IJMS INTERNATIONAL JOURNAL of MEDICAL STUDENTS

Editorial

Artificial Intelligence in Healthcare: Medical Students' Perspectives on Balancing Innovation, Ethics, and Patient-Centered Care

Eleanor Roy,[1] Sara Malafa,[2] Lina M. Adwer,[3] Houda Tabache,[4] Tanishqa Sheth,[5] Vasudha Mishra,[6] Moaz Elsayed Abouelmagd.[7] Andrea Cuscheri,[8] Sajjad Ahmed Khan,[9] Mihnea-Alexandru Găman,[10] Juan C. Puyana,[11] Francisco Javier Bonilla-Escobar.[12]

Introduction

Artificial intelligence (AI) is no longer a futuristic concept in medicine - it is increasingly shaping clinical practice, decision-making, and healthcare administration.[1] From AI-powered diagnostic tools to chatbots assisting medical students in their studies, these technologies offer enhanced efficiency in patient care, greater precision in diagnostics, and reduced workload for healthcare professionals. However, their rapid integration also introduces complex ethical dilemmas that challenge fundamental principles of medical ethics, including autonomy, justice, beneficence, and non-maleficence.[2]

A central issue in this debate is how to ensure that AI enhances rather than undermines ethical medical practice. Issues of ethical concern, such as preserving patient autonomy, balancing AI and human judgment in decision-making, ensuring transparency, addressing algorithmic bias and fairness, and safeguarding data privacy and ownership, form a large part of modern ethical discourse.[3] Recognizing the significance of these issues, various organizations, including the World Health Organization (WHO), are actively developing guidelines for best practices in AI-driven clinical applications. In particular, the WHO has identified six core principles for AI in healthcare: (1) Protect autonomy; (2) Promote human well-being, safety, and the public interest; (3) Ensure transparency, explainability, and intelligibility; (4) Promote responsibility and accountability; (5) Ensure inclusiveness and equity; and (6) Ensure AI remains adaptable and sustainable.[4]

As AI becomes deeply ingrained in healthcare, medical students, educators, and regulators must proactively address its ethical challenges. Future physicians require structured AI ethics education, institutions must establish governance frameworks and ethics committees for responsible AI deployment and regulatory bodies must implement policies that protect patient rights, ensure transparency, and uphold ethical standards in medical practice.[5] Given AI's transformative potential, it is essential to address its rapid evolution with a structured and forward-thinking approach rather than relying on reactive regulatory measures that struggle to keep pace with AI advancements or allowing AI models to self-regulate.

This editorial examines the ethical dilemmas surrounding AI in healthcare, emphasizing the importance of AI literacy in medical education, regulatory oversight, and ethical governance. As AI continues to shape medical practice, it is crucial for healthcare professionals, educators, and policymakers to implement safeguards that ensure fairness, transparency, and accountability. AI must remain a tool that supports, rather than dictates, clinical decision-making. Its integration into healthcare should be guided by rigorous oversight, continuous ethical evaluation, and a commitment to patient-centered care.

Patient Autonomy and AI Decision-Making

The increasing use of artificial intelligence in clinical settings is reshaping longstanding understandings of patient autonomy. At the heart of ethical medical practice lies the patient's right to make informed decisions about their care. While AI systems have introduced new opportunities for personalizing medicine, they also raise difficult questions about transparency, consent, and the patient's role in decision-making.

AI tools are now capable of analyzing complex clinical datasets, including electronic health records, laboratory results, and

1 MD Student, The University of Nicosia, Cyprus.
2 MD Student, Sant'Anna School of Advanced Studies, Italy.
3 MD Student, University of Nebraska Medical Center College of Medicine, USA.
4 MD Student, University Mohammed VI Polytechnic, Morocco.
5 MD Student, KJ Somaiya Medical College and Research Centre, India.
6 MBBS, MD Resident, All India Institute of Medical Sciences, Bhubaneswar, India.
7 MD Student, Kasr-Alainy Faculty of Medicine, Cairo University, Egypt
8 MD Student, Humanitas University, Italy.
9 MBBS, Birat Medical College Teaching Hospital, Morang, Nepal. Deputy Editor, IJMS.
10 MD, PhD(c) Faculty of Medicine, "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania & Department of Hematology, Centre of Hematology and Bone Marrow Transplantation, Bucharest, Romania. Scientific Editor, IJMS.
11 MD, FACS, School of Medicine, Department of Surgery, Professor of Surgery, Critical Care Medicine, and Clinical Translational Science, Director for Global Health-Surgery, University of Pittsburgh, PA, USA. O'Brien Professor of Global Surgery for Royal College of Surgeons in Ireland (RCSI). Editorial Board Member, IJMS
12 MD, MSc, PhD, Department of Ophtalmology; University of Washington, Seattle, WA, USA. Fundación Somos Ciencia al Servicio de la Comunidad, Fundación SCISCO/Science to Serve the Community Foundation, SCISCO Foundation, Cali Colombia. Grupo de investigación en Visión y Salud Ocular, VISOC, Universidad del Valle, Cali, Colombia. Editor in Chief, IJMS.

Correspondence:
Francisco J. Bonilla-Escobar, editor.in.chief@ijms.info

imaging, to provide tailored recommendations that might otherwise take hours for clinicians to compile. In theory, this enhances autonomy by equipping patients with more information about their condition and options. Evidence suggests that when patients are presented with AI-supported information, they are more likely to participate actively in care planning, which can lead to improved clinical outcomes.[6]

Yet the reality is more nuanced. Many AI systems, particularly those using deep learning techniques, are poorly understood by clinicians themselves, let alone patients. These so-called "black box" models generate outputs through processes that are not easily interpretable, which means that even when a recommendation is accurate, the reasoning behind it may be unclear. This lack of transparency undermines the shared understanding that is essential to informed decision-making.[6] In one study, patients described feeling excluded when clinicians could not explain how AI-derived conclusions were reached, weakening trust in both the care and the clinicians providing it.[6]

This challenge is compounded by a lack of clear standards around disclosure. Patients are not routinely informed when AI tools are used to support decisions about their diagnosis or treatment. Although ethical and legal frameworks emphasize the importance of informed consent, few address the role AI plays in shaping clinical judgments.[6] Without explicit acknowledgment of AI's involvement, patients may remain unaware of its influence on their care.

From the clinician's perspective, AI is often seen as a valuable support system helping prioritize cases, reduce cognitive load, and improve diagnostic precision. For example, Clare, an AI triage tool implemented at OSF Healthcare, was shown to enhance the efficiency of patient prioritization.[7] However, its effectiveness depended on the critical engagement of physicians who interpreted its outputs within the clinical context. Where AI is followed unquestioningly, it risks supplanting rather than supporting medical expertise.

There is also growing evidence that patients are not always aware when AI systems are involved. A case study found that many patients were unaware that their diagnostic journey had been shaped in part by algorithmic input, raising concerns about transparency and patient satisfaction.[8]

Meeting these challenges requires changes in how physicians are trained. Beyond understanding how AI tools work, clinicians must be able to communicate their use to patients in language that is both clear and respectful. Medical education must incorporate not only technical instruction but also ethical training, particularly around consent and patient-centered communication.[9]

While AI has the potential to support autonomy by delivering more personalized care, its success depends on ensuring that patients are fully informed, and clinicians remain actively engaged. Upholding autonomy in the AI era requires more than access to technology - it demands clarity, communication, and a commitment to preserving the patient's voice at the center of clinical care.

Algorithmic Bias and Fairness in AI

The promise of artificial intelligence in healthcare is often framed around its ability to enhance efficiency, accuracy, and consistency. However, these benefits are not universally distributed. AI systems, like any tool shaped by human input, are vulnerable to bias - particularly when the data used to train them fails to reflect the diversity of the populations they are intended to serve.

Algorithmic bias in healthcare can lead to significant disparities in diagnosis, treatment, and outcomes. This often stems from unrepresentative or incomplete datasets. For example, AI models used in dermatology have been shown to perform poorly when assessing images of darker skin tones, a consequence of training datasets dominated by light-skinned individuals.[10]

One of the most cited examples of algorithmic bias comes from a study by Obermeyer et al., which revealed that a widely used risk prediction tool consistently underestimated the healthcare needs of Black patients. The algorithm used past healthcare costs as a proxy for health status, inadvertently reinforcing structural inequities that result in lower spending on Black patients. As a result, individuals with significant medical needs were systematically deprioritized.[3]

Bias can be introduced at any stage of AI development - during data collection, algorithm design, or deployment. Its effects are often difficult to detect without proactive auditing. Nonetheless, unchecked bias can entrench existing disparities and violate fundamental ethical principles of justice and equity. Public health experts have warned that without targeted interventions, AI may exacerbate the very inequities it is often touted to reduce.[11]

Addressing algorithmic bias requires a deliberate, system-wide approach. First, training datasets must be diversified to accurately reflect variations in ethnicity, gender, socioeconomic status, and geography. Second, algorithms must be designed with fairness metrics in mind, incorporating checks at every phase of development. Regular audits and impact assessments are essential to monitor performance across different demographic groups.[12]

Transparency is also crucial. Encouraging open science practices - such as the publication of model architecture, training data sources, and validation strategies - allows independent reviewers to evaluate the fairness and reliability of AI tools.[13,14] This openness fosters accountability and helps restore public trust in healthcare systems increasingly reliant on algorithmic decision-making.

Medical professionals have a key role to play. Physicians must be

trained to recognize the potential for bias in AI outputs and understand how these tools may perform differently across patient populations. Cultural competence, critical appraisal skills, and an awareness of social determinants of health should be embedded within medical education to ensure equitable use of AI in clinical practice.[15]

Ultimately, the ethical integration of AI depends not only on its technical performance but also on its alignment with the principles of fairness and justice. To serve all patients equitably, AI systems must be designed and deployed with an awareness of the systemic inequities they risk perpetuating. Ensuring that these technologies work for everyone - not just those best represented in the data - must remain a central concern in their development and use.

Table 1 presents key examples of how algorithmic bias has impacted clinical care, highlighting the real-world consequences of deploying AI systems without adequate safeguards. These cases reflect the urgent need for deliberate, equity-focused design and oversight in healthcare AI.

Data Privacy and Ownership

The rise of artificial intelligence in healthcare has brought longstanding questions of data privacy and ownership into sharper focus. As AI models depend heavily on vast quantities of patient data to function effectively, concerns have emerged over how this data is sourced, who controls it, and whether patients retain any meaningful agency over its use.

Historically, debates over data ownership in medicine have been limited to academic and legal circles. However, the involvement of non-medical entities, particularly private technology companies, have complicated this landscape. In an increasingly competitive market, the pressure to develop more advanced and cost-effective AI tools often comes at the expense of ethical considerations around consent, privacy, and transparency.[16,17]

A widely discussed example is the use of online medical images, such as mammograms, for training AI models. While this may seem efficient, questions quickly arise: Were these images obtained with patient consent? Did the institutions that uploaded them have the right to do so? Should hospitals or companies be considered the owners of clinical data, or do those rights ultimately belong to the patients themselves?

These questions echo historical injustices, most notably the case of Henrietta Lacks. In 1951, cancerous cells were taken from her without her knowledge or consent and later became the basis of the *HeLa* cell line - one of the most important tools in biomedical research. It took decades for her family to even learn of the cells' existence, let alone be included in decisions about their use or benefit from their commercial applications.[18-23] The legacy of her case serves as a powerful reminder that scientific progress must never come at the expense of individual rights.

As medicine becomes increasingly entangled with non-medical entities, traditional ideas of consent must evolve, or risk becoming outdated. If accepted standards are applied uncritically, ethical breaches may occur. ***Table 2*** highlights how these risks may unfold in practice.

The use of patient data to train AI models today carries similar ethical risks. For instance, if publicly available scans are used without clear consent or de-identification, there may be breaches of both privacy and trust. Additionally, when such data is collected across jurisdictions, the question of which privacy laws apply becomes increasingly complex. The 2016 collaboration between DeepMind and the Royal Free NHS Foundation Trust exemplifies these concerns, as it was criticized for transferring patient data without adequate transparency or safeguards.[25]

Table 1. Illustrative Cases of Algorithmic Bias and Their Consequences in Healthcare AI.

Example	Description	Impact
Obermeyer et al. (2019) Study	AI underestimated Black patients' health needs based on cost predictions.	Potential denial of care, widening disparities.
Skin Cancer Detection	Less accurate for darker-skinned patients due to light-skinned training data.	Missed diagnoses, harming minority health.
VBAC Algorithm (2007)	Biased against non-White women by assuming White symptom patterns.	Unequal risk assessments, limiting care access.

Table 2. Scenario and Impact Analysis of Lack of Patient Autonomy in the Development of AI Systems.

Scenario	Impact
Use of scans without prior authorization from academic sources	Potential violation of intellectual property rights
Lack of patient consent for data use	Erosion of patient agency and informed choice
Use of publicly available scans without context (e.g. nationality, case history)	1. Risk of misdiagnosis or bias due to missing clinical context 2. Unregulated cross-border data transfers, including to politically sensitive jurisdictions[24]
Diagnostic outputs generated by non-medical entities (e.g. tech companies)	Circumvention of data privacy laws that apply to regulated healthcare providers

Compounding the issue is the regulatory gap between medical and non-medical actors. While frameworks like the Health Insurance Portability and Accountability Act (HIPAA) and the General Data Protection Regulation (GDPR) govern health data within clinical settings, tech companies developing AI tools often operate outside these constraints.[26-29] To address these gaps, some have proposed rethinking data ownership models. Rather than viewing data as the property of institutions, dynamic consent frameworks could position patients as active stakeholders, with rights to grant or withhold permission, define terms of use, and even share in downstream benefits.[30-32] Hospitals, as data custodians, may serve as intermediaries in this model, facilitating transparent agreements between patients and data users.

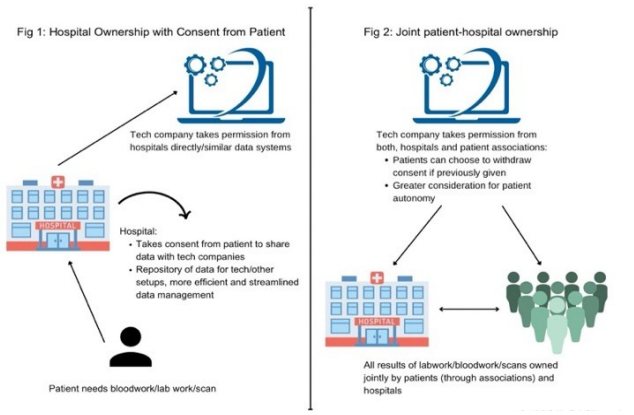
Figure 1 illustrates how responsibilities for data ownership may shift between patients, healthcare providers, institutions, and commercial developers, depending on the regulatory environment and consent model in place. This visual offers a framework for understanding the complexity of stakeholder roles in data governance and the necessity of rethinking ownership in an AI-driven healthcare system. There remains scope for improvement, as is the case with any evolving concept, but recognizing ownership and consent as dynamic is a critical first step. These principles must be actively re-evaluated and embedded in the rapidly transforming landscape of digital medicine.[33-35]

The ethical foundations of autonomy, fairness, and privacy are tightly interconnected. A lack of transparency in AI systems undermines patient autonomy and obscures bias, as opaque algorithms hinder interpretability and trust. Strong data privacy protections are essential to maintaining public confidence. Without them, patients may be less willing to share information, thereby limiting the effectiveness of AI and reinforcing health disparities.

Meeting these challenges requires collaboration among stakeholders. Medical education should incorporate AI ethics, explainability, and patient-centered communication to prepare clinicians for technology-driven healthcare environments.[9] Recent developments, such as the World Health Organization's designation of the Digital Ethics Centre at Delft University of Technology as a Collaborating Centre on AI for Health Governance in 2025, highlight growing global momentum. The WHO's six core principles - protecting autonomy, promoting safety and well-being, ensuring transparency, fostering accountability, supporting equity, and enabling sustainability - offer a robust foundation for ethical oversight.[4]

AI offers tremendous potential to transform healthcare by reducing inefficiencies, enhancing research, and improving access to specialized care, particularly in underserved regions. However, this progress must be aligned with ethical safeguards that preserve the integrity of clinical practice and uphold patient dignity. Redefining data ownership and reinforcing patient autonomy can support a shift from passive data extraction to participatory governance, positioning patients as collaborators in their care, not mere data points.

Figure 1. Conceptual Models of Data Ownership Distribution Among Healthcare Stakeholders.



Legend: Infographic created using Canva (*free version*). Author's own creation.

As legal systems work to catch up with technological change, patient awareness will remain a cornerstone of ethical implementation.[36] Grassroots advocacy can help increase understanding of data rights, identify and address bias, and push for stronger regulatory protections. Empowering patients with the technical literacy needed to understand and assert their rights will foster greater confidence and control over how their data is used.[37,38]

As AI reshapes healthcare, ethical integration is essential to ensuring that innovation serves patients rather than displacing them. By promoting transparency, securing consent, addressing bias, and safeguarding privacy, stakeholders can build a healthcare system grounded in equity, accountability, and trust.

AI Ethics in Medical Education: Preparing Future Physicians

As artificial intelligence becomes more integrated into clinical practice, its presence in medical education has become unavoidable. AI tools, including chatbots and large language models, are now widely used by students for study assistance, summarizing content, and engaging in interactive learning environments. Many report these tools as helpful for saving time and reducing anxiety during learning, particularly when managing routine tasks.[39, 40]

The use of ChatGPT among medical students has expanded significantly. By 2023, studies showed usage rates between 30–50% in high-income and international institutions, and over 75% in low- and middle-income countries.[41,42] These trends reflect growing accessibility and reliance on AI platforms in academic settings. While earlier versions of ChatGPT achieved modest accuracy on licensing exams (58% with GPT-3.5), more recent iterations, such as GPT-4, have demonstrated notable improvements, reaching 81% accuracy and passing most assessments.[43,44]

Despite these gains, ethical and academic concerns persist. A 2024 cross-sectional study of 614 medical students in Egypt found that while 78.5% had used ChatGPT and 64% found it helpful, 71.3% expressed concern about its potential misuse,

particularly regarding academic integrity, privacy, and the risk of policy violations.[42]

Medical education has always been about more than memorization or exam performance. Its foundation lies in nurturing critical thinking, ethical reasoning, and compassionate care. As AI becomes more prevalent in clinical settings, medical training must evolve accordingly. Future physicians must not only understand how to use AI but also how to question it, interpret it responsibly, and recognize its limitations.

The urgency of this transformation is reflected in recent scholarship and practice. Research suggests that physicians who integrate AI tools effectively can improve clinical outcomes.[45,46] However, meaningful integration requires more than technical skills. It demands ethical judgment and contextual awareness - particularly in settings where resource limitations or population-specific factors may challenge AI applicability. Studies from sub-Saharan Africa and Southeast Asia have demonstrated that algorithms trained on data from high-income countries often perform poorly when deployed in different clinical environments.[47,48]

To prepare students for these realities, medical education must focus on critical competencies, including:

- **Evaluating AI critically**: Students should learn when AI enhances care and when it should be challenged.
- **Balancing human and algorithmic judgment**: Clinicians must know when statistical outputs fail to capture a patient's lived experience.
- **Addressing health disparities**: Curricula must emphasize how AI can unintentionally reinforce systemic inequities.
- **Communicating transparently with patients**: Future physicians need to explain the role of AI in patient care clearly and ethically.

Yet, formal training on these issues remains rare. Evidence shows that patients interpret algorithmic health recommendations differently than those provided by physicians, creating a new layer of complexity in patient communication.[49, 50] Bridging this gap will require structured curricular reforms.

Based on current literature and educational theory, five key reforms are recommended:

1. **Case-based learning using real-world AI examples**: Embedding cases that reveal algorithmic limitations, particularly in under-resourced settings, promotes contextualized learning.[51]
2. **Interdisciplinary collaboration**: Involving ethicists, data scientists, and clinicians fosters a more complete understanding of AI's impact. [52]
3. **Structured communication training**: Teaching students to discuss AI outputs with patients in clear, honest terms helps avoid overreliance or misplaced trust.
4. **Bias recognition and mitigation**: Training on how datasets reflect and reinforce social inequities is essential for ethical AI use. [11, 53]
5. **Simulation of clinical decision-making with AI support**: Encouraging students to weigh AI recommendations against clinical judgment reinforces the principle that AI should support, not replace, human decision-making.

Ultimately, the goal is not simply to teach AI proficiency but to cultivate what scholars have called "contextual wisdom" - the ability to adapt AI use to different patient needs, settings, and ethical considerations.[54] Medical schools that succeed in this will graduate physicians who can harness the benefits of AI while remaining grounded in the values that define responsible and humane medical practice: beneficence, non-maleficence, justice, and respect for patient autonomy.

Future Directions: AI Governance & Ethical Guidelines

As artificial intelligence continues to reshape healthcare, from diagnostics and triage to administrative operations, establishing robust ethical and regulatory frameworks has become essential. Without these safeguards, AI implementation risks perpetuating biased decision-making, compromising data security, and undermining trust in medical systems.[55,56]

Recent research has emphasized both the transformative potential of AI in improving clinical workflows and the ethical vulnerabilities that arise when regulation fails to keep pace with innovation. Key challenges include algorithmic bias, cybersecurity risks, and fragmented oversight, all of which threaten the safe, equitable, and responsible adoption of AI in healthcare settings.[57, 58, 59] Addressing these concerns is not just a compliance issue but an ethical imperative. AI must enhance, not replace, clinical judgment, and it must do so in ways that are transparent, accountable, and fair.[60,61]

A comprehensive governance strategy is necessary to guide the development and deployment of AI tools. Policymakers must enact clear and enforceable regulations that define liability, mandate transparency, and incorporate mechanisms for monitoring algorithmic fairness.[62] Beyond the legal realm, educational institutions and professional boards also have a role to play. By embedding AI ethics and digital literacy into medical training, future physicians can be equipped to assess algorithmic outputs critically and advocate for their patients in increasingly complex clinical environments.[63-65]

In addition to preventive regulation, real-time oversight mechanisms are needed. The establishment of independent auditing bodies focused specifically on AI in medicine would allow for continuous evaluation of safety, equity, and efficacy as technologies evolve.[66-68] These efforts must go beyond technical performance assessments to include social, cultural, and ethical

dimensions—recognizing that the consequences of AI in healthcare extend far beyond clinical outcomes alone.

While AI has immense potential to improve healthcare delivery and outcomes, its long-term success depends on embedding ethical considerations into every stage of its lifecycle. Developing trustworthy AI systems requires ongoing collaboration among technologists, clinicians, patients, ethicists, and regulators. By ensuring that these systems are transparent, equitable, and accountable, healthcare can benefit from innovation without compromising its fundamental ethical commitments.

Conclusion

Artificial intelligence is no longer a theoretical possibility in medicine- it is an active and expanding force within clinical care, research, and education. While its potential to enhance diagnostics, streamline processes, and extend access is well recognized, its integration raises equally significant ethical considerations that demand critical attention.

This editorial has examined how AI challenges established principles of autonomy, fairness, and privacy. From the risk of opaque decision-making and algorithmic bias to questions surrounding consent and data ownership, AI has exposed ethical blind spots across multiple domains of healthcare. These are not isolated concerns; they reflect deeper systemic gaps that require coordinated responses.

Preparing future clinicians to navigate these challenges will require more than technical fluency. Medical education must be restructured to equip students with the tools to interpret, question, and ethically apply AI within diverse clinical contexts. Ethical reasoning, communication skills, and an understanding of social determinants of health must be integrated alongside digital literacy.

At the same time, governance must evolve. Regulatory frameworks must be clear, enforceable, and responsive to the rapidly changing technological landscape. Policies should ensure accountability, uphold transparency, and protect patients from harm, regardless of the complexity of the tools in use.

Crucially, patients must remain at the center of this transformation. Empowering individuals with control over their data and ensuring meaningful participation in the development and implementation of AI tools are essential steps in maintaining trust and dignity in care.

The future of AI in healthcare will be defined not only by its capabilities, but by the ethical choices that shape its use. By embedding fairness, accountability, and respect for persons at every level, from policy to practice, we can ensure that AI strengthens, rather than compromises, the foundations of medical ethics.

In This Issue

This issue features a diverse collection of original research, reviews, and experience-based articles that reflect key challenges and innovations in global health and medical education. Original studies explore a range of topics, including medication adherence in patients with chronic diseases in India,[69] the impostor phenomenon among Sudanese medical students,[70] biases in interprofessional healthcare education,[71] and the under-recognition of sports and exercise medicine.[72] Clinical research includes a case series on pediatric hepatoblastoma[73] and a national database analysis of psychiatric outcomes in patients with trigeminal neuralgia.[74] Mental health and educational innovation are further highlighted through a pilot curriculum developed for minority youth.[75] A critical review addresses academic burnout among Mexican medical students,[76] while a case report illustrates the complex management of a hydatid cyst with biliary complications.[77] The experience articles provide powerful insights from frontline work, including public health training initiatives in the UK[78] and Pakistan,[79] reflections on surgical life,[80] and educational tools for geriatric care.[81] Together, these contributions shed light on the evolving landscape of medical practice and training across different regions and discipline

References

1. Polevikov S. Advancing AI in healthcare: a comprehensive review of best practices. Clin Chim Acta. 2023;548:117519.
2. Jahn WT. The 4 basic ethical principles that apply to forensic activities are respect for autonomy, beneficence, nonmaleficence, and justice. J Chiropr Med. 2011;10(3):225–6.
3. Obermeyer, Z., Powers, B., Vogeli, C. & Mullainathan, S. (2019). Dissecting racial bias in an algorithm used to manage the health of populations. Science, 366 (6464), 447-453.
4. World Health Organization. Ethics and governance of artificial intelligence for health: WHO guidance. Available at: https://www.who.int/publications/i/item/9789240029200. Accessed: 14 Jun 2023.
5. Blackman R. Why you need an AI ethics committee. Harv Bus Rev. 2022;100(7-8):118–25.
6. Gerke S, Minssen T, Cohen G. Informed consent and medical artificial intelligence: What to tell the patient? Georgetown Law J. 2020;108(6):1425-1456.
7. Gopalratnam K, Edwards R, Sundararajan V, et al. Clare: Improving triage efficiency through AI-powered clinical prioritization. Front Med (Lausanne). 2024;11:1324963.
8. Britt P. 5 AI case studies in health care. VKTR.com. Available from: https://www.vktr.com/ai-disruption/5-ai-case-studies-in-health-care/. Last updated October 31, 2024; cited March 21, 2025.
9. Maher NA, Senders JT, Hulsbergen AFC, et al. Integrating AI education into medical curricula: Addressing the gap. JMIR Med Educ. 2023;9:e11409288.
10. Lewis T. Health Care AI Systems Are Biased. Scientific American. 2020 Nov 17. Available from: https://www.scientificamerican.com/article/health-care-ai-systems-are-biased/. Cited March 21, 2025.

11. Harvard T.H. Chan School of Public Health. Algorithmic bias in health care exacerbates social inequities—how to prevent it. Available from: https://www.hsph.harvard.edu/news/algorithmic-bias-in-health-care/. Last updated March 12, 2021; cited March 21, 2025.
12. Gianfrancesco MA, Tamang S, Yazdany J, Schmajuk G. Potential biases in machine learning algorithms using electronic health record data. JAMA Intern Med. 2018;178(11):1544–7.
13. Accuray. Overcoming AI bias: Understanding, identifying, and mitigating algorithmic bias in healthcare. Available from: https://www.accuray.com/blog/overcoming-ai-bias. Last updated November 23, 2023; cited March 21, 2025.
14. Liu X, Cruz Rivera S, Moher D, Calvert MJ, Denniston AK. Reporting guidelines for clinical trial reports involving artificial intelligence: the CONSORT-AI extension. BMJ. 2020;370:m3164.
15. Stetler C. AI algorithms used in healthcare can perpetuate bias. Rutgers University–Newark News. Available from: https://www.newark.rutgers.edu/news/ai-algorithms-used-healthcare-can-perpetuate-bias. Last updated November 14, 2024; cited March 21, 2025
16. Norval C, Janssen H, Cobbe J, Singh J. Data protection and tech startups: The need for attention, support, and scrutiny. Policy&Internet. 2021 Jun;13(2):278-99.
17. Quach S, Thaichon P, Martin KD, Weaven S, Palmatier RW. Digital technologies: tensions in privacy and data. J of the Acad Mark Sci. 2022;50(6):1299-323.
18. Khan FA. The Immortal Life of Henrietta Lacks. J Islam Med Assoc. 2011 Aug 10;43(2):93-94.
19. Jordan B. The legacy of Henrietta Lacks. Med Sci. 2021;37(12):1189-93.
20. HeLa Cases Prompt More Thinking on Ethics. Cancer Discov. 2023; 13(10):2112-3.
21. National Institutes of Health. Significant Research Advances Enabled by HeLa Cells [Internet]. Office of Science Policy. National Institutes of Health; 2022.
22. Klitzman R. Henrietta Lacks' family's lawsuits: ethical questions and solutions. Trends Biotechnol. 2022;40(7):769-72.
23. Baptiste DL, Caviness-Ashe N, Josiah N, Commodore-Mensah Y, Arscott J, Wilson PR, et al. Henrietta Lacks and America's dark history of research involving African Americans. Nurs Open. 2022;9(5):2236-8.
24. Temsah A, Alhasan K, Altamimi I, Jamal A, Al-Eyadhy A, Malki KH, et al. DeepSeek in Healthcare: Revealing Opportunities and Steering Challenges of a New Open-Source Artificial Intelligence Frontier. Cureus. 2025;17(2):e79221.
25. Murdoch, B. Privacy and artificial intelligence: challenges for protecting health information in a new era. BMC Med Ethics 22. 2021; 122.
26. Li J. Security Implications of AI Chatbots in Health Care. J Med Internet Res. 2023;25:e47551.
27. Fatehi F, Hassandoust F, Ko RKL, Akhlaghpour S. General Data Protection Regulation (GDPR) in Healthcare: Hot Topics and Research Fronts. Stud Health Technol Inform. 2020;270:1118-22.
28. Mennella C, Maniscalco U, Pietro GD, Esposito M. Ethical and regulatory challenges of AI technologies in healthcare: A narrative review. Heliyon. 2024;10(4):e26297–7.
29. Heath S. Patient advocates explore a patient bill of rights for AI. Patient Engagement. TechTarget; 2024.
30. Bleiberg J, Niam Yaraghi. Your medical data: You don't own it, but you can have it. Brookings. 2015.
31. Kathleen Liddell, David A Simon, Anneke Lucassen, Patient data ownership: who owns your health?, J Law Biosci. 2021.
32. Chiruvella V, Guddati AK. Ethical Issues in Patient Data Ownership. Interact J Med Res. 2021;10(2):e22269.
33. Liu Z, Zhang L, Wu Z, Yu X, Cao C, Dai H, et al. Surviving ChatGPT in healthcare. Front Radiol. 2023;3:1224682.
34. 1.Kahn SD, Terry SF. Who owns (or controls) health data? Scientific Data [Internet]. 2024 Feb 1;11(1):156.
35. Price WN, Cohen IG. Privacy in the age of medical big data. Nat Med. 2019;25(1):37-43.
36. Hansen J, Carlin K, Hart A, Johnson J, Wells S, Kiel J. Updating HIPAA Security to Respond to Artificial Intelligence . J AHIMA. 2023.
37. Houser, Kimberly and Voss, W. Gregory, GDPR: The End of Google and Facebook or a New Paradigm in Data Privacy? (July 11, 2018). Working Paper, 25 Rich. J. L. & Tech. 1, 2018 Forthcoming,
38. The Light Collective. Patient AI Rights Initiative. Available from: https://lightcollective.org/patient-ai-rights/. Last updated 2024: cited Mar 10, 2025.
39. Hindelang M, Sitaru S, Zink A. Transforming Health Care Through Chatbots for Medical History-Taking and Future Directions: Comprehensive Systematic Review. JMIR Med Inform. 2024 ;12:e56628.
40. Okonkwo CW, Ade-Ibijola A. Chatbots applications in education: A systematic review. Comput Educ Artif Intell. 2021;2(2):100033.
41. Alkhaaldi SMI, Kassab CH, Dimassi Z, Alsoud LO, Fahim MA, Hageh CA, et al. Medical Student Experiences and Perceptions of ChatGPT and Artificial Intelligence: Cross-Sectional Study. JMIR Med Educ. 2023; 9(1):e51302.
42. Abdelhafiz AS, Farghly MI, Sultan EA, Moaz Elsayed Abouelmagd, Youssef Ashmawy, Eman Hany Elsebaie. Medical students and ChatGPT: analyzing attitudes, practices, and academic perceptions. BMC Med Educ. 2025;25(1)
43. Liu M, Okuhara T, Chang X, Ritsuko Shirabe, Nishiie Y, Okada H, et al. Performance of ChatGPT Across Different Versions in Medical Licensing Examinations Worldwide: A Systematic Review and Meta-Analysis. J Medl Internet Res. 2024; 26:e60807–7.
44. Brin D, Sorin V, Vaid A, Soroush A, Glicksberg BS, Charney A, et al. Comparing ChatGPT and GPT-4 performance in USMLE soft skill assessments. Sci Rep. 2023;13(1).
45. Alowais SA, Alghamdi SS, Alsuhebany N, Alqahtani T, Alshaya A, Almohareb SN, et al. Revolutionizing Healthcare: The Role Of Artificial Intelligence In Clinical Practice. BMC Med Educ. 2023;23(1).
46. Garg AX, Adhikari NK, McDonald H, Rosas-Arellano MP, Devereaux PJ, Beyene J, et al. Effects of Computerized Clinical Decision Support Systems on Practitioner Performance and Patient Outcomes. JAMA. 2005;293(10):1223.
47. Owoyemi A, Owoyemi J, Osiyemi A, Boyd A. Artificial Intelligence for Healthcare in Africa. Front Digit Health. 2020;2.
48. Gore MN, Olawade DB. Harnessing AI for public health: India's roadmap. Front Public Health. 2024;12.
49. Soellner M, Koenigstorfer J. Compliance with medical recommendations depending on the use of artificial intelligence as a diagnostic method. BMC Med Inform Decis Mak. 2021;21(1).
50. Esmaeilzadeh P, Mirzaei T, Dharanikota S. Patients' Perceptions Toward Human–Artificial Intelligence Interaction in Health Care: Experimental Study. J Med Internet Res. 2021;23(11)
51. Kolb D. Experiential learning: Experience as the source of learning and development. 2nd ed. Upper Saddle River, NJ: Pearson Education, Inc; 2015.
52. Biagini G. Towards an AI-Literate Future: A Systematic Literature Review Exploring Education, Ethics, and Applications. Int J Artif Intell Educ. 2025.
53. Norori N, Hu Q, Aellen FM, Faraci FD, Tzovara A. Addressing bias in big data and AI for health care: A call for open science. Patterns. 2021;2(10):100347.
54. Tikhomirov L, Semmler C, McCradden M, Searston R, Ghassemi M, Oakden-Rayner L. Medical artificial intelligence for clinicians: the lost cognitive perspective. Lancet Digit Health. 2024;6(8)
55. Elendu C, Amaechi DC, Elendu TC, Jingwa KA, Okoye OK, John Okah M, et al. Ethical implications of AI and robotics in healthcare: A review. Medicine. 2023;102(50):e36671.
56. Mittermaier M, Raza MM, Kvedar JC. Bias in AI-based models for medical applications: challenges and mitigation strategies. npj Digit Med. 2023;6(1):113, s41746-023-00858-z.
57. Adwer L, Whiting E. Exploring Artificial Intelligence Solutions and Challenges in Healthcare Administration. In: 2024 IEEE 12th International Conference on Healthcare Informatics (ICHI). 2024. p. 528–30.
58. Panch T, Mattie H, Atun R. Artificial intelligence and algorithmic bias: implications for health systems. J Glob Health. 2019;9(2):010318.
59. Jeyaraman M, Balaji S, Jeyaraman N, Yadav S. Unraveling the Ethical Enigma: Artificial Intelligence in Healthcare. Cureus. 2023;15(8):e43262.
60. Palaniappan K, Lin EYT, Vogel S. Global Regulatory Frameworks for the Use of Artificial Intelligence (AI) in the Healthcare Services Sector. Healthc. 2024;12(5):562.

61. Alderden JG, Johnny JD. Artificial Intelligence and the Critical Care Nurse. Crit Care Nurs. 2023;43(5):7–8.
62. Zhang S, Yu J, Xu X, Yin C, Lu Y, Yao B, et al. Rethinking Human-AI Collaboration in Complex Medical Decision Making: A Case Study in Sepsis Diagnosis. In: Proceedings of the CHI Conference on Human Factors in Computing Systems; 2024. p. 1–18.
63. Rajkomar A, Hardt M, Howell MD, Corrado G, Chin MH. Ensuring Fairness in Machine Learning to Advance Health Equity. Ann Intern Med. 2018;169(12):866–72.
64. Civaner MM, Uncu Y, Bulut F, Chalil EG, Tatli A. Artificial intelligence in medical education: a cross-sectional needs assessment. BMC Med Educ. 2022;22(1):772.
65. Çalışkan SA, Demir K, Karaca O. Artificial intelligence in medical education curriculum: An e-Delphi study for competencies. PLoS ONE. 2022;17(7):e0271872.
66. Katznelson G, Gerke S. The need for health AI ethics in medical school education. Adv in Health Sci Educ. 2021;26(4):1447–58.
67. Morrell W, Shachar C, Weiss AP. The oversight of autonomous artificial intelligence: lessons from nurse practitioners as physician extenders. J Law Biosci. 2022;9(2):lsac021.
68. Meskó B, Topol EJ. The imperative for regulatory oversight of large language models (or generative AI) in healthcare. NPJ Digit Med. 2023; 6(1):120.
69. Patel J, Shah K, Jain J, Shah V. Cross Sectional Study on Adherence to Medication among Patients with Hypertension and/or Diabetes Attending One of the Tertiary Care Institutes of Ahmedabad City, Gujarat, India. Int J Med Stud. 2025 Jan-Mar;13(1):47-51.
70. Hamad H. Am I A Fraud? Occurrence and Factors Associated with Impostor Phenomenon among Medical Students of Khartoum University, 2022. Int J Med Stud. 2025 Jan-Mar;13(1):17-24.
71. Rowe M, Tahmo N, Oyewole O, King K, Cochran T, Saksena Y, et al. Let's Talk about Bias in Healthcare: Experiences from an Interactive Interprofessional Student Seminar. Int J Med Stud. 2025 Jan-Mar;13(1):25-39.
72. McGuire B, Mahfouz H, Lorenz H, Archer E. Sport and Exercise Medicine: a Misunderstood Specialty Among Medical Students and Foundation Doctors. Int J Med Stud. 2025 Jan-Mar;13(1):40-46.
73. Deng A, Kaneria P, Espiridion E. Psychiatric Outcomes in Patients with Trigeminal Neuralgia Treated with Anticonvulsants and Antidepressants: A Retrospective Cohort Study Using a National Database. Int J Med Stud. 2025 Jan-Mar;13(1):52-59.
74. Sawaya J, McRae J, Mladenov G, Radulescu A. Pediatric Hepatoblastoma: A Single-Institution Case Series. Int J Med Stud. 2025 Jan-Mar;13(1):60-66.
75. Granberry R, Mathesh V, Ford L, Thompson W, Loria H, Pak T. Development and Evaluation of a Pilot Short-Term Mental Health Curriculum with Longitudinal Evaluation for Minority Youth. Int J Med Stud. 2025 Jan-Mar;13(1):67-72.
76. Lagunes A, Méndez L, Ortiz-F. Academic Burnout in Mexican Medical Students: A Critical Review of Prevalence, Risk Factors, and Gaps in Intervention. Int J Med Stud. 2025 Jan-Mar;13(1):73-86
77. Hmaideh A, Haji B, Orabi F, Almostaffa O, Rashwany Q, Zakaria W. Hydatid Cyst Complicated by Dilated Bile Duct Treated with Endoscopic Retrograde Cholangiopancreatography (ERCP): A Case Report. Int J Med Stud. 2025 Jan-Mar;13(1):87-93
78. Poh D, Andrews S, Andrady U. Public Health Longitudinal Integrated Foundation Training (LIFT) program: A Junior Doctor's Experience. Int J Med Stud. 2025 Jan-Mar;13(1):94-96.
79. Zaheer A. Combating Rheumatic Heart Disease in Pakistan: An Experience of Training, Screening and Community Outreach. Int J Med Stud. 2025 Jan-Mar;13(1):100-102.
80. Padashetty C, Hegde S. The Measure of Success – A Day in the Life of a Pediatric Surgeon. Int J Med Stud. 2025 Jan-Mar;13(1):103-104.
81. Louca M, Gonski P. The Pupil's P's: An Alliterative Tool and Practical Framework for Managing Older Patients. Int J Med Stud. 2025 Jan-Mar;13(1):105-109.

Conflict of Interest Statement & Funding

The Authors have no funding, financial relationshipsor conflicts of interest to disclose. Dr. Juan C. Puyana work is partially funded by the National Institute of Health (NIH) of the United States with the grant UH3HL151595. The opinions expressed in this article are the author's own and do not reflect theview of the National Institutes of Health, the Department of Health and Human Services, or the United States government.

Cite as

Roy E, Malafa S, Adwer L, Tabache H, Sheth T, Mishra V, et al. Artificial Intelligence in Healthcare: Medical Students' Perspectives on Balancing Innovation, Ethics, and Patient-Centered Care. Int J Med Stud. 2025 Jan-Mar;13(1):9-16.

ISSN 2076-6327

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