Curriculum for safe and effective use of artificial intelligence in endoscopy: European Society of Gastrointestinal Endoscopy (ESGE) Position Statement

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ABSTRACT

The European Society of Gastrointestinal Endoscopy (ESGE) has identified a critical need to establish structured training for safe and effective use of artificial intelligence (AI) in endoscopy. This manuscript presents the results of a formal Delphi consensus process and outlines the official ESGE position, offering a comprehensive curriculum for acquiring and maintaining the competence needed to exploit the benefit of using AI tools in endoscopy. The proposed framework defines the prerequisites in the preadoption phase, core training components, and requirements to maintain optimal implementation. Key recommendations include: (1) ensuring basic competency in standard endoscopy procedures; (2) acquiring foundational knowledge of AI principles; (3) implementing educational programs to enhance AI literacy; (4) recognizing and mitigating cognitive biases in human–AI interaction; (5) avoiding over-reliance on AI in clinical decision-making; and (6) continuous monitoring of key performance indicators throughout AI system integration.

ABBREVIATIONS

ADR	adenoma detection rate
AI	artificial intelligence
CADe	computer-aided detection
ESGE	European Society of Gastrointestinal Endoscopy
GI	gastrointestinal
GRADE	Grading of Recommendations Assessment, Development and Evaluation
PICO	Population/problem, Intervention, Comparison, Outcome
RCT	randomized controlled trial

Introduction

Artificial intelligence (AI) is anticipated to rapidly transform gastrointestinal (GI) endoscopy by improving diagnostic accuracy, procedural efficiency, and quality assurance [1]. However, significant uncertainties remain regarding its impact on patient-important outcomes, potential AI-driven adverse events, cost-effectiveness, and the dynamics of human–AI interaction [2, 3, 4, 5]. Despite these challenges, there is no standardized training, competency framework, or structured guidance to ensure the safe and effective use of AI in endoscopy. Recognizing this gap, the European Society of Gastrointestinal Endoscopy (ESGE) has identified an urgent need to develop structured training programs for AI integration in endoscopic practice.

Promoting high quality endoscopy is a key priority for the ESGE to ensure effective treatment and optimal patient outcomes. High quality procedures depend on well-trained endoscopists with both technical and cognitive competencies – ranging from understanding clinical indications and limitations, to managing adverse events. As no standards currently exist for training in AI-assisted endoscopy, the ESGE has developed a dedicated curriculum to guide practitioners in the safe and effective use of AI. This curriculum outlines the essential training components to ensure competency in integrating AI into routine endoscopic practice.

Methods

The development of the present AI curriculum aligns with the ESGE guidance on postgraduate training in advanced endoscopic procedures [6]. A Position Statement format was considered appropriate given the educational significance of the topic and the limited expected body of evidence. This document focuses on AI in GI endoscopy, irrespective of the target organs where AI is used. We consider most statements are broadly applicable across AI tools in endoscopy, but readers should consider each tool's specific indications, effectiveness, and limitations when applying them.

In February 2024, an email invitation to participate in the curriculum was sent to all individual ESGE members. Applicants were required to submit a motivation letter and an updated curriculum vitae. The selection of applicants was carried out by the taskforce lead (Y.M.) and the chair of the Curricula Working Group (T.T.) based on the applicants' expertise in AI in medicine, clinical and research background, experience in curricula development and educational activities, and diversity in geography and sex. The ESGE Executive Committee subsequently approved the final list of 25 taskforce members. The Committee also approved three advisors in computer engineering who have extensive experience in AI in endoscopy and 65 voting members, of whom 42 made significant contributions and are included as corporate authors. The taskforce members were divided into three groups ("preadoption," "training," and "autonomous implementation and assessment of proficiency") according to the three different phases of the curriculum as described in the ESGE curricula development methodology [6]. The three groups were led by U.K., P.S., and A.E..

In May 2024, the taskforce members, together with the advisers in computer engineering, collectively determined four clinical questions that were deemed most important for the safe and effective use of AI in GI endoscopy during a virtual online meeting (**Appendix 1s**, see online-only Supplementary material). These four questions comprised two clinical questions for "preadoption," one clinical question for "training," and one clinical question for "autonomous implementation and assessment of proficiency." Clinical questions were structured using the PICO (Population/problem, Intervention, Comparison, Outcome) format.

For each of the established clinical questions, a systematic literature search was done. To standardize the literature search and methodology, a structured template was developed. **Appendix 1s** provides the PICO questions and search strategies for each of the three phases. The lack of prospective studies prevented a Grading of Recommendations Assessment, Development and Evaluation (GRADE)-based approach being taken to assess the quality and certainty of the evidence [7]. Instead, the Taskforces formulated expert opinion-based good practice statements that comprehensively reflect the available evidence to represent ESGE's position.

The taskforces collectively drafted a list of statements and explanatory texts supporting the recommendations. The consensus on these statements was determined through an anonymous Delphi process, which took place in February 2025 [8]. All of the Taskforce members, advisers in computer engineering, and voting members were invited to vote and provide written comments. Statements were graded using a 5-point Likert scale (1, strongly disagree; 2, disagree; 3, neither agree nor disagree; 4, agree; 5, strongly agree) via a web-based platform. Consensus was defined as ≥80% agreement (the sum of Agree and Strongly agree) on each statement.

As all of the draft statements reached ≥80% agreement in the first voting round with minor comments, we did not conduct the second voting round. Instead, the Taskforces gathered in April 2025 to integrate the comments into the final statements and explanatory texts, resulting in only minor amendments of the wording. Subsequently, the Taskforces prepared a preliminary manuscript, which was shared with all members for feedback. At this stage, no modifications were allowed in the content of the statements that achieved consensus during the anonymous voting (▶ **Table 1**).

The peer review process for ESGE policy documents was followed. Members from the ESGE board, the Curricula Working Group, and external experts reviewed the manuscript. The document was circulated to all national society members and individual ESGE members for feedback. The final version of the manuscript was approved by all authors and was submitted to *Endoscopy* for publication.

Good practice statements

Preadoption

STATEMENT 1
Clinicians using AI in endoscopy need to have basic competency in standard endoscopic procedures.
Agreement 93%.

Fundamental endoscopic skills [9] are considered necessary for successful integration of AI systems into clinical workflows. AI can greatly help both novice and experienced endoscopists detect and differentiate colorectal polyps in real time – as long as they are able to use AI predictions effectively during their diagnosis [10, 11, 12]. Another study also demonstrated the

▶ **Table 1** List of agreed statements.

Good practice statements	
Preadoption	
1	Clinicians using AI in endoscopy need to have basic competency in standard endoscopic procedures
2	Endoscopists require a foundational understanding of AI concepts to critically evaluate and effectively implement AI tools in clinical practice
3	Educational programs should be developed to enhance AI literacy with practical training using approved systems
Training	
4	Endoscopists should be aware of the risk of potential cognitive biases, such as automation bias, algorithm aversion, and conservatism bias, which are detrimental to human–AI interaction
5	Endoscopists should be trained not to exclusively rely on AI systems for clinical decision-making
Autonomous implementation and assessment of proficiency	
6	Key performance and quality indicators related to the intended use of the AI systems (e.g. adenoma detection rate) should be monitored before, during, and after their implementation

AI, artificial intelligence.

utility of real-time AI in improving early gastric cancer detection rates, highlighting the importance of operator proficiency in real-time scope handling and lesion visualization to maximize the benefits of AI [13]. A similar situation was observed in the assessment of Barrett's esophagus [14].

In addition to scope handling and lesion visualization capability, which are detailed in another ESGE publication [9], fundamental knowledge on interpreting endoscopy images (e.g. polyp characterization) is needed to allow optimal human–AI interaction, rather than outcomes being unwantedly biased by the AI inputs.

Furthermore, the value of AI in augmenting colonoscopy training for trainees has been shown based on the improved adenoma detection rates (ADRs) among less experienced operators when supported by AI, provided they had basic endoscopy skills, using a back-to-back method in pairs with gastroenterology experts [15]. Similarly, an AI-based gastroscopy training system significantly enhanced the diagnostic proficiency of graduate students in gastroenterology [16, 17].

The use of AI for endoscopy quality control highlights its ability to enhance the ADR or gastric precancerous conditions detection rate, when employed by skilled operators, underscoring the necessity of basic competence in endoscopy to effectively utilize AI for quality assurance [18]. Moreover, another study on AI-assisted differentiation of colorectal polyps suggested that endoscopists could adapt their procedural techniques based on AI feedback [19]. This skill adaptation relies on the operator's ability to interpret AI outputs accurately and integrate them into their decision-making processes. Though there is no supporting evidence, the results of the abovementioned studies implied that basic endoscopy skills would be a prerequisite to exploit the benefits that the AI tools provide. Studies enlightening when AI should be introduced in training are also warranted.

STATEMENT 2
Endoscopists require a foundational understanding of AI concepts to critically evaluate and effectively implement AI tools in clinical practice.
Agreement 90%.

STATEMENT 3
Educational programs should be developed to enhance AI literacy with practical training using approved systems.
Agreement 99%.

The minimum required technical knowledge to effectively use AI in endoscopy remains undefined. While comprehensive AI expertise is likely not necessary, an understanding of the fundamental concepts is essential for critical appraisal before implementation, this being called "AI literacy" [20, 21]. AI literacy programs may cover the following areas: fundamentals of machine-learning algorithms, data quality and its role in AI development, interpretation of model performance metrics, recognition of system limitations and biases, and an understanding of the clinical implications [22]. Gastroenterology societies, in partnership with industry, computer scientists, and clinical educators, are ideally positioned to develop and deliver structured educational programs.

At the same time, it is crucial to learn about and understand several potential limitations of the AI tools to maximize their benefits, including their performance variability according to the examined cases and products, technical limitations, and the presence of clinical scenarios in which the system's reliability may be compromised.

Successful AI implementation might however rely more on practical experience with specific AI tools, rather than theoretical knowledge [23]. Therefore, educational initiatives should balance basic AI literacy with hands-on training using approved systems, focusing on real-world application.

From a training perspective, another key question is when AI should be introduced into an endoscopist's education – at the very start of training, or after basic endoscopic skills and knowledge have been acquired? Currently, no recommendations can be made owing to the limited evidence, but this remains a critical research topic and should be included as a formal statement in future curricula.

Training

STATEMENT 4
Endoscopists should be aware of the risk of potential cognitive biases, such as automation bias, algorithm aversion, and conservatism bias, which are detrimental to human–AI interaction.
Agreement 93%.

In real-world practice, AI does not work alone, rather endoscopists interact with AI outputs, accepting or rejecting their suggestions in real time. This human–AI interaction is complex. It is affected by many factors like algorithm and interface design, accuracy of the model, human behavior and psychology, and trust in the technology. Such complexity of human–AI interaction likely contributes to suboptimal outcomes; endoscopists do not always accept correct suggestions by AI nor reject wrong suggestions by AI [24, 25]. Endoscopists need to understand the factors affecting human–AI interaction to maximize the benefit and minimize the risk of using AI. To achieve this goal, we may need to understand how human–AI interactions are built and biased. These biases include automation bias, anchoring bias, algorithm aversion, and conservatism bias (▶ **Table 2**).

Automation bias is the tendency of an individual to "overrely" on an external factor [26], what in AI-assisted endoscopy may emerge as a user's overdependence on AI for swift decisions holding different risks [27]. This may lead to the assumption that the AI algorithm will detect all pathology regardless of the endoscopist's performance, resulting in reduced human

▶ **Table 2** Definitions of biases observed in human–artificial intelligence (AI) interaction and potential mitigation measures.

Bias	Definition	Mitigation measures
Automation bias	The tendency of an individual to over-accept AI outputs, often resulting in a diminished awareness of the surrounding situation	(1) Limit on-screen alarms and reduce false-positive rates
		(2) Reduce the cognitive load on the endoscopist
		(3) Stimulate well-organized training on the use of the specific AI platform
		(4) Address explainability and transparency
		(5) Design adaptive user-friendly and easy-to-use interfaces
Anchoring bias	The tendency of an individual to make decisions based on irrelevant factors like imaginability when given uncertain external advice	Provide enough time to overthink a decision and weigh the different external factors against own beliefs
Algorithm aversion	The tendency of an individual to disbelieve AI in future decisions, once it makes a mistake	(1) Familiarize endoscopists with AI algorithms
		(2) Hold realistic expectations for the AI system being used, based on knowledge of the data used for its training and validation
		(3) Use the correct system for the chosen task to be fulfilled
		(4) Monitor the AI performance in the real-world
Conservatism bias	The tendency of an individual to hold on to established beliefs and information, resisting new information that challenges these beliefs	(1) Address explainability and transparency
		(2) Reduce the "black box" phenomenon

detection and potential deskilling [3, 28]. This overconfidence may also lead to an over-reliance on AI advice against one's own correct judgements, implying the need for verification of a given AI decision, which may be more challenging for less experienced endoscopists. Suggested measures to minimize automation bias may involve: (i) decreasing the prominence of false alarms; (ii) decreasing the endoscopist's cognitive load; (iii) stimulating and providing thorough training on the use of the specific AI platform; (iv) addressing explainability and transparency of decision-making; and (v) design adaptive user-friendly interfaces. [29, 30]

Anchoring bias [31] refers to the situation where people tend to be influenced by irrelevant factors, like imaginability rather than facts, when given uncertain external advice, resulting in often insufficiently adjusted decisions [32]. Overtreatment of normal mucosa that AI suggests to be a "polyp" owing to an abnormal appearance, such as irregular light reflection, is an example of anchoring bias in endoscopy. Key factors in this ineffective decision-making are the accuracy required in the endoscopist's decision and the time required to consider both their own and the external opinions; however, the rapidity of identification and decision-making is key for the efficiency of endoscopic procedures, which may facilitate the anchoring bias [33].

Algorithm aversion has another significance. When users observe an algorithm making mistakes, they tend to unconsciously disregard its input – even when it later provides accurate diagnoses that humans might otherwise miss – leading to potential under-reliance [34, 35]. Influencing factors may include the individual endoscopist's expertise, personal attitude to AI, and the initial expectations regarding the system's performance [35, 36]. A recent meta-analysis of algorithm aversion showed a positive association between experience with AI assistance and evaluation of AI decisions [37]. Several preventive measures are being suggested: (i) familiarize endoscopists with AI; (ii) create realistic expectations for each AI system, based on knowledge of the data used for training and validation; (iii) have endoscopists use the correct system for the chosen task to be fulfilled; and (iv) monitor the AI performance in the real world.

Conservatism bias is another example of the biases in human–AI interaction. As observed in human–human interactions, people usually behave conservatively when challenging established beliefs. Human–AI communication can fail owing to design flaws or the inability to understand how AI makes decisions (i. e. the black box phenomenon) and how likely AI may be to err in specific conditions. Therefore, opening the algorithm box and providing information to the user may be the first and most critical step to reduce conservatism bias.

As of today, there is no established way to eliminate these biases, with no study having addressed the specific topic of "interaction training/improvement" in the endoscopy field and beyond. However, initial experimental evidence investigating the characteristics and consequences of human–AI interaction in endoscopy is available, from which we may draw insights on how to promote optimal interaction and where to direct future research efforts [38, 39].

STATEMENT 5
Endoscopists should be trained not to exclusively rely on AI systems for clinical decision-making.
Agreement 97%.

While AI may improve the quality of endoscopy with improved detection and diagnosis, the uncritical acceptance of AI outcomes remains a concern, stressing the necessity for ongoing education, research, and direct feedback [10, 40].

The current view on AI is that it operates as an assistant to the endoscopist, reassuring or elevating the confidence level for diagnosis. Given that clinical decision-making involves more than just diagnosis, also involving patient interaction, personal history, and clinical judgment, the final decision will never solely rely on AI. It can be debated whether, in the future, AI systems that robustly outperform humans at interpreting complex tasks will still require some degree of human interference for the final decision.

To successfully integrate AI-based models into endoscopy and, by extension, the healthcare system, a well-balanced reliance with appropriate trust in digital resources for assessment, identification, interpretation, and application – referred to as "AI literacy" – is imperative as described above.

On the other hand, patient acceptance of endoscopy with AI support needs to be discussed because the users (patients in medicine) should always be central in any decision-making process in healthcare. A recently published prospective study showed that more than 90% of patients accepted optical biopsy procedures using computer-aided diagnosis in colonoscopy with well-assured quality [41].

Autonomous implementation and assessment of proficiency

STATEMENT 6
Key performance and quality indicators related to the intended use of the AI systems (e.g. adenoma detection rate) should be monitored before, during, and after their implementation.
Agreement 92%.

Endoscopic AI systems have been assessed across a range of applications in both preclinical and clinical research. In various applications, such as colonic polyp detection and upper GI neoplasia detection, randomized controlled trials (RCTs) have shown that AI enhances endoscopist performance [42, 43, 44, 45, 46, 47].

The majority of RCTs have focused on computer-aided detection (CADe) of colonic polyps, with recent systematic reviews of these RCTs suggesting that AI systems may improve detection rates of colorectal polyps [42, 43, 46]. These validations by RCTs have however been done in highly controlled settings within both referral and community-based hospitals [48, 49]. A recent meta-analysis showed that, in real-world, non-randomized studies, CADe in colonoscopies does not enhance the detection of colorectal neoplasia, raising doubts about the generalizability of the positive findings in the RCTs [50].

In addition, the integration of AI could potentially lead to deskilling of endoscopists, possibly by diverting their concentration and altering technical skills and visual gaze patterns [3, 51]. Therefore, it is essential to monitor key performance indicators related to the intended use of the AI system (e.g. ADR in colonoscopy), before, during, and after implementation. Accordingly, de-implementation of the AI systems may be considered if unwanted consequences are observed. A washout period following the implementation of an AI system might also be needed to neutrally observe the influence of AI on the capability of endoscopists.

Conclusions

ESGE has developed a comprehensive curriculum to guide training in the safe and effective integration of AI in GI endoscopy. This initiative emphasizes the importance of foundational endoscopic skills, AI literacy, and awareness of cognitive biases to ensure appropriate human–AI interaction. It also stresses that clinicians should not rely solely on AI for decision-making and should maintain independent clinical judgment. Finally, ongoing monitoring of performance and quality indicators is essential to evaluate the impact and effectiveness of AI systems in routine clinical practice. To develop an evidence-based educational strategy, future research should prioritize prospective studies that assess various training approaches for using AI in endoscopy.

Disclaimer

ESGE Guidelines and Position Statements represent a consensus of best practice based on the available evidence at the time of preparation. They might not apply in all situations and should be interpreted in the light of specific clinical situations and resource availability. Further controlled clinical studies may be needed to clarify aspects of these statements, and revision may be necessary as new data appear. Clinical considerations may justify a course of action at variance with these recommendations.

ESGE Guidelines and Position Statements are intended to be an educational device providing information that may assist endoscopists in providing care to patients. They are not rules and should not be construed as establishing a legal standard of care or as encouraging, advocating, requiring, or discouraging any particular treatment.

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Conflict of Interest

Main authors: Y. Mori has received consultancy and speaker's fees, plus equipment loan form Olympus (2017 to present) and loyalty fees from Cybernet System (2020 to present). U. Kopylov and his department have received research support and speaker's fees from Medtronic (ongoing). E. Dekker has received a speaker's fee from Fujifilm (2024), consultancy and speaker's fees from Olympus (2023 – 2025), and a speaker's fee from Pentax (2025); her department has endoscopic equipment on loan from Fujifilm (ongoing). O.F. Ahmad has received consultancy fees from Odin Vision and Olympus (2023 to present) and speaker's fees from Olympus Corporation, Boston Scientific, Medtronic, and Norgine (2023 to present). R. Kader has provided consultancy to Odin Vision (2023 to 2025) and is an external stakeholder for NICE's HealthTech program evaluating AI software to help detect colorectal polyps (2024 to present). E. Schoon has received consultancy and speaker's fees and has equipment on loan from Fujifilm (2020 to present). P. Mascagni's department received unconditional sponsorship of the Surgical Data Science Summer School 2024 and holds patent FR3111463A1 for Processing of video streams relating to surgical operations. P. Bhandari received support for concept to product development from Wise Vision (NEC; 2020–2025). G. Antonelli has provided consultancy to Medtronic (2022 to present), Odin Vision (2023), and Cosmo IMD (2024 to present), and is a consultant and advisory board member for Olympus Europe (2024 to present). M. Iacucci has received a consultancy fee and research equipment from Pentax (2024), and research grants from Eli Lilly and Olympus (both 2024 to present). O. Pech has received speaker's fees from Medtronic, Boston Scientific, and Olympus (2020 to present). X. Dray is co-founder and a shareholder of Augmented Endoscopy (2019 to present) and is co-inventor of all patents (past and present) licensed to Augmented Endoscopy, which relate to AI solutions for endoscopic detection and characterization. M. Spadaccini has provided consultancy to Boston Scientific (2024 to present) and Olympus (2025) and has received speaker's fees from Steris (2025). R. Bisschops has received speaker's fees, plus grants and research support from Pentax, Fujifilm, Olympus, and Medtronic (2019 to present); his department has received support from Pentax, Fujifilm, and Medtronic (2019 to present). P. Sinonquel, A. Ebigbo, J. de Groof, A. Saftoiu, A. Hann, J. Campion, C. Hassan, H. Messmann, L. Fuccio, A. Facciorusso, and T. Tham declare that they have no conflict of interest. Corporate authorship: F. van der Sommen has received research support from Olympus (2021–2023). A. Murino has received speaker's fees from Fujifilm (2024). A. Monged received support for an ESD training course from Fujifilm (2024). D. Karsenti has provided consultancy to Coviden and Norgine (both 2023–2024), and has received support to attend meetings from Alfasigma (2023–2024), Cook (2023), and Fujifilm (2023–2024). G.E. Tontini has provided consultancy to NTC Pharma (2024) and Invicro (2014 to present) and has received speaker's fees from Ferring (2024–2025). L.-J. Masgnaux is president of ATRACT device and Co. (2022 to present). M. Bustamante has received consultancy fees from Medtronic (2023). M. Maas's department received research funding from Pentax Medical (2020–2024) and Magentiq Eye Ltd. (2021–2024). M. Mascarenhas holds personal shares in Digestaid (2024 to present). M. Ibrahim has received consultancy and speaker's fees from Boston Scientific (2018 to present), Endotools (2018 to present), and Fujifilm (2019 to present). N. Coelho-Prabhu is a consultant for Iterative Health (2024 to present). P. Roelandt's department has received support from Pentax, Fujifilm, and Medtronic (2019 to present). R. Rameshshanker received training course support from Pentax Medical (2025). R. Sadik has received lecture fees from Olympus (2024–2025) and Pentax (2025). T. de Lange is a shareholder with 20% employment at Augere Medical AS (2019 to present). J. Bernal, T. Eelbode, A. Papaefthymiou, A. Benson, R. Bozzi, C. Yzet, E. Gibbons, E. Gadour, F. Silva, G. Tziatzios, G. Esposito, H. Rughwani, I. Jovanovic, I.D. Arciniegas Sanmartin, J. Kral, J. Santos-Antunes, K. Khalaf, K. Namikawa, K. Kurek, M.F. Balladares Salazar, M. Kalauz, M. Shiha, R.H. López, R. Sidhu, S. Stylianidis, T. Khoury, and V. Lorenzo-Zúñiga declare that they have no conflict of interest

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Supplementary Material

Curriculum for safe and effective use of artificial intelligence in endoscopy: European Society of Gastrointestinal Endoscopy (ESGE) Position Statement

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Appendix 1s PICO questions, search strategy, and search results of systematic reviews.

Preadoption

Clinical question 1:

What is the minimally required endoscopy skill to exploit benefits of using AI in endoscopy?

PICO table

PICO component	Description
Population	Endoscopists using AI tools in endoscopy (gastroscopy, colonoscopy, EUS)
Intervention	Endoscopy procedures with AI assistance
Comparison	Endoscopy without AI, or different levels of operator skill
Outcome	Successful utilization of AI, improved diagnostic accuracy, reduced procedural time, enhanced therapeutic outcomes

Search Engine: PubMed

Search Terms:

("Artificial Intelligence"[MeSH] OR "Deep Learning"[MeSH] OR "Machine Learning"[MeSH]) AND ("Endoscopy"[MeSH] OR "Gastrointestinal Endoscopy"[MeSH] OR "Endosonography"[MeSH])

AND ("Clinical Competence"[MeSH] OR "Skills"[MeSH] OR "Professional Competence"[MeSH])

Search Date: Inception to 16 September 2024

Search Results: 313 articles selected > 303 excluded > 10 included for review

Reviewed papers:

1. Jin EH, Lee D, Bae JH, Kang HY, Kwak MS, Seo JY, Yang JI, Yang SY, Lim SH, Yim JY, Lim JH, Chung GE, Chung SJ, Choi JM, Han YM, Kang SJ, Lee J, Chan Kim H, Kim JS. Improved Accuracy in Optical Diagnosis of Colorectal Polyps Using Convolutional Neural Networks with Visual Explanations. Gastroenterology. 2020 Jun;158(8):2169-2179.e8. doi: 10.1053/j.gastro.2020.02.036. Epub 2020 Feb 29. PMID: 32119927

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Repici A, Hassan C, Byrne MF, Rastogi A. Artificial Intelligence for Real-Time Prediction of the Histology of Colorectal Polyps by General Endoscopists. Ann Intern Med. 2024 Jul;177(7):911-918. doi: 10.7326/M24-0086. Epub 2024 May 21. PMID: 38768450

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4. Wu L, Zhou W, Wan X, Zhang J, Shen L, Hu S, Ding Q, Mu G, Yin A, Huang X, Liu J, Jiang X, Wang Z, Deng Y, Liu M, Lin R, Ling T, Li P, Wu Q, Jin P, Chen J, Yu H. A deep neural network improves endoscopic detection of early gastric cancer without blind spots. Endoscopy. 2019 Jun;51(6):522-531. doi: 10.1055/a-0855-3532. Epub 2019 Mar 12. PMID: 30861533

5. Meinikheim M, Mendel R, Palm C, Probst A, Muzalyova A, Scheppach MW, Nagl S, Schnoy E, Römmele C, Schulz DAH, Schlottmann J, Prinz F, Rauber D, Rückert T, Matsumura T, Fernández-Esparrach G, Parsa N, Byrne MF, Messmann H, Ebigbo A. Influence of artificial intelligence on the diagnostic performance of endoscopists in the assessment of Barrett's esophagus: a tandem randomized and video trial. Endoscopy. 2024 Sep;56(9):641-649. doi: 10.1055/a-2296-5696. Epub 2024 Mar 28. PMID: 38547927

6. Yamaguchi D, Shimoda R, Miyahara K, Yukimoto T, Sakata Y, Takamori A, Mizuta Y, Fujimura Y, Inoue S, Tomonaga M, Ogino Y, Eguchi K, Ikeda K, Tanaka Y, Takedomi H, Hidaka H, Akutagawa T, Tsuruoka N, Noda T, Tsunada S, Esaki M. Impact of an artificial intelligence-aided endoscopic diagnosis system on improving endoscopy quality for trainees in colonoscopy: Prospective, randomized, multicenter study. Dig Endosc. 2024 Jan;36(1):40-48. doi: 10.1111/den.14573. Epub 2023 May 29. PMID: 37079002

7. An P, Wang Z. Application value of an artificial intelligence-based diagnosis and recognition system in gastroscopy training for graduate students in gastroenterology: a preliminary study. Wien Med Wochenschr. 2024 Jun;174(9-10):173-180. doi: 10.1007/s10354-023-01020-w. Epub 2023 Sep 7.

8. Li YD, Zhu SW, Yu JP, Ruan RW, Cui Z, Li YT, Lv MC, Wang HG, Chen M, Jin CH, Wang S. Intelligent detection endoscopic assistant: An artificial intelligence-based system for

monitoring blind spots during esophagogastroduodenoscopy in real-time. Dig Liver Dis. 2021 Feb;53(2):216-223. doi: 10.1016/j.dld.2020.11.017. Epub 2020 Nov 30. PMID: 33272862

9. Yao L, Liu J, Wu L, Zhang L, Hu X, Liu J, Lu Z, Gong D, An P, Zhang J, Hu G, Chen D, Luo R, Hu S, Yang Y, Yu H. A Gastrointestinal Endoscopy Quality Control System Incorporated With Deep Learning Improved Endoscopist Performance in a Pretest and Post-Test Trial. Clin Transl Gastroenterol. 2021 Jun 15;12(6):e00366. doi: 10.14309/ctg.0000000000000366. PMID: 34128480

10. Byrne MF, Chapados N, Soudan F, Oertel C, Linares Pérez M, Kelly R, Iqbal N, Chandelier F, Rex DK. Real-time differentiation of adenomatous and hyperplastic diminutive colorectal polyps during analysis of unaltered videos of standard colonoscopy using a deep learning model. Gut. 2019 Jan;68(1):94-100. doi: 10.1136/gutjnl-2017-314547. Epub 2017 Oct 24. PMID: 29066576

Clinical question 2:

What is the minimally required knowledge on AI in general to exploit benefits of using AI in endoscopy?

PICO table

PICO component	**Description**
Population	Endoscopists using AI tools in endoscopy (gastroscopy, colonoscopy, EUS)
Intervention	Endoscopy procedures with AI assistance
Comparison	Endoscopy without AI, or different levels of AI knowledge
Outcome	Successful utilization of AI, improved diagnostic accuracy, reduced procedural time, enhanced therapeutic outcomes

Search engine: PubMed

Search terms:

(("Artificial Intelligence"[MeSH] OR "Deep Learning"[MeSH] OR "Machine Learning"[MeSH]) AND ((knowledge) OR (competence))) AND ("Endoscopy"[MeSH] OR "Gastrointestinal Endoscopy"[MeSH] OR "Endosonography"[MeSH])

Search date: Inception to December 2024

Search results: 1100 articles screened > 50 abstract screened > 8 full-text > 3 included for review

Reviewed papers:

1. van der Sommen F, de Groof J, Struyvenberg M, van der Putten J, Boers T, Fockens K, Schoon EJ, Curvers W, de With P, Mori Y, Byrne M, Bergman JJGHM. Machine learning in GI endoscopy: practical guidance in how to interpret a novel field. Gut. 2020 Nov;69(11):2035-2045. doi: 10.1136/gutjnl-2019-320466. Epub 2020 May 11. PMID: 32393540; PMCID: PMC7569393.

2. Rodrigues T, Keswani R. Endoscopy Training in the Age of Artificial Intelligence: Deep Learning or Artificial Competence? Clin Gastroenterol Hepatol. 2023 Jan;21(1):8-10. doi: 10.1016/j.cgh.2022.08.013. Epub 2022 Sep 14. PMID: 36113552.

3. Tham S, Koh FH; SKH Endoscopy Centre; Teo EK, Lin CL, Foo FJ. Knowledge, perceptions and behaviours of endoscopists towards the use of artificial intelligence-aided colonoscopy. Surg Endosc. 2023 Oct;37(10):7395-7400. doi: 10.1007/s00464-023-10412-3. Epub 2023 Sep 5. PMID: 37670191.

Training

Clinical question:

Do endoscopists require special training to achieve optimal human-AI interaction in GI endoscopy?

PICO table

PICO component	Description
Population	Endoscopists using AI tools in GI endoscopy
Intervention	Training programs/frameworks focusing on human-AI interaction
Comparison	No specific training programs, traditional training without an AI component, or alternative approaches
Outcome	Optimal human-AI interaction (measured through outcomes like clinical outcomes, performance enhancement, critical thinking retention, prevention of deskilling)

Search Engine: PubMed

Search terms:

(("artificial intelligence"[MeSH Terms] OR "artificial intelligence" OR "AI" OR "machine learning" OR "deep learning" OR "computer-aided")) AND (("interaction" OR "collaboration" OR "decision-making" OR "teamwork" OR "hybrid intelligence" OR "human-AI collaboration")) AND (("endoscopy"[MeSH Terms] OR "gastrointestinal endoscopy" OR "GI endoscopy" OR "digestive endoscopy" OR "colonoscopy" OR "endoscopists"))

Search date: Inception to 2nd of December 2024

Date search was conducted	
Number of Records identified through database searching	***N= 387*** *(Pubmed, Embase and Scopus search)* - 137 no full text available - 100 before 2015 - 97 not the scope ***N= 53*** *(all filtered out)*
Number of duplicates removed	***N= 0****(assisted by Eppi Reviewer)*
Number of records screened/reviewed	***N= 74***
Number of abstracts excluded	***N= 25***
Full-text articles assessed for eligibility	***N= 49***
Additional records identified through reading	***N= 6***
Full-text articles excluded, with reasons	***N= 13*** - 13 not the aim
Number of studies reviewed for the qualitative synthesis	***N= 42***

Reviewed papers:

1. Akata, Z., Balliet, D., de Rijke, M., Dignum, F., Dignum, V., Eiben, G., Fokkens, A., Grossi, D., Hindriks, K., Hoos, H., Hung, H., Jonker, C., Monz, C., Neerincx, M., Oliehoek, F., Prakken, H., Schlobach, S., van der Gaag, L., van Harmelen, F., … Welling, M. (2020). A Research Agenda for Hybrid Intelligence: Augmenting Human Intellect With Collaborative, Adaptive, Responsible, and Explainable Artificial Intelligence. *Computer*, *53*(8), 18–28. https://doi.org/10.1109/MC.2020.2996587

2. Alagappan, M., Brown, J. R. G., Mori, Y., Berzin, T. M. (2018). Artificial intelligence in gastrointestinal endoscopy: The future is almost here. *World Journal of Gastrointestinal Endoscopy*, *10*(10), 239–249. https://doi.org/10.4253/wjge.v10.i10.239

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Autonomous implementation and assessment of proficiency

Clinical question:

How does AI use affect the performance of endoscopists?

PICO question:

PICO component	Description
Population	Endoscopists
Intervention	Use of AI
Comparison	Non use of AI
Outcome	Change in performance of endoscopists using AI

Search dates: Inception to 17th of November 2024

Search engine: PubMed

Search terms

Search 1:

((endoscopist*[tiab]) OR (endoscopy*[tiab]))AND ("Artificial Intelligence"[Mesh] OR "Algorithms"[Mesh] OR artificial intelligence*[tiab] OR AI[tiab] OR machine learning[tiab] OR deep learning[tiab] OR support vector machine*[tiab] OR algorithm*[tiab] OR computer-aided[tiab] OR neural network*[tiab] OR convolutional network*[tiab] OR convolutional neural network*[tiab] OR deep learning*[tiab])
AND ("Randomized Controlled Trial" [Publication Type] OR randomized[tiab] OR randomised[tiab] OR RCT[tiab])

Search 2:

((endoscopist*[tiab]) OR (endoscopy*[tiab])) AND ("Artificial Intelligence"[Mesh] OR "Algorithms"[Mesh] OR artificial intelligence*[tiab] OR AI[tiab] OR machine learning[tiab] OR deep learning[tiab] OR support vector machine*[tiab] OR algorithm*[tiab] OR computer-aided[tiab] OR neural network*[tiab] OR convolutional network*[tiab] OR convolutional neural network*[tiab] OR deep learning*[tiab])AND (not-expert setting*[tiab] OR non-expert setting*[tiab] OR not-expert[tiab] OR non-expert[tiab] OR daily practice*[tiab] OR routin*[tiab])

Search 3:

("Endoscopy"[MAJR] OR endoscopist*[tiab] OR endoscop*[tiab])AND ("Artificial Intelligence"[Mesh] OR "Algorithms"[Mesh] OR artificial intelligence*[tiab] OR AI[tiab] OR machine learning[tiab] OR deep learning[tiab] OR support vector machine*[tiab] OR algorithm*[tiab] OR computer-aided[tiab] OR neural network*[tiab] OR convolutional network*[tiab]) AND (deskilling*[tiab] OR de-skilling*[tiab])

Search results:

Number of Records identified through database searching	***N= 1018***
Number of records screened/reviewed	***N= 1018***
Number of records excluded	***N= 910***
Reports sought for retreival	***N= 112***
Additional records identified from references	***N= 24***
Reports assessed for eligibility	***N= 136***
Reports excluded (unrelated to AI in endoscopy, pre-clinical studies, Reviews and Editorials	***N= 90***
Studies included in review	N=46

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