could introduce confounding by calendar period, center, endoscopist characteristics, and changes in patient case-mix over time. Additional moderate concerns related to post-allocation exclusions and incomplete outcome data. The measurement of ADR was considered at low risk of bias because adenoma status was confirmed histologically.

EAGLE and Hsu *et al.*[25] were considered to have some concerns related principally to missing outcome data and post-randomization exclusions. In EAGLE, 973 participants were randomized, whereas 841 were included in the final analyzed population; although the exclusions were reported with specific reasons, the extent of post-randomization attrition warranted a cautious judgment. In the Hsu trial, 1,457 participants were randomized and 1,356 were included in the final analysis, leading to a similar concern regarding outcome completeness. EAGLE used block randomization with electronic allocation procedures and blinded pathological assessment, whereas the Hsu trial used a computer-generated 1:1 randomization sequence and intention-to-treat analysis.

Spada *et al.*[28] (ACCENDO-Colo) 2025 was judged to have some concerns because of post-randomization exclusions and the open-label design. Although randomization was performed using a central computer-generated sequence, 70 of 1,228 randomized participants were subsequently excluded from the mITT analysis.

Xu *et al.*[30] was judged to have some concerns because of multiple baseline imbalances between study groups. Spada *et al.*[33] (FIT-AI) 2026 was also classified as having some concerns because of limitations in allocation concealment. Lux *et al.*[34] was judged to have some concerns because endoscopists could not be blinded to CADe allocation. This limitation is inherent to CADe-assisted colonoscopy and was not considered sufficient to indicate high risk of bias by itself. Importantly, the Lux trial used centralized randomization and was conducted as a multicenter randomized controlled study.

The remaining trials were judged to have low overall risk of bias based on the available methodological information. In particular, the use of open-label designs was not automatically interpreted as high risk because blinding of endoscopists is generally infeasible in CADe-assisted colonoscopy. Where outcome ascertainment relied on histopathological confirmation, blinded pathological assessment further reduced the potential for bias in outcome classification.

Manufacturer involvement or industry-provided equipment was considered separately as a potential source of concern but was not, in the absence of evidence of influence on trial conduct, analysis, or reporting, sufficient by itself to warrant a higher RoB 2 judgment. Accordingly, the manufacturer-supported Schauer trial

Table 3. Characteristics of included studies

Study	Year	Total N	ADR CADe (events/N)	ADR Control (events/N)	ADR RR (95% CI)	PDR CADe (events/N)	PDR Control (events/N)	PDR RR (95% CI)	AI system
Park 2024[19]	2024	805	153/437	103/368	1.25 (1.02–1.54)	271/437	191/368	1.19 (1.06–1.35)	RetinaNet-based
Alali 2025[20]	2025	102	24/51	19/51	1.26 (0.80–2.00)	40/51	29/51	1.38 (1.04–1.82)	*CAD EYE (Fujifilm)*
Lagström 2025[21]	2025	795	236/399	184/395	1.27 (1.11–1.45)	279/400	222/395	1.24 (1.11–1.38)	*GI Genius (Medtronic)*
Schauer 2026[22]	2026	776	243/383	225/393	1.11 (0.99–1.24)	298/383	286/393	1.07 (0.99–1.16)	ENDO-AID (Olympus)
Seager 2024 (COLO-DETECT)[23]	2024	1966	555/980	477/986	1.17 (1.08–1.27)	—	—	—	*GI Genius (Medtronic)*
EAGLE 2025[24]	2025	841	180/417	152/424	1.20 (1.02–1.42)	251/417	225/424	1.13 (1.01–1.28)	*CADDIEv1.4* (Odin Medical LTD)
Hsu 2026[25]	2026	1356	395/675	363/681	1.10 (1.00–1.21)	—	—	—	aetherAI Endo
Thiruvengadam 2024[26]	2024	1100	234/550	189/550	1.24 (1.06–1.44)	—	—	—	*GI Genius (Medtronic)*
Maas 2024 (DISCOVERY)[27]	2024	497	96/250	93/247	1.02 (0.81–1.28)	138/250	127/247	1.07 (0.91–1.27)	DISCOVERY (PENTAX Medical)
Spada 2025 (ACCENDO-Colo)[28]	2025	1158	290/578	235/580	1.24 (1.09–1.41)	—	—	—	*ENDO-AID OIP-1 (Olympus)*
Yabuuchi 2025[29]	2025	998	254/501	271/497	0.93 (0.83–1.05)	—	—	—	*EndoBRAIN-AY E v1.2.0* (Cybernet Systems Corp)
Xu 2025[30]	2025	390	78/195	77/195	1.01 (0.79–1.29)	131/195	111/195	1.18 (1.01–1.38)	Custom-developed CADe Software
Jeon 2026[31]	2026	998	260/497	181/501	1.45 (1.25–1.67)	359/497	273/501	1.33 (1.20–1.46)	*ENAD-DET-01* (Ainex Corporation)
Dos Santos 2025[32]	2025	711	180/354	164/357	1.11 (0.95–1.29)	240/354	225/357	1.08 (0.97–1.20)	*CAD EYE (Fujifilm)*
Spada 2026 (FIT-AI)[33]	2026	1009	342/506	301/503	1.13 (1.03–1.24)	401/506	350/503	1.14 (1.06–1.23)	*GI Genius (Medtronic)*
Lux 2026 (EndoMind)[34]	2026	914	156/452	152/462	1.05 (0.87–1.26)	243/452	252/462	0.99 (0.87–1.11)	*EndoMind (Research - developed system, University Hospital Wurzburg Group)*
Davila-Piñón 2026 (PolyDeep Advance 3)[35]	2026	827	250/411	240/416	1.05 (0.94–1.18)	286/411	286/416	1.01 (0.92–1.11)	*PolyDeep* (Galicia Sur/University of Vigo research group)

ADR, adenoma detection rate; AI, artificial intelligence; CADe, computer-aided detection; CI, confidence interval; PDR, polyp detection rate; RR, risk ratio.

Table 4. Risk of bias assessment using the Cochrane Risk of Bias 2 (RoB 2) tool

Study	D1: Randomization process	D2: Deviations from intended interventions	D3: Missing outcome data	D4: Measurement of the outcome	D5: Selection of the reported result	Overall risk of bias
Park 2024[19]	Some concerns	Low risk	Some concerns	Low risk	Low risk	Some concerns
Alali 2025[20]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Schauer 2026[22]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Seager 2024 (COLO-DETECT)[23]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
EAGLE 2025[24]	Low risk	Low risk	Some concerns	Low risk	Low risk	Some concerns
Hsu 2026[25]	Low risk	Low risk	Some concerns	Low risk	Low risk	Some concerns
Thiruvengadam 2024[26]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Maas 2024 (DISCOVERY)[27]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Spada 2025 (ACCENDO-Colo)[28]	Low risk	Some concerns	Some concerns	Low risk	Low risk	Some concerns
Yabuuchi 2025[29]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Xu 2025[30]	Some concerns	Low risk	Low risk	Low risk	Low risk	Some concerns
Jeon 2026[31]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Dos Santos 2025[32]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Spada 2026 (FIT-AI)[33]	Some concerns	Low risk	Low risk	Low risk	Low risk	Some concerns
Lux 2026 (EndoMind)[34]	Low risk	Some concerns	Low risk	Low risk	Low risk	Some concerns
Davila-Piñón 2026 (PolyDeep Advance 3)[35]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk

Table 5. Risk of bias assessment of Lagström *et al.* 2025 using ROBINS-I for the outcome adenoma detection rate

Study	D1 Confounding	D2 Selection	D3 Classification	D4 Deviations	D5 Missing data	D6 Measurement	D7 Reported result	Overall
Lagström 2025[21]	Serious	Low	Low	Moderate	Moderate	Low	Low	Serious

ROBINS-I, Risk Of Bias In Non-randomized Studies of Interventions.

was not classified as having increased RoB 2 solely on the basis of industry involvement.

Overall, the risk-of-bias assessment indicated that the contemporary evidence base was predominantly of acceptable methodological quality, with some concerns concentrated in specific aspects of randomization, allocation concealment, post-randomization exclusions, baseline comparability, and unavoidable lack of blinding in procedural CADe trials.

Among the 17 trials included in the quantitative ADR analysis, 9 (52.9%) were judged to be at low overall risk of bias, 7 (41.2%) to have some concerns, and 1 (5.9%) to be at serious overall risk of bias. The latter was the quasi-randomized study by Lagström *et al.*,[21] which was assessed separately using ROBINS-I because of its time-block allocation design. The main methodological concerns across the included studies related to quasi-randomized allocation and potential confounding, post-randomization exclusions or incomplete outcome data, baseline imbalances, limitations in allocation concealment, and the inability to blind endoscopists to CADe allocation.

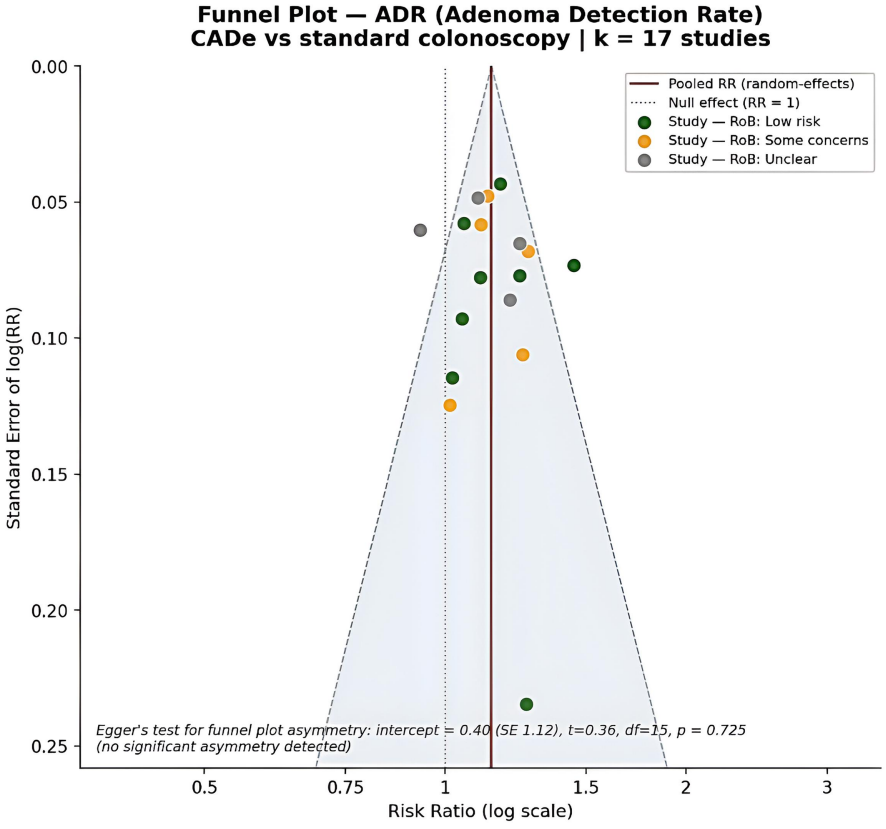

Fig. 2. Funnel plot for adenoma detection rate (ADR). CADe, computer-aided detection; RoB, risk of bias; RR, risk ratio; SE, standard error.

Publication bias assessment

Egger's regression test showed no evidence of significant small-study effects for either outcome. For ADR (k = 17), the regression intercept was 0.40 (SE = 1.12; 95% CI −1.98 to 2.78), corresponding to t(15) = 0.36, P = 0.725. For PDR (k = 12), the intercept was 1.14 (SE = 1.71; 95% CI −2.66 to 4.94), corresponding to t(10) = 0.67, P = 0.520. These non-significant intercepts, together with the visual symmetry of the funnel plots (Figs. 2 and 3), do not support the presence of substantial publication bias or small-study effects in either pooled analysis, although the limited number of included trials — particularly for PDR — constrains the statistical power of this assessment.

Effect of CADe on ADR

Pooling of all seventeen trials (k = 17) using a random-effects model with REML estimation of τ^2 showed that CADe-assisted colonoscopy significantly increased ADR compared with conventional colonoscopy (RR 1.14, 95% CI 1.09–1.20, P < 0.0001; Fig. 4). This pool showed moderate statistical heterogeneity (Cochran's Q = 34.65, df = 16, P = 0.0044; I^2 = 53.8%, τ^2 = 0.0061). A Knapp-Hartung adjustment yielded a similar 95% CI (1.08–1.21).

Effect of CADe on PDR

Twelve trials (k = 12) reported PDR as an extractable dichotomous proportion. Pooling of the remaining twelve trials using a random-effects model with REML estimation of τ^2 showed that CADe significantly increased PDR (RR 1.13, 95% CI 1.07–1.20, P < 0.0001; Fig. 5). As with ADR, this estimate showed moderate-to-substantial statistical heterogeneity (Cochran's Q = 30.04, df = 11, P = 0.0016; I^2 = 63.4%, τ^2 = 0.0054), explored further through the prespecified leave-one-out sensitivity analysis described below. A Knapp-Hartung adjustment yielded an unchanged 95% CI (1.07–1.20).

Sensitivity analysis: leave-one-out

A leave-one-out sensitivity analysis was performed for both outcomes to assess the influence of individual studies on the pooled estimate and on observed heterogeneity.

The ADR pooled estimate proved robust in direction and approximate magnitude: exclusion of any single trial produced a pooled RR within the narrow range of 1.12–1.16, remaining statistically significant in every iteration. Excluding Yabuuchi 2025 or Jeon 2026 produced the largest reductions in I^2 (to 33.2% and 35.6%, respectively), but heterogeneity remained moderate in both cases and stayed at 53–57% following exclusion of every other individual trial. This indicates that the heterogeneity observed in the expanded ADR pool does not stem from a single outlying study but instead reflects broader, multi-source between-study variance.

Excluding Jeon 2026 produced the largest reduction in I^2 (from 63.4% to 44.5%), but heterogeneity remained moderate rather than

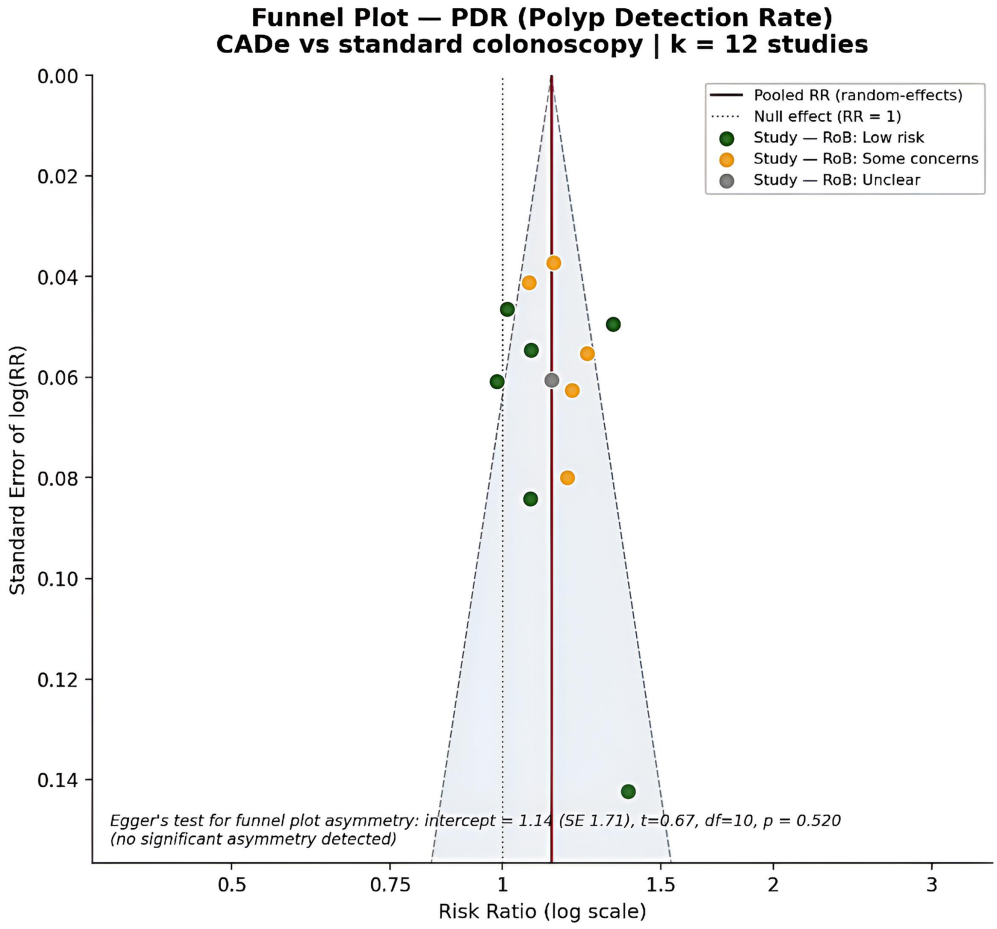

Fig. 3. Funnel plot for polyp detection rate (PDR). CADe, computer-aided detection; RoB, risk of bias; RR, risk ratio; SE, standard error.

being eliminated, and removal of any other individual trial left I^2 at 58–67%. This indicates that the heterogeneity in the PDR pooled estimate reflects distributed, multi-source variance across the evidence base rather than a single influential trial — consistent with the pattern observed for ADR.

As a post-hoc exploratory analysis addressing the cluster-based allocation design of Lagström et al., the sensitivity analysis doubled the variance of Lagström et al. to account for its quasi-randomized, cluster-based design; this left both pooled estimates essentially unchanged (ADR: RR 1.14, 95% CI 1.08–1.20, I^2 = 52.0%; PDR: RR 1.13, 95% CI 1.07–1.19, I^2 = 61.3%).

Discussion

This meta-analysis of seventeen RCTs and quasi-randomized trials, comprising 15,242 participants contributed to the ADR analysis (7,636 CADe and 7,606 control), demonstrated that CADe-assisted colonoscopy significantly increased both the adenoma detection rate (RR 1.14, 95% CI 1.09–1.20) and the polyp detection rate (RR 1.13, 95% CI 1.07–1.20; k = 12, 8,665 patients) compared with conventional colonoscopy. Both outcomes showed moderate-to-substantial statistical heterogeneity (I^2 = 53.8% for ADR and I^2 = 63.4% for PDR); a prespecified leave-one-out sensitivity analysis, detailed below, indicated that this heterogeneity reflects distributed, multi-source between-study variance rather than the influence of any single trial.

Interpretation and comparison with existing evidence

These findings are broadly consistent with previously published meta-analyses evaluating AI-assisted colonoscopy. Shiha *et al.*[41] reported a pooled ADR benefit of similar magnitude across 12 RCTs and 11,340 patients, while Hassan *et al.*,[42] in a synthesis of 21 trials, likewise confirmed a consistent ADR increase with CADe (44.0% vs. 35.9%). More recent, larger syntheses corroborate both the magnitude and the heterogeneity pattern observed here: Tan *et al.*,[15] pooling 30 studies, reported a comparable ADR effect (RR 1.20, 95% CI 1.14–1.26) alongside substantial heterogeneity (I^2 = 76.6%), and Sultany *et al.*,[43] in a 12-trial synthesis, similarly reported high heterogeneity for both ADR (I^2 = 81%) and PDR (I^2 = 79%). The pooled effect size observed in the present analysis therefore falls within the range reported by these larger contemporary syntheses, reinforcing the robustness of the association despite the increase in observed heterogeneity. The present analysis is based exclusively on trials published in 2024–2026, offering an updated perspective spanning an expanded and geographically diverse set of trial settings and

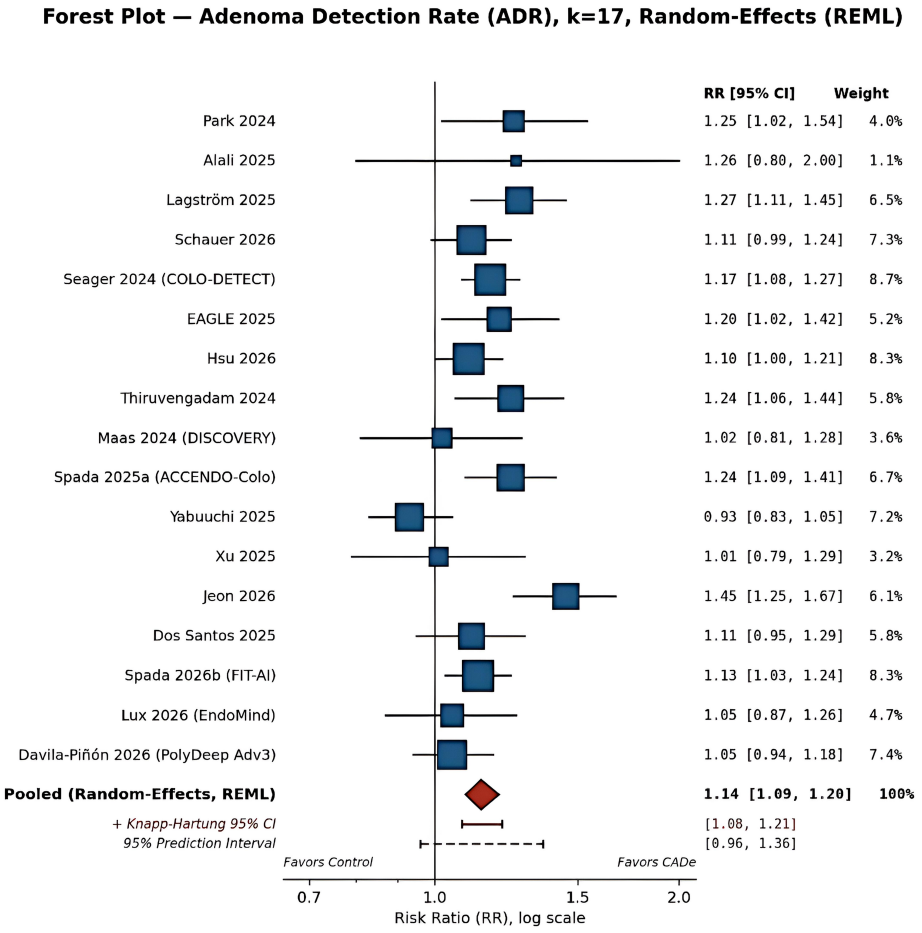

Fig. 4. Forest plot – Adenoma Detection Rate (ADR). CI, confidence interval; REML, restricted maximum likelihood.

incorporating newer-generation, as well as nonprofit and academically developed, CADe platforms not evaluated in earlier syntheses.

Heterogeneity interpretation

The pool showed moderate-to-substantial heterogeneity for both ADR (I^2 = 53.8%) and PDR (I^2 = 63.4%). Leave-one-out sensitivity analysis (Tables 6 and 7) demonstrated that no single trial was responsible[19-35]: the pooled RR remained within a narrow range (ADR 1.12–1.16; PDR 1.11–1.15) regardless of which study was excluded, and I^2 fell substantially only after removing Yabuuchi *et al.*[29] or Jeon *et al.*[31] from the ADR pool (to 33.2% and 35.6%, respectively) or Jeon *et al.*[31] from the PDR pool (to 44.5%), never approaching the near-zero values; this indicates that heterogeneity in the current evidence base is distributed across multiple studies rather than attributable to one outlying trial.

A plausible qualitative explanation lies in the technological diversity of the included trials: the seventeen studies employed eleven distinct CADe systems, ranging from established commercial platforms (GI Genius, ENDO-AID, CAD EYE) to newer commercial systems and, in two cases, non-commercial, academically developed platforms (EndoMind, PolyDeep). Because most individual platforms in the present pool are represented by only one or two trials, a formal platform-based subgroup analysis was not adequately powered and was not undertaken.

Clinical implications

Both ADR and PDR showed a comparable degree of heterogeneity, and both outcomes should therefore be interpreted with similar caution regarding generalizability across clinical settings and platforms. ADR nonetheless retains particular clinical importance because, unlike PDR, it specifically captures the detection of adenomatous (precancerous) lesions and is the outcome most directly linked to interval cancer risk and mortality,[6,44] whereas PDR reflects detection of any polyp, including non-neoplastic lesions. The consistency of the point estimate throughout the leave-one-out sensitivity analysis - despite the statistical heterogeneity - continues to support a genuine, clinically meaningful average benefit of CADe on both quality indicators.

Limitations

Several limitations should be acknowledged. First, although this meta-analysis includes seventeen trials, comparable in scale to

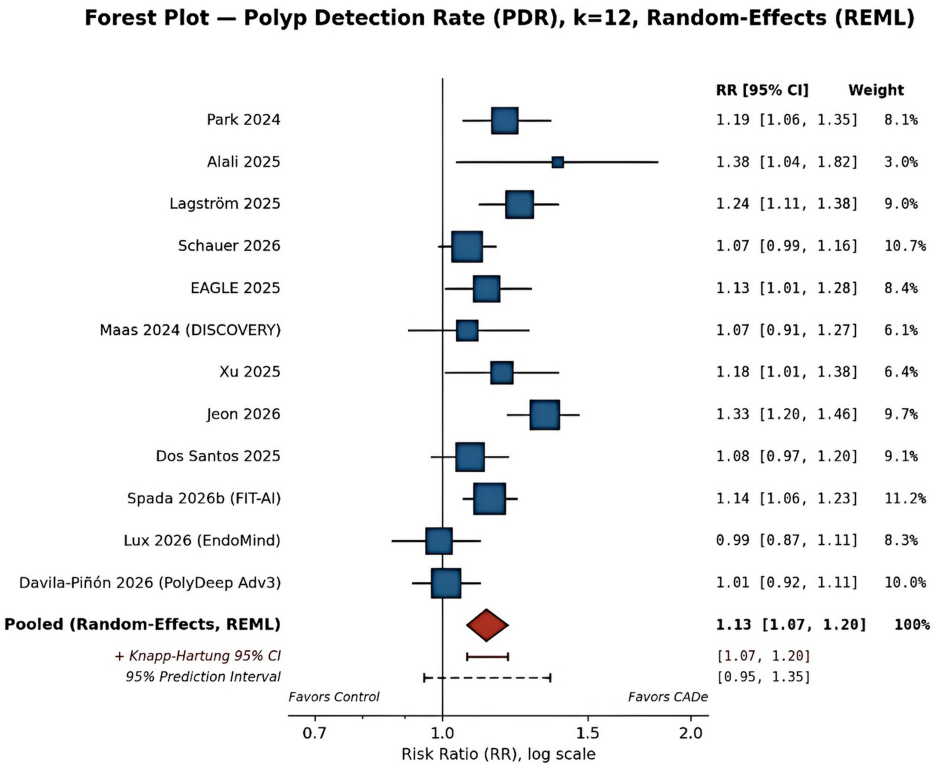

Fig. 5. Forest plot for polyp detection rate (PDR). CI, confidence interval; REML, restricted maximum likelihood.

several recently published meta-analyses, the evidence base remains smaller than the largest available syntheses, and statistical power for subgroup or platform-specific analyses remains limited; consequently, only the leave-one-out sensitivity analysis, the sole approach prespecified in the protocol, was performed. Second, the included trials employed eleven different CADe systems, nine of which were represented by only a single trial; this fragmentation substantially limits the generalizability of the pooled estimate to any single commercial or research-developed platform and precluded a formally powered platform-based subgroup or meta-regression analysis. Third, one trial (Lagström *et al.*[21]) employed a quasi-randomized, cluster-based allocation design, introducing a potential risk of temporal selection bias despite stable referral criteria across periods. Because this trial did not report an intracluster correlation coefficient, its contribution to the primary pooled estimates could not be adjusted for clustering using a principled, trial-specific design effect; it was therefore included using its unadjusted patient-level event counts, consistent with the other included trials. A post-hoc sensitivity analysis doubling this trial's variance as a conservative bounding approximation left both pooled estimates materially unchanged, but this adjustment was exploratory and not based on an empirically derived ICC, and should be interpreted as a robustness check rather than a definitive correction for the clustering effect. Fourth, PDR could not be pooled for five of the seventeen trials (Seager *et al.*, Hsu *et al.*, Thiruvengadam *et al.*, Spada *et al.* [ACCENDO-Colo], and Yabuuchi *et al.*), as this outcome was not reported as a standalone proportion in the original publications, reducing the precision of the secondary outcome estimate relative to ADR. Fifth, and most notably, the substantial statistical heterogeneity observed for both outcomes could not be fully explained through the prespecified leave-one-out sensitivity analysis; residual heterogeneity of this magnitude, reflected in prediction intervals crossing the null for both outcomes, warrants caution in extrapolating the pooled estimates to individual clinical settings. Future updates of this synthesis, incorporating a larger number of trials per CADe platform, should consider preregistered subgroup analyses or meta-regression by platform, risk of bias, and publication year to formally test these as potential moderators. Finally, this meta-analysis was restricted to ADR and PDR as detection-based quality indicators; although the well-established inverse relationship between ADR and interval CRC incidence supports the clinical relevance of these surrogate outcomes,[6,44] none of the included trials were designed or powered to evaluate downstream clinical endpoints such as interval cancer incidence or long-term mortality, which remain the ultimate measures of clinical benefit.

Conclusions

This meta-analysis supports an average improvement in adenoma and polyp detection with AI-assisted colonoscopy; however, moderate-to-substantial heterogeneity and variability across settings and platforms warrant cautious interpretation rather than an unqualified recommendation for routine adoption. Therefore, these findings suggest that the beneficial effect of CADe observed in earlier evidence syntheses persists in the contemporary

Table 6. Leave-one-out sensitivity analysis — Adenoma Detection Rate (full model: RR = 1.14, 95% CI 1.09–1.20, I^2 = 53.8%)

Study excluded	RR	95% CI	I^2
None (full model)	1.14	1.09–1.20	53.8%
Park 2024[19]	1.14	1.08–1.20	55.7%
Alali 2025[20]	1.14	1.08–1.20	56.5%
Lagström 2025[21]	1.13	1.08–1.19	53.0%
Schauer 2026[22]	1.15	1.09–1.21	56.4%
Seager 2024[23]	1.14	1.08–1.20	56.1%
EAGLE 2025[24]	1.14	1.08–1.20	56.1%
Hsu 2026[25]	1.15	1.09–1.21	55.9%
Thiruvengadam 2024[26]	1.14	1.08–1.20	55.1%
Maas 2024[27]	1.15	1.09–1.21	55.5%
Spada 2025[28]	1.14	1.08–1.20	54.4%
Yabuuchi 2025[29]	1.16	1.11–1.21	33.2%
Xu 2025[30]	1.15	1.09–1.21	55.6%
Jeon 2026[31]	1.12	1.08–1.17	35.6%
Dos Santos 2025[32]	1.14	1.09–1.21	56.5%
Spada 2026[33]	1.14	1.08–1.21	56.7%
Lux 2026[34]	1.15	1.09–1.21	55.7%
Davila-Piñón 2026[35]	1.15	1.09–1.21	54.2%

CI, confidence interval; RR, risk ratio.

Table 7. Leave-one-out sensitivity analysis — Polyp Detection Rate (full model: RR = 1.13, 95% CI 1.07–1.20, I^2 = 63.4%)

Study excluded	RR	95% CI	I^2
None (full model)	1.13	1.07–1.20	63.4%
Park 2024[19]	1.13	1.06–1.19	65.7%
Alali 2025[20]	1.13	1.07–1.19	64.3%
Lagström 2025[21]	1.12	1.06–1.19	62.6%
Schauer 2026[22]	1.14	1.08–1.21	64.4%
EAGLE 2025[24]	1.13	1.07–1.20	66.7%
Maas 2024[27]	1.14	1.07–1.20	66.3%
Xu 2025[30]	1.13	1.07–1.20	66.3%
Jeon 2026[31]	1.11	1.06–1.16	44.5%
Dos Santos 2025[32]	1.14	1.07–1.21	65.8%
Spada 2026[33]	1.13	1.06–1.21	66.6%
Lux 2026[34]	1.15	1.09–1.21	59.8%
Davila-Piñón 2026[35]	1.15	1.09–1.21	58.3%

CI, confidence interval; RR, risk ratio.

evidence base, but they do not establish a uniform treatment effect across all systems or clinical settings. Future research should focus on evaluating the impact of CADe on longer-term clinical outcomes, including interval colorectal cancer incidence and cancer-related mortality, as well as on cost-effectiveness and comparative performance across the expanding range of commercial and research-developed platforms.

Supporting information

Supplementary material for this article is available at https://doi.org/10.14218/CSP.2026.00015.

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During the preparation of this work, the authors used AI-based tools (OpenAI GPT-4 and Anthropic Claude) to assist with language editing and with organizing and drafting text related to data extraction. These tools were not used to perform, generate, or verify statistical analyses; all statistical computations were conducted independently by the authors using the metafor package in R. After using these tools, the authors reviewed and edited all content and take full responsibility for the content of this publication.

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Conflict of interest

The authors declare no conflicts of interest relevant to this publication.

Author contributions

Investigation (GA, VM), project administration (GA), formal analysis (GA), conceptualization (GA), validation (VM), and writing—review and editing (GA, VM). All authors have made a significant contribution to this study and have approved the final manuscript.

Ethical statement

Not applicable.

Data sharing statement

The original contributions presented in this study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

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