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Teaching AI ethics in medical schools: a scoping review protocol on the ethical–technical balance in curricular frameworks

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ABSTRACT

Introduction The rapid integration of artificial intelligence (AI) technologies in healthcare, ranging from diagnostic tools to clinical decision support systems, is transforming medical practice and education. However, without deliberate integration of ethics, there is a risk that medical education will reproduce a technosolutionist orientation by privileging efficiency and data-driven outputs over patient autonomy, justice and professional integrity. While AI-related courses are increasingly being introduced into medical curricula, ethical considerations often remain peripheral, with most frameworks emphasising technical skills over moral reasoning. As future clinicians will face complex ethical challenges related to autonomy, safety, bias, transparency and accountability in AI-integrated clinical settings, there is an urgent need to evaluate how ethics is incorporated into AI education. With AI curricula still in their formative stages, this moment presents a critical opportunity to proactively design ethical components, rather than introducing them after harms have emerged. This scoping review aims to systematically map the ethical–technical balance in AI-related medical education curricula, identifying current practices, gaps and opportunities for curriculum development.

Methods and analysis This scoping review will follow the Joanna Briggs Institute methodology and be reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews guidelines. The review will address how ethical considerations are integrated into AI-related curricula in medical education and examine the balance between ethical and technical content. A comprehensive search strategy will be employed across multiple databases, including MEDLINE, Web of Science, Google Scholar, EBSCO, the Virtual Health Library, the Bioethics Literature Database and PhilPapers, as well as grey literature sources such as institutional reports, curricula and policy documents. Publications from January 2020 to December 2025 will be included. Data will be charted and analysed using descriptive qualitative content analysis, followed by a theory-informed interpretive analysis drawing on the hidden curriculum theory of medical education.

Ethics and dissemination This review does not require ethics approval, as it involves analysis of publicly available data. Findings will be disseminated through a peer-reviewed publication and presented at relevant conferences and workshops focused on medical education or bioethics.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Systematically maps the integration of ethical considerations into artificial intelligence-related curricula for medical education.
⇒ Uses the Joanna Briggs Institute methodology and follows Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews guidelines to ensure methodological rigour and transparency.
⇒ Focus on the balance between technical and ethical content offers actionable insights for curriculum developers and educators.
⇒ Comprehensive search across multiple databases and grey literature sources to maximise coverage of relevant evidence.
⇒ Restricting the review to English-language publications may introduce language bias and exclude relevant studies in other languages.

INTRODUCTION

Background

Artificial intelligence (AI) is increasingly transforming healthcare, particularly with recent advances in generative AI and large language models (LLMs). These developments are not only expanding applications in clinical domains such as medical imaging, predictive analytics, decision-making, diagnostics and treatments[1–6] but also changing medical education, where AI-driven tools are being used to support learning, simulation of clinical scenarios and clinical training.[7] Emerging research suggests that incorporating AI into educational settings could improve diagnostic accuracy, clinical decision-making and procedural skill acquisition.[7–9]

The wider integration of AI into clinical practice and medical education raises

complex ethical and professional questions about how clinicians should interpret, challenge and responsibly deploy these systems. These concerns highlight the need for future physicians to develop technical competence alongside ethical and critical reasoning skills.[10–12] However, the competencies required for the ethical and responsible use of AI remain insufficiently defined and inconsistently addressed in medical education. While AI-related content is increasingly being incorporated into curricula, existing approaches tend to prioritise technical competencies, such as data literacy and machine learning model interpretation, with comparatively less attention to ethical, legal and sociocultural dimensions.[9]

This imbalance is particularly concerning given the ethical challenges associated with AI, often framed within core bioethical principles, including justice (bias, inequities), autonomy (machine paternalism, informed consent), beneficence and non-maleficence (safety, over-reliance, dehumanisation) and professional integrity (accountability, deskilling, transparency).[10 13–16] These challenges have direct implications for clinical decision-making, patient interactions and the formation of professional identity. In practice, without adequate preparation, students may develop unwarranted trust in rapidly evolving AI systems, make flawed clinical decisions or inadvertently reproduce existing societal inequities. Over-reliance on AI also risks diminishing the humanistic dimension of medical practice, potentially reinforcing perceptions of medicine as 'dehumanised'.[11 17] This, in turn, could undermine the social prestige and trust on which the medical profession depends.

To use AI safely and effectively, medical students must develop both the technical proficiencies required to operate these systems and the ethical and critical reasoning skills needed to interpret outputs, recognise limitations and safeguard patient autonomy and beneficence. Moreover, these principles do not operate in isolation but often in tension; for example, maximising efficiency and beneficence may compromise transparency and autonomy, while improving predictive accuracy may exacerbate inequities and undermine justice. Curricula must therefore prepare medical students to navigate such tensions rather than simply reciting principles.

Despite growing recognition of these concerns, existing reviews indicate that ethical considerations in AI-related medical education are introduced sporadically, often treated as peripheral to technical content, and that there is limited consensus on pedagogy, timing or assessment.[13 18 19] For instance, Weidener and Fischer[19] identified a limited number of studies on AI ethics education, most of which focused on theoretical discussions without concrete curricular models or evaluated frameworks, while Gordon *et al*[9] highlighted ethics as a key need but did not examine its integration into curricula. More recent reviews have expanded this discussion by identifying a broader range of ethical challenges, including privacy, bias, transparency and accountability; however, they similarly focus on conceptual analyses and provide limited insight into how these issues are operationalised within curricula or integrated alongside technical training.[20 21] Proposed strategies remain general, vary in their placement across training stages and rarely link to measurable outcomes.[10 22] These gaps risk perpetuating a technosolutionist curriculum that privileges technical capability over moral reasoning and critical reflection.

Rationale

Historically, ethics in medicine has often evolved reactively, with ethical frameworks emerging in response to troubling events, such as the Tuskegee syphilis study and the subsequent development of the Belmont Report.[23] In the case of AI, however, this reactive cycle need not be repeated. As AI curricula are only beginning to take shape, there is a unique opportunity to integrate ethical considerations proactively into medical education. Unlike past medical ethics crises, AI offers the chance to embed ethical literacy *before* harms become entrenched.

A growing number of medical schools have begun integrating AI-related content into their curricula.[9 24] However, recent reviews indicate that a standardised AI curriculum within medical education is still lacking.[13 18 25] Medical schools also vary widely in how they approach the ethical–technical balance in their efforts to integrate AI into curricula. Some introduce AI ethics in optional seminars or late in training, while others embed it superficially within technical modules. Few explicitly articulate learning objectives that integrate technical competence with ethical reflection, and even fewer assess whether students can critically evaluate AI systems in practice.[10 19]

In this context, a well-rounded curriculum for medical education must strike a meaningful balance between technological proficiency and ethical literacy. In this review, 'balance' refers not simply to proportional time allocation but also to the integration of ethical reasoning into technical modules, so that students learn to interrogate both what AI systems do and what they ought to do. However, to date, no scoping review has systematically examined how this balance is conceptualised and operationalised within medical education frameworks. Following the emergence of generative AI, the literature in this area has expanded rapidly,[20 26 27] further underscoring the need for an updated synthesis. Existing reviews largely focus on cataloguing AI topics, assessing student readiness or outlining general competencies. Less is known about the normative foundations of curricula and the relative weight given to ethical considerations.

This scoping review addresses this gap by mapping existing curricular frameworks through a dual lens of technical competence and ethical formation and examines how ethical components are positioned within AI-related medical education, recognising that their formal inclusion does not necessarily reflect their practical emphasis. This perspective is informed by insights from hidden curriculum theory, which highlights how implicit lessons are conveyed through the culture, structure, and everyday

practices of medical training, rather than through formal teaching.[28 29]

This evidence is needed to guide curriculum reform that prepares medical students to work alongside AI while ensuring that professional values, clinical reasoning, and commitment to patient welfare remain central in an AI-enabled future of clinical practice.

METHODOLOGY

This scoping review will follow the *Joanna Briggs Institute (JBI) Manual for Evidence Synthesis*, which provides structured guidance for mapping conceptually complex and heterogeneous evidence.[30] The process will include five main stages: (1) search strategy, (2) source of evidence selection, (3) data extraction, (4) analysis of the evidence and (5) presentation of the results.[31] The results will be reported in accordance with the Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines (online supplemental file 1).[32] All study activities, including the writing of this protocol, will take place between July 2025 and December 2026 or until completion.

This review will be guided by the Population, Concept, Context (PCC) framework as detailed by the *JBI Manual for Evidence Synthesis*.[30 31] The Population will include undergraduate medical students, interns, residents and medical educators involved in AI-related teaching. The Concept will focus on integrating ethical considerations into AI-related education and on the balance between ethical and technical content in existing educational frameworks. In particular, the Concept centres on how curricula balance the 'how' of AI (technical operation) with the 'should' of AI (ethical and professional implications). The Context will encompass formal medical education globally, including preclinical, clinical and medical residency curricula and competency frameworks.

Primary research question

An iterative process was used to develop the primary research question of this scoping review, and guided by the PCC framework, namely: *How are ethical considerations integrated into AI-related curricula in medical education, and what is the balance between ethical and technical content in these frameworks?*

Furthermore, several subquestions will help guide this review, including but not limited to:

- At what stage(s) of training are ethical aspects of AI introduced relative to technical ones?
- Are AI ethics and technology taught in integrated modules or as distinct units?
- What particular pedagogical methods (eg, case-based learning, reflection) are used for ethical content in developing AI-related curricula in medical education?
- How is the importance of ethics versus technical knowledge emphasised in learning outcomes or assessment criteria?
- Do curricular frameworks reinforce or resist a techno-solutionist orientation?
- What ethical domains are included (eg, bias, privacy, patient autonomy) in AI-related curricula?

Stage 1: search strategy

The search strategy will identify both published and unpublished studies and follow a three-step approach. First, an initial search will be conducted in two electronic databases—the National Library of Medicine (PubMed/MEDLINE) and the Virtual Health Library—to identify relevant articles and refine the search terms. Second, a comprehensive search strategy incorporating all identified keywords and index terms will be developed using the PCC framework and adapted to each database's syntax and indexing systems. Searches will be conducted in PubMed/MEDLINE, Web of Science, Google Scholar, EBSCO, the Virtual Health Library, the Bioethics Literature Database and PhilPapers. Moreover, reference lists of included studies will be hand-searched to identify additional relevant sources. Third, grey literature searches will include unpublished studies, evaluation reports, guidelines, committee reports, theses, organisational reports, institutional curricula and conference proceedings. These searches will be conducted using Google, BASE, and WorldCat, as well as the databases listed above, to identify relevant non-indexed material.

All retrieved records will be exported to EndNote for deduplication, then uploaded to Covidence in eXtensible Markup Language (XML) format for screening. Two reviewers (TB and MB) will independently screen titles and abstracts against the eligibility criteria. Before formal screening, the reviewers will pilot the eligibility criteria on a random sample (approximately 10%) of records to assess consistency. Inter-rater agreement will be assessed using Cohen's kappa, with a target of at least 0.85.[33] Discrepancies will be discussed and criteria clarified where needed before full screening proceeds. Records will be classified as 'yes', 'no' or 'maybe', with those marked 'yes' or 'maybe' taken forward to full-text review.

Full texts of potentially relevant studies will be retrieved and independently assessed by the same reviewers to confirm eligibility. Reasons for exclusion at the full-text stage will be documented to ensure transparency and reproducibility. Disagreements at any stage will be resolved through discussion or, if necessary, by consultation with a third reviewer (HD).

The search terms will be developed as follows:

- Population: medical students and medical educators
  - ("medical students" OR "undergraduate medical education" OR "graduate medical education" OR "medical trainees" OR intern* OR residency OR resident* OR "medical educators" OR "medical faculty" OR "medical training" OR "clinical education").

- Concept: AI and ethics
  - (("artificial intelligence" OR AI OR "machine learning" OR "deep learning" OR "large language model*" OR LLM OR "generative AI" OR ChatGPT OR Claude OR Gemini OR "clinical decision support systems") AND (ethic* OR bioethic* OR "ethical considerations" OR professionalism OR responsibility OR autonomy OR transparency OR accountability OR bias)).
- Context: Curriculum frameworks and educational content
  - (curricul* OR syllab* OR framework* OR "teaching methods" OR "instructional design" OR "learning outcome*" OR pedagogy OR "course content" OR "competency-based education" OR assessment OR integration).

These terms will be combined using Boolean operators (AND/OR) and adapted for each database, including the use of controlled vocabulary where available, such as Medical Subject Headings (MeSH).

Stage 2: source of evidence selection

This review will include studies published between January 2020 and December 2025 to ensure coverage of the most recent developments in integrating AI into medical education. This time frame reflects rapid advances in AI technologies, the acceleration of digital learning following the COVID-19 pandemic[34] and the increasing use of generative AI tools in recent years,[26 27] alongside the growing prominence of ethical concerns such as algorithmic bias, data privacy and accountability.[35] Restricting the search to this period captures current educational practice, regulatory standards and technological capabilities, making the findings more relevant to curriculum developers and educators.

Eligible sources will include peer-reviewed articles, original research, conceptual or theoretical analyses, curriculum descriptions, opinion pieces, editorials, book chapters, thesis chapters and institutional or organisational reports. Grey literature, including institutional reports, curricula and policy documents, will also be included. Only sources published in English will be considered, as this is the shared working language of the research team.

Systematic reviews, meta-analyses and scoping reviews will be excluded because the aim is to identify original contributions and curricular innovations, rather than summarise aggregated evidence. This will allow a more detailed mapping of how AI is being introduced across preclinical, clinical, and residency education, and where ethical content is absent or underdeveloped.

The PCC framework will guide the evidence selection as outlined below:

- Population: sources must focus on medical students in preclinical or clinical settings, interns, residents or medical educators involved in formal educational programmes.
- Concept: sources must examine frameworks, curricula, models, tools or pedagogical methods for integrating AI into medical education.
- Context: studies must pertain to medical education within preclinical or clinical settings. Sources focusing exclusively on AI education in other health professions (eg, nursing, public health) or outside formal medical education contexts (eg, massive open online courses for the general public) will be excluded.

A PRISMA-ScR flow diagram[32 36] will be used to systematically document the study selection process, including the number of records identified, screened, excluded (with reasons) and ultimately included in the review.

Stage 3: data extraction

Two reviewers (TB and MB) will extract data from the included sources using the Covidence online software. To address the objective of this scoping review, a draft data extraction form as shown in table 1 below will be used.

As data are extracted, additional unanticipated information that is relevant to answering the review question may be incorporated. In such cases, the research team will update the data table continuously. Extracted data will be reviewed by one or two team members to ensure completeness and accuracy. Any disagreements between the reviewers (TB and MB) will be resolved through discussion or, if necessary, with the involvement of a third reviewer (HD). Where required and feasible, authors of included sources will be contacted to obtain missing or supplementary data. Records identifying each included source will be retained for potential further review.

Findings from the included sources will be summarised using graphs, charts or tables to illustrate the distribution of studies by year or publication period, country of origin, proposed frameworks or curricula and the consideration of AI ethics in medical education. These visual summaries will be accompanied by a narrative synthesis that describes how each source's findings relate to the review's objectives and research questions.

Stage 4: analysis of the evidence

The results of the review will be reported in accordance with the PRISMA-ScR guidelines.[32] The extracted data will be analysed using basic descriptive content analysis, as outlined by Elo and Kyngäs,[37] consistent with guidance from the JBI.[38] This descriptive analytical approach will follow three phases—preparation, organising and reporting—to structure the analysis within this scoping review.[37]

A combined deductive and inductive approach to qualitative content analysis will be employed. An initial coding framework will be developed based on the review objectives and existing literature, with preliminary categories including the type, depth and mode of integration of ethical content within AI curricula. During data extraction, this framework will be applied to the included studies (deductive phase),

Table 1 Data charting table

Category	Data to be extracted
Article information	Author(s), year of publication and country of origin
Characteristics of the learner population	Whether learners are undergraduate, graduate, residents or educators
Framework or curricular model used for AI integration	Suggested curricular model(s) for AI integration
AI topics covered	Main AI topics included in the suggested curricula
Ethical content included and its thematic focus	Main ethical topics/content covered and their thematic focus (eg, bias, accountability, transparency, data privacy)
Ethical framework	Ethical theories or bioethical principles guiding instruction (*if any*)
Structure and integration of ethical and technical content	How ethical content is integrated with technical training (eg, standalone modules, integrated sessions)
Pedagogical approaches used for AI ethics instruction	Instructional strategies used (eg, case-based learning, small group discussion, experiential learning) and whether ethics is taught as abstract theory or as professional practice, and how this shapes curricular integration.
Delivery method	Delivery methods and/or tools mentioned or suggested (eg, lectures, workshops, online modules, simulations)
Timing	Suggested grade/year or phase (preclinical/clinical) for integration
Learning outcomes	Explicitly stated goals or competencies for ethical and/or technical components
Evaluation methods for AI-related competencies	Methods used to assess technical and/or ethical competencies (eg, examinations, OSCEs, reflective assignments)
Challenges	Reported challenges in implementing ethical AI education (eg, lack of sufficient teaching staff, lack of AI expertise, overloaded medical curricula)
Other	The 'other' option indicates the potential to create new categories during the data charting process, if necessary.

AI, artificial intelligence; OSCEs, Objective Structured Clinical Examinations.

while remaining open to the emergence of new codes and themes not captured by the initial structure (inductive phase). The coding framework will be iteratively refined throughout the analysis, allowing both concept-driven and data-driven insights to inform the process. This approach enables a structured yet flexible analysis, supporting the identification of recurring patterns as well as gaps in how ethical considerations are incorporated into AI-related medical education. Such flexibility is widely recognised in qualitative health professions education research, where analytic frameworks are expected to remain responsive to the data while being informed by prior theoretical orientations.[39]

In addition to descriptive analysis, an interpretive analysis will be conducted using the theory of the hidden curriculum in medical education. This framework highlights how educational environments convey implicit values and priorities beyond formal curricular content. Accordingly, while AI-related curricula may explicitly include ethical components, their relative emphasis may be shaped by what is assessed, prioritised and integrated into practice.[28 29]

Stage 5: presentation of the results

The findings will be presented through narrative summaries, charting tables, thematic maps, and other visual displays, as appropriate. Results will be organised according to the review objectives and research questions, highlighting patterns, gaps, and variations in the integration of ethical and technical content across AI-related medical education curricula.

Patient and public involvement

Patients or the public were not involved in the design, conduct, reporting or dissemination of our research.

Ethics and dissemination

Ethical approval is not required, as this review is retrospective and based on publicly available data. A manuscript summarising the results of this scoping review will be submitted to a peer-reviewed journal in medical education or bioethics. Key findings will also be disseminated through academic conferences and/or workshops focused on medical education and bioethics.

DISCUSSION

This scoping review has several strengths. By considering both technical and ethical dimensions of AI-related medical curricula, this review moves beyond descriptive mapping to explore how these domains are prioritised and integrated. The use of a theoretically informed perspective, including insights from

hidden curriculum theory, enables a more nuanced understanding of how ethical content may be conveyed alongside formal teaching.

Several limitations should be acknowledged. As a scoping review, this study aims to map the breadth of existing literature rather than assess the quality of individual studies. The included literature is likely to be heterogeneous and ethical content may not be consistently reported or fully reflect implementation in practice. Language restrictions and the scope of accessible literature may also limit the interpretation of the findings.

In terms of practical implications for medical education and clinical practice, this review may highlight underexplored areas in AI education and inform the development of more integrated curricular approaches. These insights may support curriculum design and contribute to preparing clinicians who are better equipped to critically evaluate and responsibly use AI in clinical practice, with potential benefits for patient care.

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