The Ethics of AI in Medical Research: A Call for Open and Honest Discussion

Dr. Shazma Tahseen[1], Muhammad Ali Memon[2], Shah Muhammad Kamran[3], Kamran Taj Pathan[4]

Dr. A.H.S. Bukhari postgraduate Centre of Information and Communication Technology, and Department of Information Technology, University of Sindh, Jamshoro, Pakistan, Mehran University Institute of Science, Technology & Development (MUISTD), Jamshoro, Pakistan, Department of Software Engineering, University of Sindh, Jamshoro, Pakistan

Correspondence:
Dr. Shazma Tahseen, Dr. A.H.S. Bukhari postgraduate Centre of Information and Communication Technology, University of Sindh, Jamshoro, Pakistan

Email: shazmatahseen@hotmail.com

DOI: 10.38106/LMRJ.2024.6.2-07
Received:26.02.2024
Accepted: 20.06.2024
Published:30.06.2024

ABSTRACT

Artificial intelligence (AI) in healthcare is gaining rapid popularity in terms of its application and research. A significant reason for its success is due to the advances it has made and the ease of use it incorporates. Because of its implications, issues, and benefits in terms of ease, AI has been debated and researched extensively. This study examined the ethical dilemmas associated with artificial intelligence in medical research. The research uses a qualitative research method based on content analysis. Authentic Internet resources were used to collect secondary data. Once AI is fully integrated into healthcare, several ethical dilemmas will likely arise, including patient privacy, data security, algorithmically biased results, transparency, and human error. Minimizing ethical dilemmas with continuous monitoring is possible, but they cannot be eliminated. It is possible with the advancement of technology and AI enables it to imitate the cognitive processes of humans, which may enhance its reliability but can also lead to negative consequences. As a result, the new technological developments must be applied ethically. An open and honest discussion is essential for the awareness and understanding of AI ethics, honoring patient rights, and maintaining public trust.

Keywords: AI Ethics,Ethics in Medical Research, Algorithm Bias, Privacy and Security

INTRODUCTION

Emerging technologies, like artificial intelligence (AI) and machine learning, are bringing positive changes and advancements in many fields of life including medical and public health (1). AI is a system that imitates human-like learning, reasoning, and decision-making to achieve defined objectives, independent of computer programming (2). AI is an umbrella concept, that covers, natural language processing, robotics, and machine learning, these supportive techniques are augmenting different areas including, health and medical research, education, and other related fields (3). AI has the potential to significantly enhance the efficiency of any given healthcare system, by improving precision, timely and accurate diagnostics, quality service, and affordable cost (4–6). Machine learning algorithms can identify unexplored patterns in large and heterogeneous data, helping innovation and advancement in diagnostic, better treatments, and optimal allocation of resources in the healthcare and welfare sectors. Globally healthcare sector faces a scarcity of resources (7), it can be optimized through AI applications for administrative redesign and clinical decision-making (4,8).

Different entities, including technology firms, pharmaceutical enterprises, medical research organizations, healthcare service providers, and public health agencies, are actively amassing, utilizing, and progressively

disseminating individual-level health data. This information encompasses factors such as age, self-assessed health status, disease category, and income details, spanning an extensive array of data from sources like smartphone apps, wearable devices, medical records, and social and demographic information (9,10). These datasets frequently undergo amalgamation, aggregation, and interconnection to enhance the effectiveness of products and services within our society. However, sharing and reusing personal data can pose risks and challenges related to privacy, fair and open data use, and data security (11–15). Traditional safeguards and oversight practices struggle to address the changing notions of consent and anonymization in data-intensive contexts (16,17). Also, algorithmic bias and human-induced errors in system development are challenges to medical ethics (18– 20).

Creating strategies and establishing consistent protocols for managing individual data is of paramount importance to strike a balance between harnessing the advantages of data-driven technologies and safeguarding the rights of data subjects and communities (21). Achieving this equilibrium involves considering the viewpoints of both data subjects and data collectors/legal entities, which can sometimes diverge interests (21). An expanding body of scholarly work centers on investigating the inclinations and perspectives of the general public, research participants, and patients concerning data sharing. Elements such as the level of identifiability, transparency in data-sharing practices, and obtaining informed consent all play pivotal roles in addressing the concerns related to privacy (22–24).

Health data governance deliberations need to be scrupulously addressed in a way that reconciles security hesitations with societal expectations, comforting privacy, security, equity, and openness. The approach will make it possible to optimally use health data in the building of favorable initiatives. As the key stakeholders in the analysis of private health data at the personal level, the researchers need to take the ethical angle of research, understand the legal requirements and then translate them into practice (25). It is crucial to take into account the various viewpoints of the stakeholders regarding the use of AI in medical research because doing so will help identify any flaws and potential gaps that moral and legal considerations should fill. Differences between the policies and practices arise as a result of such discrepancies, and so governance preconditions can be obtained. AI implementation has brought up as many moral dilemmas in healthcare as technological development. Despite the research undertaken to overcome at least some of these ethical issues, there is still a necessity for a more comprehensive study.

This study aims to sort the ethical dilemmas of patient privacy and data security that come with AI application in medical research, as well as algorithmic bias, transparency, and human error. Understanding the ethical issues associated with the AI usage will help to develop a new technical solutions and legal regulations that will provide more safety to the application of AI in medicine. Results of the study will help the AI and healthcare professionals to address such issues while applying AI in medicine to ensure ethical considerations. Through identifying and resolution of ethical issues and challenges, patient's right of privacy and ethically advancement of the artificial intelligence can be ensured.

RESEARCH METHODOLOGY

Qualitative research methodology was employed, and content analysis was done through systematic review methods. A deductive approach was adopted to highlight and evaluate the ethical issues of AI application in health and medical research. To get a more nuanced understanding of the issue, a different approach from the traditional review was used (26–28). Traditional review methods use established analytical frameworks, that miss the contextual information from the data, whereas alternative methods look for more related contextual

information from the data (29).

The research was carefully planned and rigorously implemented, below is a brief and comprehensive explanation of steps.

Systematic execution of the research was ensured for rigorous review of available literature about the issues related to AI applications in healthcare. Execution includes the criteria setting for inclusion and exclusion, selection of relevant databases, and qualitative synthesis of studies to extract useful information. Results were thematically organized, for easy analysis and interpretation summarization of the finding with supporting evidence and finally systematic presentation. Results of the study brought useful insight for medical and AI research.

The research was planned and executed as follows:

- A systematic approach.
- A qualitative synthesis of the data.
- A thematic organization of the studies.
- A comprehensive presentation of the results.

This study confirms the transparency and replicability of systematic reviews approach, in order to ensure the use of existing evidence in future research. Systematic reviews provide the following benefits (Table 1):

Table 1: Benefits of Systematic Review

Accuracy	**In systematic reviews, studies are identified and appraised systematically and transparently, which makes them more accurate.**
Reliability	**systematic reviews use a consistent process, other researchers can reproduce them.**
Credibility	**A rigorous process is used to identify and appraise studies, which makes them more credible.**
Breadth	**systematic review provides a broader overview than a traditional literature review.**
Depth	**A systematic review measures the quality of the studies, which provides a deeper understanding of the literature.**

Stepwise detail of the review process is as follows;

Methodological Procedures for Search, Inclusion and Exclusion

The research employed distinct criteria and techniques to delineate and examine the realm of AI ethics and ethical concerns linked to AI in medical research. Only peer-reviewed articles that met empirical, conceptual, or review criteria were considered. Exclusion criteria were applied to AI application and ethical issues studies, published in edited books or conference proceedings, and non-electronically accessible articles. The search involved a thorough examination of relevant academic journals using specific keywords. Two senior investigators manually reviewed all papers, ensuring alignment with search parameters; the initial search brought 195 articles. Additionally, a second search was performed to address potentially missed studies. The final sample for analysis comprised 40 articles after applying inclusion and exclusion criteria.

Conducting Review

At the beginning of the study, a search protocol was established defining exclusion and inclusion criteria for

the literature search. Based on the guidelines described in the protocol, keywords from the latest research were derived to ensure the inclusion of all relevant AI-Ethics-Medical research. Books, reports, and conference papers were excluded from the search pool because of their obscure review process and limited access. Journal articles were especially searched for; they are regarded as reliable and authentic because of the rigorous peer review procedure.

Literature was searched from April 2020 to March 2023. Definitive work during this period serves the guiding principles of including articles, further refined by keyword search by academic search engines like Google Scholar and ScienceDirect. After thorough screening in the first phase of the search, 109 articles were shortlisted. However, in the second phase of scrutiny more articles were excluded because of their scope of work, only the 50 most recent and influential research articles with validated knowledge were compiled for the analysis (Table 2).

Table 2: Qualitative Database Development

Methodological Procedures	Description
Inclusion and Exclusion Criteria	Inclusion: Peer-reviewed articles meeting empirical, conceptual, or review criteria. Exclusion: Studies published in edited books or conference proceedings, and non-electronically accessible articles.
Search Process	- specific keywords search for in-depth examination of relevant academic journals. - All papers reviewed by two senior investigators manually. - Search resulted 195 articles initially - A second search performed to address potentially missed studies - 40 articles finalized for analysis.
Conducting Review	A comprehensive inclusion and exclusion criteria were established, to analyze only reliable research of peer reviewed journal articles.
Time Span	April 2020 to March 2023
Analysis	The final 35 articles were reviewed to thoroughly understand the AI-Ethic-Medical issue.

RESULTS AND DISCUSSION

A. Data Protection and Privacy

Protection from cyber and other threats and the privacy of medical datasets is critical to AI- medical research. Medical datasets contain sensitive personal information, including medical, insurance, and genetic data. It is,

therefore, crucial to ensure the confidentiality of personal information. Institutions applying AI techniques must adhere to strict security standards to protect data. That can be achieved through rigorous encryption frameworks in sorting and transmission of data, it will prevent unauthorized access and decryption of the data. Moreover, strict control over data access through authorization can ensure limited rights to view, process, or modify data. A more sophisticated "need-to-know" protection layer considerably avoids data breaches or unauthorized use. Data anonymization can also add an extra layer of privacy protection; it assigns a unique ID to the identifiable information and refrains from linkage to the individual-specific data. Anonymization minimizes the possible risk of re-identification.

Additionally, routine assessments and security audits to examine the vulnerabilities in the system are critical to rectify possible loopholes. Implementation and compliance with data protection standards, e.g. GDPR and HIPPA, can help the development of feasible data protection frameworks. These standards cover the basic requirements of consent, storage, and breach issues.

Data protection and privacy are extremely important when applying AI for medical research. Robust encryption protocol, limited and authorized access to data, anonymization, and security audits can help achieve privacy and protection (30–36).

B. Algorithmic Bias

Though AI algorithms are becoming more intelligent, it is crucial to acknowledge that they can be biased, potentially leading to unfair or discriminatory decisions. The bias can stem from the data used to train the algorithm or from inherent flaws in the algorithm's design. If the data used to train the algorithm is biased, it can perpetuate and amplify the biases present in society. For instance, an algorithm is trained on historical data about disease incidences in a particular location. In future diagnostic decisions, it may increase the chances of new cases in the exact location.

Furthermore, the design of the algorithm can also cause bias. It may happen when the algorithm relies on closely correlated features with protected attributes, e.g. ethnicity or gender identification, leading to unfair results. Adoption of a proactive approach is critical to address this bias. This approach includes carefully compiled data for training, that is representative, diverse, and free from biases. Assessment of the algorithm's design for potential biases is also crucial to mitigate the issue.

Algorithmic biases can be mitigated by critical design audit, transparency, and accountability of design and deployment through documentation of the decision-making process. The involvement of diverse stakeholders in the scrutiny and evaluation process is essential to avoid bias. Iterative monitoring and evaluation are also essential to desist algorithmic biases' reoccurrence and maintenance of fairness (37,38,39–47).

C. Transparency and Accountability

Though AI algorithms can significantly increase and improve decision-making efficiency, complexity and opaqueness are growing concerns. Challenges to understanding the workings of algorithms because of the complexity make it further difficult to take corrective measures.

Transparency of the AI process is essential, clear, and understandable inner working of the algorithm for experts and novices alike. Public availability of algorithms' source code and scrutiny and assessment of logic function can help identify possible biases or flaws for improved transparency. Documentation of the algorithms, explaining data sources, functionality, and decision-making process enhances transparency. Comprehensive and understandable documentation allows users to conclude the algorithms.

To hold the AI system accountable for the decision, a clear job description and a line of responsibility imply

responsibility for development, deployment, and performance. Assessment and monitoring by experts from associated fields can help establish the accountability framework for the system.
Third-party audits, with diverse expertise in medical research ethics and AI-machine learning, as well as the feedback from the users and affected individuals, can improve the system's performance and transparency and build trust by highlighting potential biases in decision-making.
Third-party audits, with diverse expertise in medical research ethics and AI-machine learning, as well as the feedback from the users and affected individuals, can improve the system's performance and transparency and build trust by highlighting potential biases in decision-making (48–57).

Table 3. Transparency and Privacy in Artificial intelligence

Issues	Description
Data Protection and Privacy	**⚜Data security and privacy is vital, especially, while training the machine with large datasets.** **-Substantial encryption, controlled and authorized access, and anonymization techniques are essential.** **-Compliance with relevant privacy and protection standards are mandatory.**
Algorithmic Bias	**-AI algorithms can produce biased and discriminatory decisions.** **-Bias may be a result of skewed or biased data or biased design of algorithm.** **-Biased can be mitigated through algorithm audit, transparency, and monitoring and evaluation of the system.**
Transparency and Accountability	**-Making source code publicly available to achieve transparency.** **⚜Providing comprehensive documentation.** **⚜Establishing clear lines of responsibility and mechanisms for auditing and independent evaluation leads towards accountability.**
The Role of Humans	**⚜Healthcare professionals are responsible for interpreting and applying AI. AI should complement and support human expertise, not replace it.**

D. The Role of Humans in AI-powered Medical Decision-Making

Artificial intelligence is remarkably augmenting medical and health research, and the development of sophisticated models allows precise and critical decisions to be made by analyzing complex data. However, artificial intelligence still lacks the judgment potential of human decision-making related to treatment. While AI provides immense help and insight to healthcare professionals, humans are still responsible for final decisions regarding the interpretation and execution of AI-generated information, considering preference, context, and norms. This approach keeps the human element intact to address inherent issues of medical data and foster the healthcare system. Based on the

patterns and correlations in the datasets, trained AI systems are prone to biases and errors. There is a chance of omission error and a lack of patient-specific information, yet it shows high accuracy because of the task-specific design. However, clinicians and related professionals use intuition, empathy, and contextual knowledge to address these issues in decision-making with ethical consideration. Furthermore, human-to-human interaction gives patients a sense of understanding, comfort, and compassion, which leads to hope and better recovery.

While AI algorithms have become increasingly sophisticated and are used to make more complex decisions, they should not replace human judgment in healthcare. AI integration into medical practice should complement and support healthcare professionals' expertise and medical researchers' findings. As a decision support system, AI algorithms can help healthcare providers increase the accuracy of their clinical decisions while maintaining patient-centered care (58, 59, 60–68).

CONCLUSION

The application of artificial intelligence in medical and health research raised many critical concerns, especially the privacy and security of data with sensitive and personal information. Protection of patients' private information including medical, financial records, and genetic data is vital and needs to be secured. Confronting algorithmic bias may avert the discriminatory decisions caused by the biased design of algorithms or biased training. Vigilance and corrective measures are crucial to address the bias. Inherited complexity and opacity of artificial intelligence algorithms, make it challenging to be liable, therefore, transparency in design is essential. By ensuring transparency, algorithmic decisions can be comprehended and trusted. Lastly, while AI algorithms are utilized to assist in the complex decision-making process in medicine, it is vital to retain human involvement to prevent substituting human judgment with AI algorithms. Despite advances in artificial intelligence, humans must remain a critical component of diagnosis, treatment, and decision-making.

REFERENCES

1. Costa FF. Big data in biomedicine. Drug Discov Today. 2014 Apr;19(4):433–40.
2. Du-Harpur X, Watt FM, Luscombe NM, Lynch MD. What is AI? Applications of artificial intelligence to dermatology. Br J Dermatol. 2020 Sep;183(3):423–30.
3. Ramesh AN, Kambhampati C, Monson JRT, Drew PJ. Artificial intelligence in medicine. Ann R Coll Surg Engl. 2004 Sep;86(5):334–8.
4. AlAhmad YM, Mahmoud Haggeer D, Alsayed AY, Haik MY, AbuAfifeh LM, Hussain Aljaber M, et al. The effect of telemedicine on patients' compliance in family medicine follow-ups in Qatar. Avicenna. 2022 Feb;2022(1).
5. Barman M, Hussain T, Abuswiril H, Noor Illahi M, Sharif M, Talat Saman H, et al. Embracing healthcare delivery challenges during a pandemic. review from a nodal designated COVID-19 center in qatar. Avicenna. 2021 Sep;2021(2).
6. Sidhom O. Physical and mental health aspects in COVID-19: Two sides of a coin. Avicenna [Internet]. 2021 Sep;2021(2). Available from: https://www.qscience.com/content/journals/10.5339/avi.2021.6
7. OECD. Trustworthy AI in Health. Riyadh, Saudi Arabia; 2020. (Background Paper for the G20 AI Dialogue, Digital Economy Task Force).
8. Dilsizian SE, Siegel EL. Artificial Intelligence in Medicine and Cardiac Imaging: Harnessing Big Data and Advanced Computing to Provide Personalized Medical Diagnosis and Treatment. Curr Cardiol Rep. 2014 Jan;16(1):441.
9. Badawi O, Brennan T, Celi LA, Feng M, Ghassemi M, Ippolito A, et al. Making Big Data Useful for Health

Care: A Summary of the Inaugural MIT Critical Data Conference. JMIR Med Informatics. 2014 Aug;2(2):e22–e22.

10. Gadde SS, Reddy VD, Kalli. Descriptive Analysis of Machine Learning and Its Application in Healthcare. Int J Comput Sci Trends Technol. 2008;8(2):189–96.

11. Verma P, Kumar S, Sharma SK. Multiple dimensions of e-healthcare ethics and its relationship to the ethical concerns of the consumer. Int J Ethics Syst. 2021 Jan;37(1):70–89.

12. Saheb T, Saheb T, Carpenter DO. Mapping research strands of ethics of artificial intelligence in healthcare: A bibliometric and content analysis. Comput Biol Med. 2021 Aug;135:104660.

13. Geneviève LD, Martani A, Wangmo T, Paolotti D, Koppeschaar C, Kjelsø C, et al. Participatory Disease Surveillance Systems: Ethical Framework. J Med Internet Res. 2019 May;21(5):e12273–e12273.

14. Petersen C, Subbian V. Special Section on Ethics in Health Informatics. Yearb Med Inform. 2020 Aug;29(01):77–80.

15. Price WN, Cohen IG. Privacy in the age of medical big data. Nat Med. 2019 Jan;25(1):37–43.

16. Mostert M, Bredenoord AL, Biesaart MCIH, van Delden JJM. Big Data in medical research and EU data protection law: challenges to the consent or anonymise approach. Eur J Hum Genet. 2016 Jul;24(7):956–60.

17. Mascalzoni D, Bentzen HB, Budin-Ljøsne I, Bygrave LA, Bell J, Dove ES, et al. Are Requirements to Deposit Data in Research Repositories Compatible With the European Union's General Data Protection Regulation? Ann Intern Med. 2019 Mar;170(5):332.

18. Chen IY, Pierson E, Rose S, Joshi S, Ferryman K, Ghassemi M. Ethical Machine Learning in Healthcare. Annu Rev Biomed Data Sci. 2021 Jul;4(1):123–44.

19. Choudhury A, Asan O. Impact of accountability, training, and human factors on the use of artificial intelligence in healthcare: Exploring the perceptions of healthcare practitioners in the US. Hum Factors Healthc. 2022 Dec;2:100021.

20. Sujan M, Pool R, Salmon P. Eight human factors and ergonomics principles for healthcare artificial intelligence. BMJ Heal Care Inf. 2022 Feb;29(1):e100516–e100516.

21. de Hert P, Sajfert J. Regulating Big Data in and out of the Data Protection Policy Field: Eur Data Prot Law Rev. 2019;5(3):338–51.

22. Shabani M, Bezuidenhout L, Borry P. Attitudes of research participants and the general public towards genomic data sharing: a systematic literature review. Expert Rev Mol Diagn. 2014 Nov;14(8):1053–65.

23. Aitken M, de St. Jorre J, Pagliari C, Jepson R, Cunningham-Burley S. Public responses to the sharing and linkage of health data for research purposes: a systematic review and thematic synthesis of qualitative studies. BMC Med Ethics. 2016 Dec;17(1):73.

24. Clayton EW, Halverson CM, Sathe NA, Malin BA. A systematic literature review of individuals' perspectives on privacy and genetic information in the United States. Wang W, editor. PLoS One. 2018 Oct;13(10):e0204417–e0204417.

25. Viberg Johansson J, Bentzen HB, Mascalzoni D. What ethical approaches are used by scientists when sharing health data? An interview study. BMC Med Ethics. 2022 Dec;23(1):41.

26. Sandelowski M, Barroso J. Creating Metasummaries of Qualitative Findings. Nurs Res. 2003 Jul;52(4):226–33.

27. Walsh D, Downe S. Meta-synthesis method for qualitative research: a literature review. J Adv Nurs. 2005

Apr;50(2):204–11.

28. Weed M. A Potential Method for the Interpretive Synthesis of Qualitative Research: Issues in the Development of 'Meta-Interpretation.' Int J Soc Res Methodol. 2008 Feb;11(1):13–28.

29. Macpherson A, Holt R. Knowledge, learning and small firm growth: A systematic review of the evidence. Res Policy. 2007 Mar;36(2):172–92.

30. Car J, Sheikh A, Wicks P, Williams MS. Beyond the hype of big data and artificial intelligence: building foundations for knowledge and wisdom. BMC Med. 2019 Dec;17(1):143.

31. Ng WY, Zhang S, Wang Z, Ong CJT, Gunasekeran D V, Lim GYS, et al. Updates in deep learning research in ophthalmology. Clin Sci. 2021 Oct;135(20):2357–76.

32. Zaman U, Imran, Mehmood F, Iqbal N, Kim J, Ibrahim M. Towards Secure and Intelligent Internet of Health Things: A Survey of Enabling Technologies and Applications. Electronics. 2022 Jun;11(12):1893.

33. Rafik H, Maizate A, Ettaoufik A. Data Security Mechanisms, Approaches, and Challenges for e-Health Smart Systems. Int J Online Biomed Eng. 2023 Feb;19(02):42–66.

34. Ali O, Abdelbaki W, Shrestha A, Elbasi E, Alryalat MAA, Dwivedi YK. A systematic literature review of artificial intelligence in the healthcare sector: Benefits, challenges, methodologies, and functionalities. J Innov Knowl. 2023 Jan;8(1):100333.

35. Khawar Hussain H, Tariq A, Yousaf Gill A. Role of AI in Cardiovascular Health Care; a Brief Overview. J World Sci. 2023 Apr;2(4):794–802.

36. Alshehri M. Blockchain-assisted cyber security in medical things using artificial intelligence. Electron Res Arch. 2023;31(2):708–28.

37. Aggarwal R, Sounderajah V, Martin G, Ting DSW, Karthikesalingam A, King D, et al. Diagnostic accuracy of deep learning in medical imaging: a systematic review and meta-analysis. npj Digit Med. 2021 Apr;4(1):65. z

38. Zhou Q, Chen Z, Cao Y, Peng S. Clinical impact and quality of randomized controlled trials involving interventions evaluating artificial intelligence prediction tools: a systematic review. npj Digit Med. 2021 Oct;4(1):154.

39. Xu Z, Wang X, Zeng S, Ren X, Yan Y, Gong Z. Applying artificial intelligence for cancer immunotherapy. Acta Pharm Sin B. 2021 Nov;11(11):3393–405.

40. van de Sande D, van Genderen ME, Huiskens J, Gommers D, van Bommel J. Moving from bytes to bedside: a systematic review on the use of artificial intelligence in the intensive care unit. Intensive Care Med. 2021 Jul;47(7):750–60.

41. Kleppe A, Skrede O-J, De Raedt S, Liestøl K, Kerr DJ, Danielsen HE. Designing deep learning studies in cancer diagnostics. Nat Rev Cancer. 2021 Mar;21(3):199–211. 42. Vagliano I, Chesnaye NC, Leopold JH, Jager KJ, Abu-Hanna A, Schut MC. Machine learning models for predicting acute kidney injury: a systematic review and critical appraisal. Clin Kidney J. 2022 Nov;15(12):2266–80.

43. Weaver CGW, Basmadjian RB, Williamson T, McBrien K, Sajobi T, Boyne D, et al. Reporting of Model Performance and Statistical Methods in Studies That Use Machine Learning to Develop Clinical Prediction Models: Protocol for a Systematic Review. JMIR Res Protoc. 2022 Mar;11(3):e30956–e30956.

44. Dhiman P, Ma J, Andaur Navarro CL, Speich B, Bullock G, Damen JAA, et al. Methodological conduct of prognostic prediction models developed using machine learning in oncology: a systematic review. BMC Med Res

Methodol. 2022 Apr;22(1):101.

45. Xie Q, Wang X, Pei J, Wu Y, Guo Q, Su Y, et al. Machine Learning–Based Prediction Models for Delirium: A Systematic Review and Meta-Analysis. J Am Med Dir Assoc. 2022 Oct;23(10):1655-1668.e6.

46. Bullock GS, Hughes T, Arundale AH, Ward P, Collins GS, Kluzek S. Black Box Prediction Methods in Sports Medicine Deserve a Red Card for Reckless Practice: A Change of Tactics is Needed to Advance Athlete Care. Sport Med. 2022 Aug;52(8):1729–35.

47. Kaiser I, Mathes S, Pfahlberg AB, Uter W, Berking C, Heppt M V, et al. Using the Prediction Model Risk of Bias Assessment Tool (PROBAST) to Evaluate Melanoma Prediction Studies. Cancers (Basel). 2022 Jun;14(12):3033.

48. Trocin C, Mikalef P, Papamitsiou Z, Conboy K. Responsible AI for Digital Health: a Synthesis and a Research Agenda. Inf Syst Front. 2021 Jun;

49. Nair A V, Ramanathan S, Sathiadoss P, Jajodia A, Blair Macdonald D. Barriers to artificial intelligence implementation in radiology practice: What the radiologist needs to know. Radiol (English Ed. 2022 Jul;64(4):324–32.

50. Qayyum A, Qadir J, Bilal M, Al-Fuqaha A. Secure and Robust Machine Learning for Healthcare: A Survey. IEEE Rev Biomed Eng. 2021;14:156–80.

51. Recht MP, Dewey M, Dreyer K, Langlotz C, Niessen W, Prainsack B, et al. Integrating artificial intelligence into the clinical practice of radiology: challenges and recommendations. Eur Radiol. 2020 Jun;30(6):3576–84.

52. Kiener M. Artificial intelligence in medicine and the disclosure of risks. AI Soc. 2021 Sep;36(3):705–13.

53. Khan R, Srivastava AK, Gupta M, Kumari P, Kumar S. Medicolite-Machine Learning-Based Patient Care Model. Keravnou E, editor. Comput Intell Neurosci. 2022 Jan;2022:1–12.

54. Hermann E. Leveraging Artificial Intelligence in Marketing for Social Good—An Ethical Perspective. J Bus Ethics. 2022 Aug;179(1):43–61.

55. Durán JM, Jongsma KR. Who is afraid of black box algorithms? On the epistemological and ethical basis of trust in medical AI. J Med Ethics. 2021 Mar;medethics-2020-106820. 56. Lysaght T, Lim HY, Xafis V, Ngiam KY. AI-Assisted Decision-making in Healthcare. Asian Bioeth Rev. 2019 Sep;11(3):299–314.

57. Redrup Hill E, Mitchell C, Brigden T, Hall A. Ethical and legal considerations influencing human involvement in the implementation of artificial intelligence in a clinical pathway: A multi-stakeholder perspective. Front Digit Heal. 2023 Mar;5.

58. Rathore FA, Rathore MA. The Emerging Role of Artificial Intelligence in Healthcare. J Pak Med Assoc. 2023 Jun;73(7):1368–9. 59. Buabbas AJ, Miskin B, Alnaqi AA, Ayed AK, Shehab AA, Syed-Abdul S, et al. Investigating Students' Perceptions towards Artificial Intelligence in Medical Education. Healthcare. 2023 May;11(9):1298.

60. Secinaro S, Calandra D, Secinaro A, Muthurangu V, Biancone P. The role of artificial intelligence in healthcare: a structured literature review. BMC Med Inform Decis Mak. 2021 Dec;21(1):125.

61. Jussupow E, Spohrer K, Heinzl A, Gawlitza J. Augmenting Medical Diagnosis Decisions? An Investigation into Physicians' Decision-Making Process with Artificial Intelligence. Inf Syst Res. 2021 Sep;32(3):713–35.

62. Homayoun H, Rad HS, Ardakani AA. The Role of Artificial Intelligence in Urology Practice. Transitional Res Urol. 2022;4(1):1–3. 63. Pezzo M V, Beckstead JW. Algorithm Aversion Is Too Often Presented as Though It Were Non-Compensatory: A Reply to Longoni et al. (2020). Judgm Decis Mak. 2020;15(3):449–51. 64. Manickam P, Mariappan SA, Murugesan SM, Hansda S, Kaushik A, Shinde R, et al. Artificial Intelligence (AI) and Internet of

Medical Things (IoMT) Assisted Biomedical Systems for Intelligent Healthcare. Biosensors. 2022 Jul;12(8):562.

65. Humairo CN, Hapsari A, Bramanti I. The Role of Artificial Intelligence in Many Dental Specialties. Gunadi, Yamada T, Pramana AAC, Ophinni Y, Gusnanto A, Kusuma WA, et al., editors. BIO Web Conf. 2021 Dec;41:3005.

66. Naqvi SG, Nasir T, Azam H, Zafar L. Artificial Intelligence in Healthcare. Pakistan J Humanit Soc Sci. 2023 Jun;11(2).

67. Talwar V, Chufal KS, Joga S. Artificial Intelligence: A New Tool in Oncologist's Armamentarium. Indian J Med Paediatr Oncol. 2021 Dec;42(06):511–7.

68. Seetharam K, Shrestha S, Sengupta PP. Cardiovascular Imaging and Intervention Through the Lens of Artificial Intelligence. Interv Cardiol Rev Res Resour. 2021 Oct;16.

69. Mahdi SS, Battineni G, Khawaja M, Allana R, Siddiqui MK, Agha D. How does artificial intelligence impact digital healthcare initiatives? A review of AI applications in dental healthcare. Int J Inf Manag Data Insights 2023 Apr;3(1):100144.