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Ethical Considerations in the Implementation of Artificial Intelligence in Radiological Decision-Making: A Comprehensive Review

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Abstract

Background: Artificial Intelligence (AI) technologies are rapidly transforming the medical landscape, particularly in radiology, where they enhance diagnostic accuracy and efficiency. However, the integration of AI raises significant ethical concerns that necessitate thorough investigation. This review systematically explores the ethical implications of AI in radiological decision-making, focusing on issues such as informed consent, bias, and data privacy.

Methods: Employing a systematic literature review methodology, we analyzed academic publications from 2014 to 2023 using five prominent search engines: Google Scholar, Microsoft Academic, PubMed, Scopus, and Web of Science.

Results: Our findings indicate a growing consensus on the potential advantages of AI in improving analytical performance and patient care. However, we also identified critical challenges, including the risk of perpetuating existing biases and the necessity for robust ethical frameworks. Key ethical principles such as beneficence, justice, and autonomy were examined, revealing a need for interdisciplinary approaches to address these complexities. The review highlights the inadequacy of current frameworks in addressing systemic biases and emphasizes the importance of integrating diverse perspectives in AI development and deployment.

Conclusion: In conclusion, while AI holds substantial promise for enhancing radiological practices, its ethical implications must be rigorously addressed to ensure equitable and responsible use. Future research should focus on developing comprehensive ethical guidelines that incorporate social values and address the intersectionality of identity factors in AI applications.

Keywords: Artificial Intelligence, Radiology, Ethical Implications, Bias, Informed Consent

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1. Introduction

Artificial Intelligence (AI) is considered a promising advancement in the medical field. The term AI refers to a machine's capacity to replicate intelligent human behavior (1). Machine learning (ML) is a subset of artificial intelligence (AI) extensively used in medical imaging (2) and encompasses deep learning (DL), which generates data with various degrees of abstraction (3). These technologies have been designed to enhance predictive analytics and diagnostic efficacy, particularly in terms of accuracy and support for personalized decision-making, as researchers have shown that they can "outperform humans" in medical image analysis (4). Numerous researchers have articulated the aspiration to enhance healthcare delivery, particularly via facilitating expedited diagnoses to manage the increased workload from heightened screening (5) and to promote health fairness. AI systems are anticipated to have a substantial influence on radiology.

Artificial Intelligence (AI) is a prevalent topic of discussion" (6). Advancements in artificial intelligence are advancing swiftly within the medical sector. This is shown by the substantial rise in publications concerning the advancement of AI systems in radiology, specifically from around 100–150 annually in 2007–2008 to 700–800 annually in 2016–2017 (2). Nonetheless, the advancement in the debate around these technologies has not aligned with the adoption of these technologies in healthcare. The current level of AI hype much surpasses the actual status of AI research, particularly regarding validation and preparedness for use in patient care (7). Few radiological AI systems have been deployed in the NHS; however, others are pending clearance (5).

In the advancing domain of AI Ethics, research is conducted on the extensive implications of AI across several societal sectors. AI is becoming significant in the medical domain; hence, researchers and practitioners are meticulously evaluating the ethical and sociological ramifications of AI implementation to prevent detrimental effects on persons and groups, particularly the most vulnerable populations. AI will significantly influence radiology, impacting end users and presenting extensive issues in clinical practice. While the introduction of AI is changing the role of the "radiologists-in-the-loop," patients and other societal groups are being confronted with complex questions concerning the scope of informed consent, biases that may result in inequality, and risks associated with data privacy and protection, as well as open questions regarding responsibility and liability. These questions are accompanied by concerns that AI systems could perpetuate or even amplify ethical and societal injustices. Based on key ethical values such as respect, autonomy, beneficence, and justice (8), several guiding principles and recommendations have been formulated to tackle these issues (9, 10)—Such principles and recommendations have also been communicated on EU level (11), and initiatives such as FUTURE-AI (12) have been started, which have been developed to ensure that advances in AI systems and advances in AI ethics do not contradict one another.

In this paper, we contribute to the discourse on the ethics of AI in radiology by reviewing the state-of-the-art literature and discussing the findings from a philosophical and social science perspective. We consider the comment made by (13), namely, that "reviewing the literature is a first step to conduct ethical foresight, in the sense that it allows one to distinguish between issues and implications that are currently under consideration and those that are not yet acknowledged or require further attention." In our review, we highlight underexplored ethical and societal aspects and point out the necessary future research directions in the field.

2. Methods

We conducted an exhaustive examination of ethical and societal concerns previously identified and deliberated, along with the measures taken to address these issues within the realm of AI. This involved a systematic review of contemporary academic literature from 2014 to 2023. Five search engines (Google Scholar, Microsoft Academic, PubMed, Scopus, and Web of Science) were employed to locate pertinent articles on these matters.

3. Anticipations

The literature analysis indicates that the implementation of AI systems in healthcare has been positively received, aligning with anticipated outcomes. Consequently, we identified three primary domains where changes and improvements are anticipated: enhanced analytical performance, advantages for patients, clinicians, and society, and a transformation in the professional role of radiologists.

The expectation that AI will significantly improve diagnostics and patient care is a key assumption that is expressed throughout the sample. Choy et al. (14) describe current AI applications to help with case triage, maximize image quality, detect and interpret findings automatically, and perform automated processes related to treatment (e.g., in radiotherapy) and point out that these applications can support the personalization of treatment via predictive analytics by making scheduling easier. Hosny et al. (15) identify three radiological tasks in which AI can play a significant role: in the detection of abnormalities, their characterization, and in monitoring changes. Other authors note that further applications of AI are expected to increase analytical power (i.e., to perform analyses more rapidly than humans and to minimize human error) and to identify as-yet unknown relationships (2, 16). Eventually, such applications can be used to detect diseases earlier and to provide proper treatment with fewer unnecessary procedures, better cost efficiency, and lower inter- and intra-reader variability (17).

The advancements in medical diagnostics are anticipated to advantage end users. For example, Kelly et al. (18) delineate a quadruple aim for the implementation of AI systems in healthcare: enhancing the experience of care, improving population health, decreasing per capita healthcare costs, and enriching the work life of healthcare providers. Ryan and Stahl (10) underscore the ethical principle of beneficence, asserting that AI should serve societal interests and promote the common good.

The expectations regarding radiologists are ambiguous, with some scholars highlighting the fact that AI will outperform clinicians and be able to diagnose more rapidly and accurately. Bjerring and Busch (19) state “We can at least with some warrant adopt the assumption that AI systems will eventually outperform human practitioners in terms of speed, accuracy, and reliability when it comes to predicting and diagnosing central disease types such as cancer, cardiovascular diseases, and diseases in the nervous system.” On the other hand, some scholars consider that AI will not be able to perform all the tasks that health practitioners currently do without any human intervention. Naqa et al. (20) propose what they consider to be a realistic vision that keeps “humans in the loop.” According to this perspective, AI systems will serve as physicians' partners, enabling them to deliver improved healthcare by combining AI/ML software with the best human clinician knowledge. This partnership would allow the delivery of healthcare that outperforms what either can deliver alone, thus improving both credibility and performance.

4. Obstacles

Despite the hype surrounding AI implementation in healthcare and radiology, numerous authors highlight the challenges this can raise. One key challenge concerns the data that is used to train AI, such as the lack of labeled (i.e., annotated) data. Massive amounts of data are needed to train algorithms (21), and training images must be annotated manually. This challenge is accompanied by a secondary challenge: the fact that the amount of radiological imaging data continues to grow at a disproportionate rate as compared to the number of available, trained readers (15). While some authors propose using a model that has been developed to keep “the loop,” others consider that the availability of human validation will limit the promises of AI. Tizhoosh and Pantanowitz (22) comment that “The pathologist is the ultimate evaluation if AI solutions are deployed into clinical workflow. Thus, full automation is neither possible, it seems, nor wise as the Turing test postulates.”

The cost of essential computational resources presents a significant challenge (22). Geis et al. (23) indicate that AI may exacerbate disparities in resource allocation, resulting in a divide between institutions with varying levels of 'radiology decision-making capabilities. Smaller or resource-constrained institutions may struggle to provide the necessary resources to operate sophisticated AI systems, particularly those that are proprietary. The authors (23) assert that “Almost certainly some radiology AI will be proprietary,

developed by large academic or private health care entities, insurance companies, or large companies with data science expertise but little historical radiology domain knowledge. This may exacerbate disparities in access to radiology AI."

The scarcity of resources is intricately linked to potential biases, particularly automation bias, defined as the "tendency for humans to favor machine-generated decisions, disregarding contrary data or conflicting human judgments" (24). Geis et al. (23) contend that automation bias may result in errors of omission, wherein individuals may overlook or dismiss the shortcomings of AI tools. This situation may conflict with the literature's advocacy for a "human-in-the-loop" approach, as "risks may be magnified in resource-poor populations because there is no local radiologist to veto the results" (23).

Concerns have been expressed in the literature regarding the feasibility of integrating AI into routine clinical practice, as real-world applications remain infrequent, and only a limited number of algorithms have undergone clinical evaluation or implementation (5, 18). Consequently, the realism of this integration is questioned, and the effective amalgamation of AI systems with human decision-makers remains ambiguous (22). Additionally, other researchers (25) have observed that in the few instances of system implementation, no evidence of enhanced clinical outcomes has been demonstrated, while Kelly et al. (18) identify various challenges associated with such systems, including logistical obstacles, quality assurance, human resistance, and claims regarding algorithmic interpretability.

5. Discussion

This literature review was conducted to identify ethical issues addressed in recent academic literature regarding the application of AI in healthcare and to ascertain how these issues are being addressed in the context of biomedical research, particularly in radiology and oncology imaging. This review allowed us to identify key themes emphasizing expectations surrounding medical AI, challenges associated with this technology, and strategies to ensure ethical AI utilization. Most of these themes are articulated by the authors as principles. In this section of the article, we critically analyze our findings from an ethical and social science perspective.

Several expectations are expressed in the literature regarding the potential for medical AI use to improve diagnostic performance and patient outcomes, but the socio-technological conditions under which these expectations can be met, and, at the same time, challenges can be managed are not clearly defined. We previously quoted that "the state of AI hype has far exceeded the state of AI science, especially when it pertains to validation and readiness for implementation in patient care" (7). This statement illustrates an important gap: The contexts in which medical AI tools are being implemented have not been thoroughly explored. Considering the results of our review, this holds particularly true regarding the close connection between AI algorithms and societal structures. Although some scholars have discussed the fact that AI use "can increase systemic risks of harm, raise the possibility of errors with high consequences, and amplify complex ethical and societal issues" (23), few studies have clearly defined exactly how AI tools interact with pre-existing systemic harm, how they can contribute to this harm, or how complex ethical and societal issues might be amplified through the use of such tools. In the reviewed literature, we identified a need for profound, specific, and interdisciplinary conversations about how firmly AI is embedded in systemic structures and power relations that intersect with identity traits (e.g., gender, race, class, ability, education) and about the implications of private ownership and the role of corporations, profit-making, and geopolitical structures.

We have noted that bias has not been contextualized within power dynamics and societal conditions, nor has it been linked to existing research on how gender and race influence biomedicine and healthcare practices (26-29) or how gender and racial bias in algorithms can adversely affect certain societal domains (30,31). Bias has been demonstrated to impact every phase of data processing (i.e., generating, collecting, and labeling data utilized for training AI tools) and to influence the variables and rules employed by algorithms. Consequently, AI tools can be programmed to discriminate, perpetuate social stereotypes, and underperform with minority groups, posing significant risks in the healthcare sector (32,33).

In the analyzed sample, little attention was given to sex and gender bias in AI systems used in healthcare. Nonetheless, research has already been done to analyze in detail how sex and gender bias is generated, how it affects patients and society, and how its effects can be mitigated. Using sex- and gender-imbalanced datasets to train deep-learning-based systems may affect the performance of pathology classification with minority groups (34). Other authors also show that these social categories could influence the diagnosis although there is no direct link to the disease, and that potentially missed detection of breast cancer at mammography screening was greater among socioeconomically disadvantaged groups (35). Unfortunately, most of the currently used biomedical AI technologies do not account for bias detection, and most algorithms ignore the sex and gender dimensions and how these contribute to health and disease. In addition, few studies have been performed on intersex, transgender, or non-binary individuals due to narrow and binary background assumptions regarding sex and gender (36). Ignoring how certain identity traits affect the application of AI systems in healthcare can lead to the production of skewed datasets and harm certain minority people and groups. Applying feminist standpoint theory (37,38), some authors argue that all knowledge is socially situated and that the perspectives of oppressed groups are systematically excluded from general knowledge and practices that ignore the specific identity traits of certain individuals. Based on this argument, knowledge must be presented in a way that enables people to be aware of intersecting power relations that influence its production. The results of our literature review indicate that rather than ignoring sex, gender, or race dimensions, close attention must be paid to these dimensions in datasets (34, 39), even to the extent of introducing an amount of desirable bias to counteract the effects of undesirable biases that result in unintended or unnecessary discrimination (36, 40).

Diversity in the datasets becomes an increasingly important point that is being addressed by researchers to counteract bias that can be potentially harmful (41). Nonetheless, ensuring diversity in and of itself is not enough; more research is needed to understand how discrimination intersects with socioeconomic factors to keep bias from being introduced into healthcare algorithms through structural inequalities in society (42). Anticipating structural bias in datasets and understanding the social implications of using AI systems before their implementation is considered best practice; some authors in the sample even propose that failing to do so should be qualified as scientific misconduct (43). This will require reflecting on how social categories are constructed in big data-driven research and on how the underlying social classification and categorization systems are incorporated into and reproduced in the knowledge produced from analyzing the existing datasets (44).

6. Deficiency in Analytical Precision

We observed that explainability and interpretability were often used interchangeably with other terms such as understandability and even transparency in our sample, as clear definitions of and analytic distinction between the terms are lacking. The lack of analytical precision that can be observed in the ethics of AI literature often leads to a lack of specificity and vague assumptions that do not enable scholars to reach the core of certain issues that are associated with epistemic justice (45). The GDPR, for instance, states that subjects have a right to understand their lived experiences, especially experiences of injustice. Although research addresses the problem of how this right to an explanation is outlined in the legislation (46), we argue that the lack of knowledge about why and how certain decisions that impact (negatively) our lives are made constitutes a specific wrongful act, i.e., epistemic injustice (45). This injustice results in someone being wronged specifically in their capacity as a possessor of knowledge; they are wronged, therefore, in a capacity essential to human value. The opacity of AI and the implications of the use of AI tools make it difficult for patients to exercise their autonomy. This inability is consequently also reflected in their practical limitation to give their informed consent and affects their capacity to contest decisions. To address epistemic injustices, knowledge must be made available to people affected by the decisions made by AI technology.

In the literature we examined, the accessibility and comprehensibility of information are frequently regarded as technical attributes of AI. This perspective may suggest that these challenges are merely technical issues solvable through technical solutions addressing black boxes. However, we have identified a necessity for a social sciences perspective to attain a more nuanced understanding of how our epistemic

capabilities are interlinked with power dynamics. In "AI ethics, technical artifacts are predominantly perceived as discrete entities that can be refined by specialists to devise technical solutions for technical dilemmas. What is often overlooked is an examination of the broader contexts and the intricate relational networks in which technical systems are situated" (47). It is imperative to meticulously analyze the frameworks surrounding the creation and dissemination of knowledge by conducting further investigations into the ethics of AI in healthcare.

Trust was often mentioned as an important factor in the reviewed literature, and trustworthiness has become a key principle regarding ethical AI. As we have shown, a clear definition and deeper understanding of the complexities of trust in AI are lacking. In the reviewed literature, for example, we found that trustworthiness is conflated with acceptance (24) or explainability. Some authors have mentioned that "a possible imbalance in the data should be considered when developing the model to ensure the trustworthiness of the model". However, for a model to be considered worthy of trust, more than simple technical solutions that even out technical "imbalances" in the training phase are needed, especially when a risk of gender or racial bias exists. This is a more complex issue that will need to be addressed. Also, while it is important to encourage trust in technology, trust is built on the foundation of social relations. Healthcare practitioner-patient relationships are based on trust and empathy, and decision-making in the medical context, especially in connection to technology, is often based on "gut feelings".

Previous research has shown that trust cannot be understood as unidirectional. Instead, trust needs to be understood as a complex, situated, context-dependent, and relational concept that involves several trustor/trustee relationships, such as trust in persons (e.g., scientists who trust each other, patients who trust scientists and clinicians), technology, and institutions (45). Trust involves "the willingness to accept vulnerability based on positive expectations about another's intentions or behaviors […] Trust makes decision-making more efficient by simplifying the acquisition and interpretation of information. Trust also guides action by suggesting behaviors and routines that are most viable and beneficial under the assumption that the trusted counterpart will not exploit one's vulnerability". In building trust, embodied experience matters, and this experience occurs as an emotional reaction, e.g., in the form of the aforementioned "gut feelings" (23). Trust or more precisely trusting relationships are fragile and require continuous work, which means that they need to be actively established and sustained. This includes trustworthiness (i.e., the idea that a person or object is worthy of being trusted), which is a key requisite for the sustainability of a trusting relationship (3). To ensure trustworthiness, researchers must understand how trusting relationships are constituted via the social process, how trust in technologies is established and sustained, and under what conditions AI can be deemed trustworthy.

This discourse underscores the significance of trust in the practitioner-patient relationship concerning the utilization of medical AI, highlighting the expectations and needs of these stakeholders. Regrettably, the existing literature seldom addresses the perspectives of patients and radiologists, with few notable exceptions. Nonetheless, Ferretti et al. (6) asserted that "more research is needed to understand patients' and physicians' attitudes toward opacity in AI systems." Patients desire transparency regarding the usage of their health data, a stipulation also mandated by the GDPR. Engaging the public, patients, practitioners, and technology developers will be essential to foster trust and secure both public and professional endorsement.

7. Conclusions and Prospective Pathways

In conducting this literature review, we examined contemporary discourses concerning the ethical and societal implications of AI utilization in radiology. We identified conceptualizations of science and technology as neutral, universal, and independent of societal frameworks, concepts previously articulated in the philosophy of science and science and technology studies (STS) (37).

We have observed that the current literature discourse does not delve into the broader origins and implications of bias, especially when bias is treated only as a technical problem with a technical solution. We believe that integrating a social science perspective into the analysis of ethical and societal issues associated with AI use in radiology is crucial to understanding the scope of these issues. To thoroughly

address the topic of ethical AI use in radiology, a perspective must be taken to analyze how science is situated in a certain socioeconomic context and to understand the application of AI systems in medicine as a situated practice. Understanding the socioeconomic context is a fundamental step that will enable scholars to gain this perspective. In the future, inter- and trans-disciplinary research should be carried out to help situate knowledge production and its ethical and societal implications. In this sense, it will be necessary to shift from DL to a deep understanding of the societal implications, and in particular to an understanding of the interactions of social values and categories with scientific knowledge production, of the relations between knowledge and societal trust that affects how science functions in society, and especially of how new technologies are perceived and accepted in society.

This review and the subsequent discussion highlighted a deficiency in the precision of terminology concerning principles proposed for the ethical application of AI technology in the future. Terms such as trustworthiness, transparency, and trust are frequently employed in the literature, often without explicit definitions of their intended meanings. Researchers engaged in the ethics of AI in medicine must pursue accuracy and precision by offering clear definitions for these concepts within this specific context and situating them within a broader framework. To achieve this, interdisciplinary collaboration with social scientists and clinicians to integrate clinical concepts will be essential (12).

More interdisciplinary and concrete research will deepen our understanding of biases in radiology. Adopting an intersectional perspective that takes into consideration how different traits of our identity intersect will be crucial, especially in the case of breast cancer. As previous research has shown, other factors that intersect with gender contribute to the formation of bias, such as ethnicity, skin color, socioeconomics, geography, or breast density (12). In this regard, the issue of gender bias in female-only datasets requires a more detailed analysis. Considering breast cancer in connection to gender can lead to the abridged conclusion that gender bias could not have a significant impact. However, this reflects a one-dimensional understanding of gender as a social category, since gender is never isolated, but occurs at the intersection with other categories. Therefore, women cannot be assumed to be a homogeneous group, but are differentiated along other categories such as age, race, and socioeconomic background, which, as has been shown, could influence breast cancer diagnosis.

In conclusion, the value of AI in radiology would be enhanced by incorporating a more accurate and interdisciplinary understanding of the societal context in which AI is developed, thereby fostering equitable outcomes and ensuring equal access to the advantages of these promising applications for all societal members.

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الاعتبارات الأخلاقية في تنفيذ الذكاء الاصطناعي في اتخاذ القرارات الإشعاعية: مراجعة شاملة

الملخص

الخلفية :تعمل تقنيات الذكاء الاصطناعي (AI) على تحويل المشهد الطبي بسرعة، لا سيما في مجال الأشعة، حيث تعزز دقة التشخيص وكفاءته. ومع ذلك، فإن دمج الذكاء الاصطناعي يثير مخاوف أخلاقية كبيرة تتطلب تحقيقًا دقيقًا. تستكشف هذه المراجعة بشكل منهجي الآثار الأخلاقية للذكاء الاصطناعي في اتخاذ القرارات الإشعاعية، مع التركيز على قضايا مثل الموافقة المستنيرة، والتحيز، وخصوصية البيانات.

الطرق :باستخدام منهجية مراجعة الأدبيات المنهجية، قمنا بتحليل المنشورات الأكاديمية من 2014 إلى 2023 باستخدام خمسة محركات بحث بارزة: Google Scholar، Microsoft Academic، PubMed، Scopus، و Web of Science.

النتائج :تشير نتائجنا إلى وجود توافق متزايد حول الفوائد المحتملة للذكاء الاصطناعي في تحسين الأداء التحليلي ورعاية المرضى. ومع ذلك، حددنا أيضًا تحديات حاسمة، بما في ذلك خطر استمرار التحيزات الحالية وضرورة وجود أطر أخلاقية قوية. تم فحص المبادئ الأخلاقية الرئيسية مثل النفعية، والعدالة، والاستقلالية، مما يكشف عن الحاجة إلى نهج متعدد التخصصات لمعالجة هذه التعقيدات. تسلط المراجعة الضوء على عدم كفاية الأطر الحالية في معالجة التحيزات النظامية وتؤكد على أهمية دمج وجهات نظر متنوعة في تطوير الذكاء الاصطناعي ونشره.

الخاتمة :في الختام، بينما يحمل الذكاء الاصطناعي وعدًا كبيرًا لتحسين الممارسات الإشعاعية، يجب معالجة آثاره الأخلاقية بشكل صارم لضمان الاستخدام العادل والمسؤول. ينبغي أن تركز الأبحاث المستقبلية على تطوير إرشادات أخلاقية شاملة تأخذ في الاعتبار القيم الاجتماعية وتعالج تقاطع عوامل الهوية في تطبيقات الذكاء الاصطناعي.

الكلمات المفتاحية :الذكاء الاصطناعي، الأشعة، الآثار الأخلاقية، التحيز، الموافقة المستنيرة.