Ethical principles for the application of artificial intelligence (AI) in nuclear medicine

Abstract:

intelligence (AI) in Nuclear Medicine is a game-changing technology that has the potential to revolutionize clinical and scientific practice. Although artificial intelligence (AI) is not new to nuclear medicine, medical imaging, or medicine in general, recent developments in machine learning (ML) and deep learning (DL) have accelerated the adoption of novel algorithms. The task of identifying and resolving ethical dilemmas arises as a result of this development. With the fast adoption of ML and DL in Nuclear Medicine, ethical challenges are being recognized at the same time as innovation and deployment, yet contingencies and ethical underpinnings for proactive management are behind. In clinical and research practice, ethical issues are divided into three categories: data usage, algorithm selection, and deployment strategy. The ethical issues surrounding the use of AI in Nuclear Medicine are examined in this paper, and 16 ethical principles are offered as a framework for applying AI principles in Nuclear Medicine

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Introduction:

Artificial intelligence (AI) in Nuclear Medicine is a game-changing technology that has the potential to revolutionize clinical and scientific practice. Although artificial intelligence (AI) is not new to nuclear medicine, medical imaging, or medicine in general, recent developments in machine learning (ML) and deep learning (DL) have accelerated the adoption of novel algorithms. The task of identifying and resolving ethical dilemmas arises as a result of this development. With the fast adoption of ML and DL in Nuclear Medicine, ethical challenges are being recognized at the same time as innovation and deployment, yet contingencies and ethical underpinnings for proactive management are behind. In clinical and research practice, ethical issues are divided into three categories: data usage, algorithm selection, and deployment strategy. Artificial intelligence (AI) is a broad phrase that refers to algorithms that are supposed to mimic certain characteristics of intelligent human behavior, such as pattern recognition, problem solving, and reasoning. In medical imaging, an artificial neural network (ANN) is an image processing system made up of layers of linked nodes that imitate the neuronal connections of the human brain. ANNs are algorithms that analyze data and identify trends or patterns that may be used to make predictions (e.g. classification of disease). A convolutional neural network (CNN) is a deep learning ANN that uses a convolutional procedure to extract features from an image, while an ANN usually takes feature data as input. Machine learning (ML) is a kind of AI that applies ML techniques without being explicitly programmed via data analysis. After learning from human-defined instructional scenarios characteristic of an ANN, ML is often connected with addressing logic issues. Deep learning (DL) is a sub-type of machine learning (ML) that uses a number of processing layers (depth) to discover complicated patterns in images, similar to a CNN. Artificial intelligence (AI) essentially imitates human intellect, but synthetic intelligence (SI) delivers real higher-order reasoning utilizing technologies such as quantum logic. In general, AI has two sorts of presence in the patient care experience in healthcare: virtual and physical. Virtual AI solutions are most widely used in Nuclear Medicine. However, as the area develops, it will be necessary to tackle the ethical issues that come with physically present AI solutions. AI in Nuclear Medicine and Molecular Imaging ushers in a new age of clinical and scientific capabilities that have been reengineered and redesigned. AI has the ability to enhance workflow and efficiency while also lowering costs, improving accuracy, and facilitating research and discovery. This entails a responsibility of care to

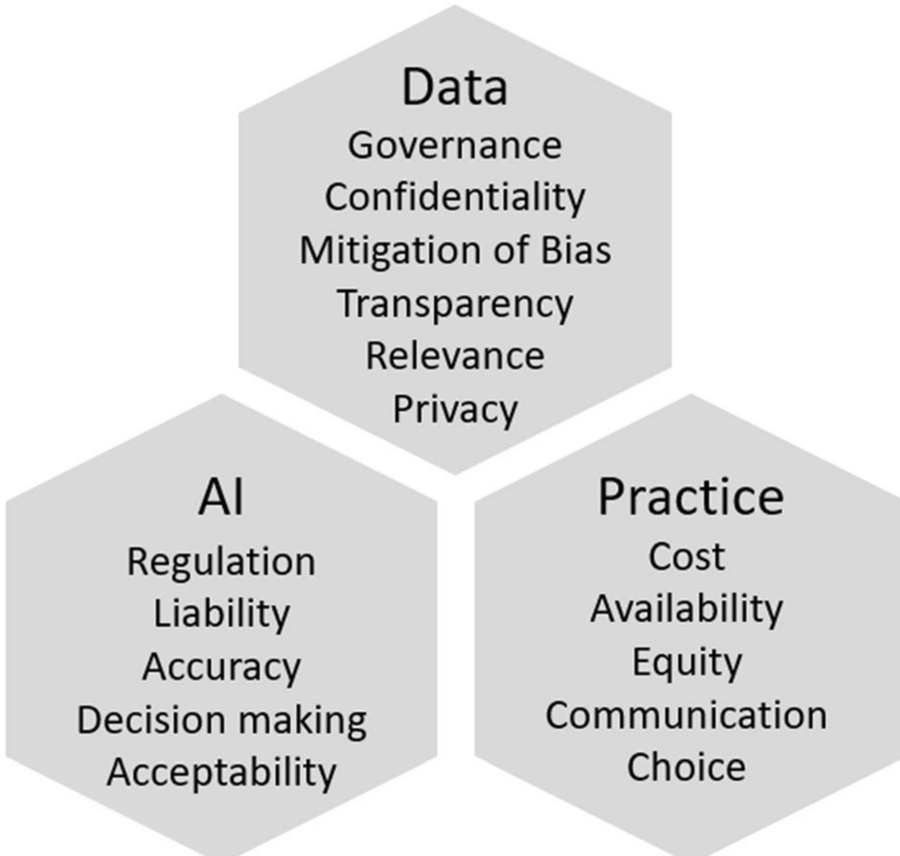

Figure 1: Data, AI, Practice.

patients to ensure that AI-assisted diagnosis or therapy results in the best possible outcomes. The ethical issues that occur when utilizing human data to construct person-targeted applications are perhaps the most challenging problem to handle in AI application to Nuclear Medicine. These ethical concerns are divided into three categories: the data utilized, the algorithms employed, and the way they are used in practice. These three areas in the interplay between ethical and social challenges for AI in medical imaging are also identified in a white paper from the French radiology community and a joint declaration from European and North American associations (Fig. 1)

Ethical challenge:

In imaging, ethics in AI is being learned at the same time as invention and application (6). There is a responsibility to fully comprehend the technology, its advantages, and threats. Many AI algorithms work in a ”black box” setting, which means that the underlying stages in the analysis aren’t visible. In the face of fast changing technology, the inability to attain profound comprehension poses a huge ethical dilemma. AI is confronted with the fundamental ethical issues of autonomy, beneficence, fairness, and knowledge respect. The distinction between data privacy and confidentiality is a critical idea that occurs from the early processing of data. Confidentiality refers to the obligation of maintaining privacy whereas privacy refers to the control over personal information. The potential to considerably enhance health and well-being has spurred demand for not just better (well-labeled) data, but also commercial access to it (6). There is a trade-off between this beneficence and the potential for maleficence via commercial data exploitation or real damage to patients or the ”common good” (6). Large data sets for training and validation are the cornerstone of ANN capacity. This necessitates the use of ”big data.” Data must then be exported to third-party providers in order for ML and DL algorithms to be commercialized. Whether the data is utilized for training, validation, research, or therapeutic purposes, privacy and confidentiality concerns include whether the patient is aware that their data is being used, to what degree, and which components of their data are being used (9). Patients should also know who has access to their information and if (and to what extent) it has been de-identified (9). A patient should be informed of the possibility for their data to be exploited for financial gain by others, as well as if future legislative changes could enhance data vulnerability, particularly if there is a risk that the data will be used in a manner that is damaging to the patient (9). There is still some disagreement regarding who owns patient data and what can and cannot be done with it. Informed permission, privacy and data protection, ownership, impartiality, and injustice relating to those who have or lack the means to process the data are five fundamental characteristics of ethical data management in AI. Humans anticipate ethical/moral relationships with and with non-human intelligent life forms, as represented in movies. When dealing with super-logic and human or superior-tohuman intellect (e.g., humanoid, android, etc.), it is expected to follow the same social, ethical, and moral standards as humans. Humanoid or android creatures, by extension, should be held to the same standards. In terms of accountability and responsibility, AI is presently unaccountable. The fuzzy lines between duties will be more questioned in the future if AI and SI learn unsupervised. Human control of science capable of supremacy over humans, with blurred lines between what is human, human-like, and non-human, might be regarded here. It's fitting that the name Frankenstein is widely used, without distinguishing between Dr. Frankenstein and Frankenstein's monster. Is it a matter of awareness, or is it a matter of perception? If the Turing test is intended to examine AI's capacity to think like a human, we may be worried about reaching a point when AI passes the Turing test, but we must also consider the possibility of SI purposefully failing the Turing test. The slogan of "first, do no harm" applies equally to causing damage by adding AI as it does to causing harm by removing it, and to causing harm by having inequitable access to it. Patients do, however, have the right to have their treatment tailored to their cultural or philosophical choices. This might include AI-assisted healthcare, but it should be distinct from the right to have a human physician make decisions. Is it possible to discriminate against AI or SI? Given the debate above about societal norms, would declining to accept treatment from an AI- /SI-based system based on those grounds alone be any different from rejecting care from a healthcare practitioner based on their gender or ethnicity? Such concerns must be taken into account. Inadequate representation of a certain population (e.g., a minority, a vulnerable group, a pathological subtype, etc.) in the training and validation data may cause bias and inaccuracy in predictions, as well as contribute to the worsening of the health equity gap. This necessitates a few crucial considerations. To begin, one must understand the training data in relation to the data being input before using an AI system. Second, while analyzing the output of an algorithm, ecological validity must be taken into account. Finally, algorithm currency must be maintained to guarantee that prior training data is still relevant for today's data. Finally, when there is a mismatch between training data and the equipment utilized for real patient data, technology-based bias or error should be taken into account. This is particularly essential since the neural network function is sometimes compared to a magician's box, in which we can see what goes in and what comes out but have no idea what transpires within. Indeed, the genuine magic may be found beyond the confines of the box. Transparency, justification, and knowledge sharing are all ethical concerns. The area of operation and criteria associated with unsupervised learning, in particular, are not established by the users, but rather retrieved from the data itself. The capacity to audit this process is crucial for instilling trust in AI outputs, improving AI algorithm quality assurance, and enabling human learning from

AI. In the context of Nuclear Medicine, considerable thought should be given to AI's disruptive character in terms of human interactions (staff/staff and staff/patients), health inequities (positive or negative), decision-making (human, AI, or hybrid), and regulation. Furthermore, major ethical and social issues for AI usage in Nuclear Medicine include data use, storage, and sharing, algorithm openness and trustworthiness, and need (medical benefit and patient preferences). These are mostly dismantled and encapsulated in the ethical standards listed below.

summary of ethical principles:

Beneficence

AI/SI solutions should be conceived and executed for the greater good, with some value to humans. Non- maleficence When it comes to building and deploying AI/SI solutions, results, care, and treatment (including costs) should not be compromised. Justice and fairness Processes should be in place for designing and implementing AI/SI solutions to guarantee that algorithms treat all patients fairly and equally.

Safety

Prioritize preserving and presenting proof of patient safety and quality of care while building and deploying AI/SI systems. To securely incorporate AI/SI technologies into their practices, healthcare practitioners must be adequately taught and equipped.

Reliability

When AI/SI solutions are adopted, they must be designed to be dependable and repeatable, including ecological validity. Methods for quality assurance and performance assessment should be in place for AI/SI mechanisms.

Security

All data must be kept and transported securely within the scope of regulatory regulations while creating and implementing AI/SI systems. Without patient agreement and ethical clearance, data should not be moved beyond the physical/electronic borders of the healthcare provider.

Confidentiality and privacy

AI/SI solutions should be developed and implemented in such a way that all data may be de-identified, while also protecting privacy and confidentiality for large data, allowing cross-institutional cooperation, and allowing commercial use of AI algorithms. Bias Reduction (Mitigation of Bias) When it comes to designing and implementing AI/SI solutions, rigorous, evidence-based clinical trials must be used, the data used for algorithm training and validation must be transparently valid for target populations, and all limitations and potential bias must be disclosed. 8

Transparency and visibility are important.

The usage of, dependence on, and input from AI/SI solutions, as well as how predictions are convolved in the algorithm (magician's box), should be planned and executed to give transparency to patients and service customers. Patients must keep their autonomy in order to comprehend how AI/SI technologies are employed in their treatment and decision-making.

Comprehensibility and explainability

Any influence on patient care, diagnosis, or treatment must be acknowledged and properly explainable/justified when creating and deploying AI/SI systems. AI/SI systems should be built in such a way that they can explain their thinking and have their outputs interpreted by humans.

Human values are important

. Wherever possible, a human-in-the-loop process should be incorporated into AI/SI solutions to apply humanitarian values, accommodate patient values and preferences (including social and cultural norms), and augment AI/SI predictions.

Self-determination, judgment, and decision-making

A human-in-the-loop process must be incorporated when designing and implementing AI/SI solutions to ensure that judgment and decision-making in relation to patient care takes into account the patient's presentation, history, findings, and preferences after a conversation between the patient and the healthcare provider.

Collegiality

Through interdisciplinary collegiality, cooperation, and using the unique competencies of team members in the AI/SI pipeline, AI/SI solutions should be conceived and deployed to optimize results.

Accountability

Prior to developing AI/SI solutions, acknowledgement of shared responsibility among stakeholders must be established and recorded; accountability should not be placed only on the end user interpreting the AI result. Governance To guarantee compliance with ethical principles, legal regulations, and professional standards, AI/SI solutions should be conceived and deployed under an overall governance structure.

Inclusiveness

When building and implementing AI/SI solutions, all stakeholders should be included and empowered, and, in the event of disruptive technologies, the effect or displacement of labor should be minimized

Figure 2: Framework,professional,patient

Conclusion:

The ability of AI applications in Nuclear Medicine to allow deeper, more meaningful interactions between the patient and the clinician has the greatest influence on the patient experience. The paradigm change brought about by AI applications in Nuclear Medicine has the potential to inspire a cultural transformation in which the importance of the patient-provider contact is emphasized. AI provides a strong toolset for the speedy and safe automation of laborious or repetitive operations, as well as deep analysis beyond the human mind's capabilities, freeing up time and energy for doctors to study patient data and connect with patients more skillfully. Integrating AI into patient care solutions has the potential to change the patient-physician relationship's trust dynamic. The patient-physician interaction is altered by the use of AI in practice, from data privacy and security to possible abuse and an enhanced balance of shared responsibility and risk. While AI is transformational, it also poses a variety of ethical and societal issues that demand careful consideration and the development of standards and policy papers

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