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Review

Artificial intelligence in endoscopy: navigating risk, responsibility and ethical challenges

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ABSTRACT

Artificial intelligence (AI) technologies, particularly computer-assisted detection (CADE) and computer-assisted diagnosis (CADx), are increasingly being introduced into routine gastrointestinal endoscopy, especially in colonoscopy. CADE systems assist in real-time polyp detection, while CADx offers in-vivo optical characterisation to guide resection and surveillance decisions.

Robust evidence supports CADE's ability to improve adenoma detection rate, a critical quality metric linked to reduced postcolonoscopy colorectal cancer. However, these clinical gains must be weighed against recognised limitations, including false positives and risks of operator over-reliance. While CADx holds theoretical appeal, recent data have questioned its incremental value over optical diagnosis done by experienced endoscopists, highlighting the ongoing challenges in human–AI interaction and system generalisability. This review synthesises the latest evidence and examines the ethical and practical implications of AI integration in endoscopic practice. We focus on two emerging domains of responsibility: forward-looking responsibility—encompassing clinicians' roles in understanding, applying and communicating AI use—and outcome responsibility, which considers how accountability is shared across clinicians, developers and institutions when adverse events occur.

As these technologies continue to evolve, their successful implementation will depend on clear clinical guidance, robust training programmes and thoughtful governance. CADE and CADx not only enhance detection and diagnostic consistency but also require a re-evaluation of endoscopists' professional responsibilities in a technologically mediated environment. Supporting clinicians in using these systems

KEY POINT

WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ Computer-assisted detection (CADE) and computer-assisted diagnosis (CADx) are the most established applications of artificial intelligence (AI) in endoscopy. However, their integration into routine clinical practice must be guided by careful evaluation of clinical value, cost effectiveness and ethical implication.
- ⇒ While this AI technology supports lesion detection (CADE) and diagnostic consistency (CADx), concerns include false positives, over-reliance, alarm fatigue and potential deskilling.
- ⇒ Limitations exist around dataset bias, performance across diverse populations and variable effectiveness in real-world versus trial settings.

WHAT THIS STUDY ADDS

- ⇒ Endoscopists must maintain technical competence, critically appraise AI outputs, communicate AI use effectively to patients and avoid over-reliance (forward-looking responsibility).
- ⇒ Responsibility for AI-enabled care should be shared across clinicians, institutions, developers and regulators, supported by governance and audit frameworks (outcome responsibility).

HOW THIS STUDY MIGHT AFFECT RESEARCH OR POLICY

- ⇒ Safe integration requires structured training, robust oversight and clear ethical guidance to ensure AI strengthens, rather than undermines, clinical practice and patient trust.

safely and ethically will be essential for ensuring they contribute meaningfully to patient care.

INTRODUCTION

Artificial intelligence (AI) applications are increasingly being adopted across healthcare, with the aim of improving diagnostic accuracy, workflow efficiency and patient outcomes. In gastrointestinal (GI) endoscopy, where real-time image interpretation is essential for accurate diagnosis and effective clinical decision-making, AI offers particularly relevant applications.

The most established uses of AI in GI endoscopy are computer-assisted detection (CADE) and computer-assisted diagnosis (CADx) systems. CADE tools assist endoscopists in identifying colorectal polyps during colonoscopy, a cornerstone procedure in the early detection and prevention of colorectal cancer. Strong clinical evidence supports the value of CADE in increasing adenoma detection rate (ADR), which is directly associated with a reduced incidence of postcolonoscopy colorectal cancer (PCCRC).^{1,2} Meanwhile, CADx systems are being developed to offer real-time optical characterisation of polyps, supporting immediate decisions on resection, whether to send specimens for histological analysis and surveillance intervals.³

As these technologies become more embedded in routine practice, they raise important questions around safety, accountability and ethical use.⁴ How should responsibility be allocated when AI is involved in clinical decisions? What new expectations are placed on endoscopists who rely on these tools? This review explores these issues, with a particular focus on how CADE and CADx are reshaping the moral responsibilities of endoscopists. These shifts emerge not only in response to the potential risk posed by such technologies but also in reaction to broader ethical challenges they create. We first summarise the clinical benefits and the potential risks of these systems before turning to the broader implications for responsibility and accountability in routine endoscopic practice.

Computer-assisted detection and computer-assisted diagnosis systems

CADE and CADx are among the most advanced applications of AI in GI endoscopy. Designed to assist endoscopists in real time, CADE systems automatically highlight suspicious lesions—typically via visual overlays—improving polyp detection during colonoscopy.¹ CADx systems extend this functionality by offering in vivo optical characterisation, distinguishing neoplastic from non-neoplastic polyps based on mucosal and vascular features.⁵ These tools are powered by deep learning algorithms, most commonly convolutional neural networks, trained on large datasets of annotated endoscopic images.⁶

CADx has also been shown to support cost reduction by enabling accurate histological prediction in real

time, potentially reducing unnecessary polypectomies and pathology-related expenses.^{3,7} Most commercial CADE and CADx systems are developed by industry partners and have undergone validation in prospective multicentre clinical trials, demonstrating improvements in ADR, lesion characterisation and procedural safety.^{1,8}

Globally, CADE systems have received regulatory approval in the USA, Europe and parts of Asia. In the UK, adoption remains limited, although several hospitals are piloting their use through research and innovation pathways.⁹ CADx systems are currently less widely deployed and remain under evaluation for clinical utility.¹⁰

A shared challenge for both systems is transparency. Although their outputs are visible to the operator, the underlying decision-making processes remain opaque, characteristic of so-called ‘black box’ AI.¹¹ While designed to be user-friendly, these systems still require appropriate training, critical oversight and sound clinical judgement to ensure safe and effective integration into practice.

Benefits, risks and drawbacks

AI systems such as CADE and CADx hold promise for improving the quality and consistency of colonoscopy. Although there is no clear ‘best’ CADE or CADx system, general benefits include enhanced lesion detection, standardisation of performance and support for optical diagnosis strategies.¹² CADE has been associated with improvements in ADR—a key marker linked to reduced PCCRC¹—and higher adenoma detection per colonoscopy, especially of flat or subtle lesions. These tools may also reduce interoperator variability, particularly among less experienced endoscopists, and help mitigate fatigue-related oversight through real-time prompts.¹³

CADx, by enabling real-time optical characterisation, supports ‘diagnose-and-leave’ and ‘resect-and-discard’ strategies for diminutive lesions, helping to reduce reliance on histopathology and streamline procedural efficiency.^{3,7} However, a recent meta-analysis found that CADx did not confer significant additional benefit over high-quality optical diagnosis, raising questions about its real-world value.^{8,14} This may reflect challenges in human–AI interaction, such as varying levels of trust and digital literacy among clinicians.¹⁵

Importantly, a modelling study by Halvorsen *et al* suggested that the life-years gained from routine CADE use in average-risk screening populations are modest.¹⁶ Reflecting this and other studies in this field, three major organisations issued differing recommendations in 2025: the British Medical Journal Rapid Recommendations panel issued a weak recommendation against routine use;¹⁷ European Society of Gastrointestinal Endoscopy supported a weak recommendation in favour, citing patient preference¹⁸ and American Gastroenterology Association made no

recommendation due to low certainty and concerns about surveillance burden.¹⁹ These variations highlight ongoing uncertainty regarding CADE's cost-effectiveness and overall impact.

False positive rates ranging from 1.44% to 3.40% may lead to unnecessary interventions and prolonged procedures.⁸ False negatives—missed or misclassified lesions—remain a concern, with rates up to 1.03%.¹ Repetitive alerts may cause alarm fatigue, distracting endoscopists and potentially reducing focus.⁶ There are also concerns about over-reliance on AI, which may erode endoscopic skills over time, particularly among trainees and early-career practitioners.²⁰ Ethical considerations include the need for transparency in consent, safeguarding opportunities for skill development and ensuring equity in performance across patient subgroups. Although no gender-based bias has been reported,¹⁴ more evidence is needed to evaluate AI performance in patients with Inflammatory Bowel Disease (IBD), melanosis coli or under-represented ethnic groups. An additional consideration is the potential for CADE and CADx to exacerbate healthcare disparities, locally and across global healthcare systems, as access may be limited by cost, infrastructure and regulatory variation.

Despite positive findings in controlled settings, a meta-analysis of non-randomised real-world studies found no significant improvement in ADR with CADE, suggesting limited generalisability.²¹ Furthermore, increased detection of diminutive lesions may drive more frequent surveillance, with associated costs, patient anxiety and system-level strain.¹⁰

In summary, while CADE and CADx systems offer promising advancements, their integration must be guided by careful evaluation of clinical value, cost-effectiveness and ethical implications. It is also important to be aware of the potential bias in training datasets, which may under-represent certain ethnic groups and fail to reflect the diversity and case mix seen in routine UK endoscopy practice. Implementation should be accompanied by structured training, robust oversight and clear governance frameworks. In the next section, we examine the concept of moral responsibility as a critical lens through which to ensure safe and accountable use of AI in endoscopy.

Forward-looking responsibilities

Current debates on the safety and ethics of medical AI often emphasise the technical features of these systems and suggest embedding certain values such as transparency,²² fairness²³ and explainability²⁴ into their design. While these design features are vital to ensure AI systems function safely, they do not fully address the practical responsibilities faced by clinicians operating these tools in real-world settings.²⁵

Endoscopists are a crucial part of the AI implementation process and play a central role in ensuring that these systems are used effectively, safely and



Figure 1 Forward-looking responsibilities of endoscopists using AI. AI, artificial intelligence.

ethically. Clinicians are not passive users of AI but active participants in a complex sociotechnical system, where human and machine decisions are closely intertwined.²⁶ Understanding what is expected of clinicians in this context is essential, particularly as their responsibilities may evolve with the adoption of AI (figure 1).

One way to conceptualise these expectations is through the notion of forward-looking responsibility (figure 1). These are prospective duties and tasks an individual should perform, typically to prevent or decrease the risk of future harmful outcomes. These include ensuring technical competence with CADE and CADx, understanding system limitations, maintaining critical engagement with AI outputs and safeguarding patient trust through clear communication.

Despite its importance, the medical AI literature has paid limited attention to how these forward-looking responsibilities apply to specific clinical tools such as CADE and CADx.²⁷ This gap may be concerning. Even the most accurate AI systems can pose clinical risks if used inappropriately or without adequate oversight. In the next section, we explore how these technologies may be reshaping the scope and nature of clinician responsibilities in endoscopy.

Shifting forward-looking responsibilities (CADE and CADx)

The safe and effective use of CADE and CADx systems requires endoscopists to develop new areas of technical competence that go beyond traditional procedural skills. A key aspect of technical awareness involves not only knowing how to use these tools but also understanding when and where they may underperform.²⁵

For example, clinicians must understand that AI systems can be vulnerable to bias, particularly when trained on unrepresentative datasets.²⁸ While some evidence suggests CADE improves adenoma detection across various patient groups,⁸ other studies highlight the lack of prospective data validating its performance in diverse populations, such as in the USA.²⁹ Clinicians should be aware of such variability and apply appropriate caution when interpreting results in under-represented groups.

Technical competence also includes understanding environmental factors that influence system performance. Most current AI tools in endoscopy are narrow AI systems—highly specialised and dependent on consistent input quality.³⁰ For example, CADE systems may perform better when polyps are fully visible; reduced performance has been observed when lesions are partially obscured.²⁹ To deploy CADE ethically and safely, endoscopists have a forward-looking responsibility to recognise and understand these variations in system performance, as well as the conditions that may impact AI reliability. Based on this awareness, clinicians should adjust how they use these tools in clinical practice.

There is also growing discussion around the need for clinicians to monitor AI performance over time, reporting any decline or inconsistencies.²⁵ While longitudinal evaluation may be burdensome in practice, the expectation that clinicians critically assess individual outputs remains a central aspect of responsible use.³¹ While CADE and CADx are designed to support endoscopic procedures, clinical decision-making ultimately rests with the endoscopist. Exercising professional expertise in this context requires critically evaluating the output of their assistive tools. Doing so mitigates the risk associated with false positives and false negatives generated by the technologies. This mirrors a ‘human in the loop’ design approach, where human judgement is integrated into the AI’s decision-making process.

In addition to developing technical competencies, forward-looking responsibility includes patient communication. Explainability is a widely accepted condition on the ethical and safe use of medical AI systems.^{24 32 33} The exact nature of effective explanations for medical AI remains an open question. Suggested attributes for explanation include validity and completeness,³⁴ fidelity,³⁵ appropriateness³⁶ and contextual awareness.³⁷ We suggest that, at minimum, endoscopists will be responsible for understanding and communicating two critical pieces of information that relate directly to patient care. The first is to explain how CADE and CADx are used during the procedure and what role they play in decision-making. The second is to explain why CADE and CADx are being used, emphasising their impact on patient safety outcomes and highlighting any risk and variation in performance. Together, these two types of information

Table 1 Minimum standards for safe and effective use of CADE and CADx in endoscopy

Domain	Minimum standard
Operation of integrated technology	Ability to operate the technology in real time during endoscopy.
Bias awareness	Awareness of potential bias in the training dataset.
Understanding limitations	Knowledge of limitations and factors influencing optimal performance.
Patient communication—how it works	Ability to explain, in simple terms, how the technology works to patients.
Patient communication—why it is used	Ability to explain, in simple terms, why the technology is being used.
CADE, computer-assisted detection; CADx, computer-assisted diagnosis.	

may enhance transparency, support informed consent and provide essential justification for the technology’s deployment.

Finally, clinicians must guard against over-reliance and skills decline. Although CADE is designed to support detection, evidence suggests it may alter user behaviour in subtle ways and can risk deskilling of the endoscopist.²⁰ One study showed that trainee endoscopists using CADE had reduced eye movement across the screen, focusing instead on areas where visual alerts were expected.³⁸ This shift could risk deskilling over time if reliance on AI replaces active search strategies. Preventing this requires ongoing training and reinforcement of core detection skills, even in the presence of assistive technology.³⁹

In summary, the introduction of AI in endoscopy brings with it new expectations for how clinicians engage with technology, interpret its outputs and maintain their own expertise. These evolving responsibilities must be recognised and supported through structured education, governance frameworks and practical guidance in day-to-day endoscopic practice (table 1).

Outcome responsibility in AI-enabled endoscopy

In addition to shaping clinicians’ forward-looking duties, AI systems such as CADE and CADx raise important questions about how responsibility should be allocated when outcomes fall short of expectations or when harm occurs—‘*outcome responsibility*’. In current clinical practice, endoscopists remain accountable for the decisions made during a procedure, including those informed or supported by AI.⁴⁰ This reflects a traditional, individualistic model of responsibility, where outcomes—good or bad—are attributed to the clinician’s actions or omissions.

However, this model may no longer be suitable in the context of increasingly complex AI-integrated workflows. As CADE and CADx systems become more autonomous and embedded into clinical processes, diagnostic decisions are no longer the sole product of human judgement—they are coproduced by

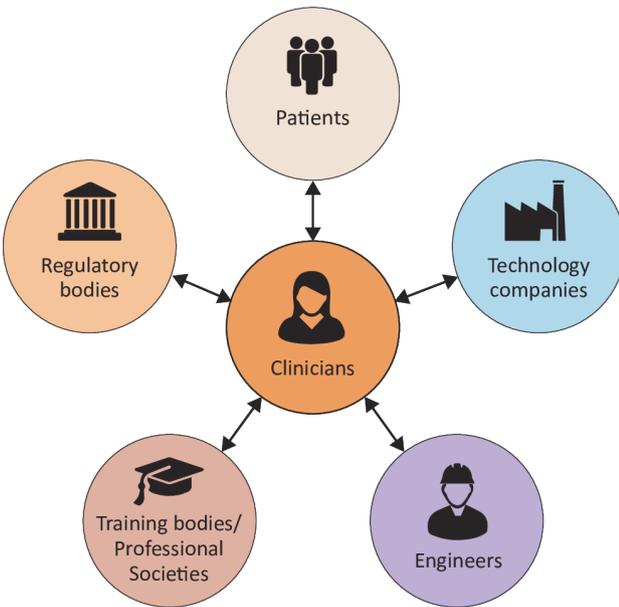


Figure 2 Outcome responsibilities of AI in endoscopy (and healthcare). AI, artificial intelligence.

human–machine systems. In these contexts, an error may not result solely from a lapse in clinical skill but from a broader interplay of factors: algorithmic bias, poor system design, limited training data or suboptimal integration into the clinical environment.

This has led some to argue for a shift towards shared responsibility frameworks, which acknowledge that accountability in the use of AI must be distributed across the entire ecosystem of stakeholders involved in its development and deployment (figure 2).^{41–43} These stakeholders include developers, technology companies, regulatory authorities, healthcare institutions, clinicians and patients (figure 2). For instance, a misclassification by a CADx system may not solely reflect clinician error but could stem from limitations in the algorithm’s training data, issues with system integration or insufficient education regarding its capabilities and boundaries. Enhancing foundational AI literacy among healthcare professionals and patients alike is therefore essential—not only to support informed decision-making but also to uphold autonomy and ensure safe, ethical adoption of AI technologies in clinical practice.

Such models are particularly relevant in healthcare settings, where decision-making is often collaborative, and errors typically result from a chain of events rather than a single point of failure.⁴⁴ A practical approach to implementing shared responsibility in healthcare AI is to embed responsibility frameworks within governance structures.⁴⁵ This requires clearly defined forward-looking responsibilities for regulators, developers, clinicians and hospitals, supported by multistakeholder audit trails that document decision points and system outputs. Such measures, combined with joint AI training and certification, can enhance patient

safety, clinician confidence and accountability.⁴⁶ Shared structures, such as multiparty oversight committees or ethics boards, can further ensure responsibility is distributed rather than concentrated in a single point of failure.

Importantly, allocating responsibility must avoid the ‘pie fallacy’⁴⁷—the mistaken assumption that responsibility is a fixed quantity to be divided among contributors.⁴⁷ Instead, each stakeholder’s responsibility depends on their specific actions, intentions and causal influence and does not diminish simply because others are also accountable. This perspective underscores that all stakeholders retain full accountability for their contributions in ensuring the safe and effective integration of AI into endoscopy practice.

Applying this lens to endoscopy could help ensure a more realistic, fair and forward-thinking approach to responsibility when things go wrong. For an endoscopist, this does not mean diminished accountability. Rather, it underscores the importance of clearly defined roles, robust training, and transparent documentation around how AI systems are used in practice. As these tools become standard in endoscopic practice, shared responsibility frameworks may provide a more ethically grounded and legally appropriate way of supporting safe and accountable care (table 2).

CONCLUSION

The use of AI technologies such as CADe and CADx in GI endoscopy presents clear opportunities to enhance adenoma detection, streamline decision-making and improve patient outcomes. However, the integration of these systems also introduces new layers of clinical responsibility. Endoscopists must not only understand the technical capabilities and limitations of these tools but also ensure they are used safely, responsibly and in a way that supports—rather than undermines—core

Table 2 Practical advice for stakeholders and clinicians using CADe and CADx in endoscopy

Domain	Practical advice
Operation of integrated technology	Technology companies should provide structured, standardised training on safe use.
Bias awareness	Regulatory bodies should mandate transparency on dataset composition and encourage audits for bias.
Understanding limitations	Professional societies should issue guidelines on understanding model limitations and mitigating over-reliance.
Patient communication—how it works	National societies (eg, British Society of Gastroenterology) should create patient communication guidance on AI use.
Patient communication—why it is used	National societies (eg, British Society of Gastroenterology) should include guidance on informed consent and explaining the rationale for AI integration in clinical practice.
CADe, computer-assisted detection; CADx, computer-assisted diagnosis.	

clinical skills. This includes maintaining vigilance against over-reliance, being able to critically evaluate system outputs and effectively communicating the role and reliability of AI to patients during consent and shared decision-making processes.

Beyond individual practice, these technologies raise broader questions about how responsibility should be shared among clinicians, institutions and developers when diagnostic errors occur. As AI becomes increasingly embedded in clinical workflows, the traditional model of individual accountability may no longer be sufficient. Recognising the shared and systemic nature of responsibility is essential to ensuring patient safety, transparency and trust in AI-assisted care.

The ongoing implementation of AI in endoscopy must be matched by robust training, governance and evaluation strategies. Clear guidelines on clinician competencies, system oversight and ethical use will be critical for integrating AI into routine practice in a way that is clinically effective and ethically sound. As these technologies advance, careful scrutiny and reflection will be essential to ensuring they deliver on their promise without compromising standards of care.

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