

Integrating Ethics and Innovation: Navigating the Future of Artificial Intelligence in Healthcare

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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AI's Role in Healthcare

In the rapidly evolving landscape of the 21st century, the advent of artificial intelligence (AI) marks a seminal shift in technological capability, extending its influence beyond traditional boundaries and into the critical sphere of healthcare. This incursion promises a transformative impact, offering opportunities for enhancing diagnostic precision and personalizing patient treatment. The potential of AI to revolutionize healthcare is immense, suggesting a future where medical interventions are not only more efficacious but also tailored to the individual needs of patients. However, this promise is entwined with ethical concerns, particularly around the protection of patient data and the assurance of fairness in algorithmic processes. (Davenport, T., & Kalakota, R., 2019) Despite the fact that studies demonstrate that employing AI in the medical area is a much cheaper and cost-effective means of doing research, and sometimes even better than human researchers and providers, many people still do not trust it. The reluctance in using medical AI is mainly due to the lack of understanding in both medical providers and patients. (Cadario, R., Longoni, C. & Morewedge, C.K., 2021) Addressing these concerns requires a nuanced examination of AI's ethical application in healthcare, ensuring that its deployment enhances patient care without undermining fundamental ethical principles.

To navigate the complex interplay between AI and healthcare, we engage with the Social Construction of Technology (SCOT) theory, an analytical framework from the field of Science, Technology, and Society (STS) studies. SCOT allows us to explore how AI technologies are not merely shaped by technical parameters but are also co-constructed by societal forces, user practices, and regulatory frameworks within the healthcare domain. This perspective emphasizes the role of human actors—patients, healthcare professionals, policymakers, and developers—in influencing the development and implementation of AI technologies. By adopting SCOT, we can

critically assess the social dynamics and ethical considerations that shape AI's integration into healthcare systems, shedding light on how these technologies can be developed and utilized in ways that align with societal values and ethical standards.

Central to our inquiry is the question: How can Artificial Intelligence in healthcare be ethically applied to enhance diagnostic accuracy and patient treatment while ensuring data privacy and algorithmic fairness? This research question steers our exploration towards understanding the potential of AI to innovate healthcare practices and the ethical imperatives that must guide its integration. Our aim is to articulate a balanced approach that leverages the capabilities of AI to transform healthcare while rigorously addressing the ethical challenges it poses. Through this investigation, we seek to contribute to the ongoing dialogue on the ethical deployment of AI in healthcare, proposing pathways that foster innovation in alignment with ethical integrity and the promotion of equitable patient care.

Research Question

How can the integration of Artificial Intelligence (AI) in healthcare ethically enhance diagnostic accuracy and patient care while ensuring data privacy and algorithmic fairness?

Methods

The research for answering this question employs a comprehensive review of existing literature and policy documents. This approach allows for an in-depth examination of ethical considerations surrounding AI in healthcare. Focusing on the intersection of technology and ethics, this study scrutinizes scholarly articles and healthcare policies using targeted search terms such as "Artificial Intelligence in healthcare," "ethical implications," "data privacy," and

"fairness in algorithms." By analyzing the content and implications of these documents, the research aims to uncover how AI can be responsibly leveraged in medical settings. The literature review is structured to capture a wide array of perspectives on the ethical integration of AI technologies, highlighting successes, challenges, and lessons learned from various healthcare contexts. Through this analysis, SCOT is applied to demonstrate the significance of societal input and stakeholder collaboration in shaping the ethical deployment of AI in healthcare. The findings and discussions derived from the literature and policy review intend to offer actionable insights and recommendations for policymakers, healthcare practitioners, and technologists to navigate the ethical complexities of AI adoption in healthcare environments.

The Evolution of AI in Healthcare

The evolution of healthcare is on the brink of a transformative era, propelled by the integration of Artificial Intelligence (AI). This technological leap holds the promise of revolutionizing the way healthcare is delivered, making diagnostics more accurate, treatments more effective, and patient care highly personalized. The roots of AI in healthcare can be traced back to its initial applications in data analysis and pattern recognition, gradually expanding to more complex tasks such as predictive analytics, personalized treatment plans, and even robotic surgeries. These advancements have been made possible by AI's unparalleled ability to sift through and interpret vast datasets—deciphering patterns and insights beyond human capacity, and at a fraction of the time. (Padhi, A., Agarwal, A., Saxena, S.K., 2023)

However, the rapid advancement and application of AI in healthcare have not been without controversy. Ethical considerations surrounding the use of AI have become increasingly prominent, as the reliance on algorithms and data analytics introduces a range of potential risks

and dilemmas.(Whittlestone, J., Nyrup, R., Alexandrova, A., Dihal, K., & Cave, S. 2019) The utilization of personal health information (PHI) is a double-edged sword; while it is essential for the development of effective AI tools, it also raises significant concerns about data privacy and security. (C. Pandit, H. Kothari and C. Neuman, 2020) Questions of consent and the ethical use of data are paramount, as is the need for stringent measures to protect sensitive patient information against breaches.

Moreover, the specter of algorithmic bias presents a formidable challenge, with the potential to exacerbate existing disparities in healthcare access and outcomes. The development of AI algorithms is not immune to the biases of their creators, which can inadvertently lead to outcomes that favor certain groups over others. This introduces a pressing need for transparency and accountability in the development and deployment of AI systems within healthcare. The pursuit of algorithmic fairness must be relentless, requiring continuous efforts to identify, understand, and mitigate biases.

From a consequentialist viewpoint, the benefits of AI in healthcare are undeniable. AI has the potential to significantly reduce diagnostic errors, streamline the delivery of care, and make high-quality healthcare more accessible to underserved populations. (Johnson, K.B., Wei, W.-Q., Weeraratne, D., Frisse, M.E., Misulis, K., Rhee, K., Zhao, J. and Snowdon, J.L., 2021) It offers hope for breakthroughs in the treatment of complex diseases, enabling personalized medicine that can adapt to the unique genetic makeup of individual patients.

Yet, from a deontological perspective, the ethical deployment of AI in healthcare demands a rigorous adherence to principles over outcomes. It emphasizes the importance of patient autonomy, ensuring that individuals remain at the center of their care decisions.

(Karimian, G., Petelos, E. & Evers, S.M.A.A., 2022) The development of AI technologies must

be governed by ethical principles that prioritize the protection of patient privacy, the confidentiality of health data, and the fairness of treatment outcomes.

Navigating the ethical landscape of AI in healthcare requires a comprehensive strategy that balances innovation with ethical integrity. This involves not only ensuring the transparency of AI algorithms and systems but also actively engaging in efforts to detect and correct biases. Protecting patient privacy necessitates a commitment to going beyond compliance with existing regulations, such as HIPAA, and adopting proactive measures to safeguard against the evolving threats to data security in the digital age.

As we look deeper into the ethical challenges and opportunities presented by AI in healthcare, it is clear that a balanced approach is essential. By acknowledging the transformative potential of AI and adhering to a robust ethical framework, we can move toward a future in which AI not only enhances the healthcare experience but does so in a manner that upholds the dignity and rights of every patient. This background forms the basis for a more detailed exploration of how AI can be ethically integrated into healthcare, aiming to maximize its benefits while addressing the ethical concerns that accompany its use.

SCOT and AI Integration in Healthcare

Introducing Artificial Intelligence into healthcare is a narrative rich with innovation, closely knit into our social fabric, echoing the essential nature of human connections. As we venture into this novel territory, we're not merely encountering devices with superior computing power. We envision a healthcare landscape revolutionized by AI—where patient care is remarkably personalized, diagnostic processes achieve unparalleled precision, and treatments are

custom-fitted for each individual. However, navigating this promising horizon comes with its set of ethical dilemmas and challenges.

The lens of the Social Construction of Technology (SCOT) allows us to peer beyond the binary code and machinery of AI. It serves as a reminder that technology's birth and evolution are deeply rooted in human influence, cultural values, and societal norms. SCOT reveals the diverse perceptions of AI between healthcare providers and patients. Where a physician might see AI as a breakthrough in combating illness, a patient might express concerns over the erosion of personal interaction or anxieties about data privacy. (Topol, E.J, 2019) Such divergent views necessitate a harmonized approach to AI's introduction into healthcare, striving for a balance between its technological merits and the ethical values it must uphold. (Sara G., Timo M., Glenn C., 2020)

Furthermore, SCOT sheds light on how technology carves its niche within our lives, emphasizing that innovation isn't merely about creation but also about societal acceptance, adaptation, and utilization. It underlines the collective endeavor of integrating AI into healthcare—a collaborative process involving algorithm developers, regulatory bodies, medical personnel, and the patients themselves. This shared effort underlines the importance of establishing transparent ethical guidelines that prioritize patient confidentiality, promote fairness, and maintain the essence of human-centric care.

Implications of AI in Healthcare

AI, in its quest to revolutionize healthcare, promises a future where diagnoses are more precise and treatments more personalized. Yet, this future is clouded by concerns over biases that may skew AI's judgment, potentially leading to disparities in patient care. The integration of AI

in healthcare, particularly in radiology, has surged, driven by a global shortage of radiologists and the burgeoning number of medical imaging devices. Japan, with its distinctive position of having the lowest number of radiologists per capita alongside the highest count of CT and MRI machines among OECD countries, has become a fertile ground for AI applications in radiology (Ueda, D., Kakinuma, T., Fujita, S. et al., 2023). This scenario underscores the pressing need to address AI fairness, ensuring that AI tools perform equitably across diverse patient groups.

Fairness in AI is a concept rooted deeply in the ethical obligations of healthcare to offer quality care to all, irrespective of age, gender, ethnicity, or social standing. However, achieving this fairness is fraught with challenges, primarily due to biases inherent in AI systems. These biases can emerge from the data used to train AI algorithms or the algorithms themselves, potentially leading to discriminatory practices and outcomes. For instance, "cardiovascular risk prediction tools, historically trained predominantly on male patient data, have shown inaccuracies in assessing risk among female patients," highlighting the critical issue of minority bias. "The reliance on non-representative training data can result in a training-serving skew, where AI tools exhibit diminished performance when applied to external datasets," underscoring the importance of diverse and representative data in AI development (Ueda, D., Kakinuma, T., Fujita, S. et al., 2023). Mitigating these biases necessitates a concerted effort involving algorithm auditing, validation, and the fostering of transparency and accountability in AI applications. Regular audits and independent validations of AI algorithms are essential to identify and rectify biases, ensuring that AI systems remain fair and effective across varied healthcare settings (Ueda, D., Kakinuma, T., Fujita, S. et al., 2023). Moreover, educating both clinicians and patients about the potential biases in AI is vital for fostering an informed

healthcare community, capable of critically evaluating AI-generated recommendations and making decisions that reflect the best interests of patients.

When it comes to moral and legal issues, protecting patient privacy about their data stands out as being crucial. The ethical deployment of AI in healthcare must navigate the delicate balance between leveraging data for innovation and protecting individual privacy rights. Establishing robust frameworks for liability and accountability further underscores the need for clear delineation of responsibilities among AI developers, healthcare providers, and institutions, ensuring that the benefits of AI are realized without compromising ethical standards.

AI's potential to revolutionize healthcare is underscored by its capability to enhance diagnostic accuracy and patient treatment, offering hope for a future where medical interventions are not only more effective but also personalized. "Healthcare systems across the globe are struggling with increasing costs and worsening outcomes...AI, particularly Machine Learning, could offer great opportunities for the improvement of healthcare services" (Morley, J. et al., 2023). This assertion aligns with the growing consensus among policymakers, clinicians, and technologists who view AI as a critical component in addressing the multifaceted challenges of modern healthcare systems.

The ethical terrain of AI in healthcare is mapped across multiple dimensions, highlighting concerns that span from individual to societal levels. At the heart of these concerns lies the dual challenge of ensuring data privacy and algorithmic fairness, two pillars essential for maintaining trust and equity in AI-enhanced healthcare systems. The discourse on ethics emphasizes the importance of a proactive approach, advocating for the anticipation and mitigation of ethical dilemmas before they manifest in clinical practice. "If these AI solutions are to be embedded in clinical practice, then at least three issues need to be considered: the technical possibilities and

limitations; the ethical, regulatory, and legal framework; and the governance framework" (Morley, J. et al., 2023). This perspective ensures that AI's integration into healthcare is not only technologically sound but also ethically responsible and aligned with societal values. The synthesis of these findings within the Social Construction of Technology (SCOT) framework provides a robust theoretical lens through which to understand AI's role in healthcare. SCOT's emphasis on the mutual shaping of technology and society offers valuable insights into how AI technologies are perceived, developed, and utilized in healthcare settings. It illuminates the importance of considering the social dynamics that influence technological adoption and the ethical imperatives that must guide this process.

Moving forward from the ethical frameworks discussed, it's essential to consider how Artificial Intelligence (AI) has seamlessly integrated into various facets of healthcare, transcending traditional methods to offer solutions that are both innovative and cost-effective. AI's role in healthcare is multifaceted, from basic tasks like temperature measurement to more complex challenges such as tumor detection and other critical diagnostics. The efficiency and cost-effectiveness of AI in performing tasks traditionally handled by healthcare professionals underline its transformative potential. Yet, despite the clear advantages and cost savings demonstrated by numerous studies, there remains a notable hesitancy among healthcare providers and patients towards fully embracing AI technologies.

A number of issues, including a lack of knowledge and confidence in AI's capabilities and decision-making processes, contribute to this hesitation. Romain Cadario, Chiara Longoni, and Carey K. Morewedge's essay "Understanding, explaining, and employing medical artificial intelligence" provides information on why, despite its obvious advantages, there is a divide in the adoption of AI in healthcare. AI's potential to improve service delivery at scale is demonstrated

by the quick spread of algorithms within healthcare systems, which enable anything from telehealth to the supply and demand of inpatient care services. This indicates that AI can provide expert-level accuracy in patient management and diagnostics. However, eliminating mistrust and increasing patient confidence in these systems are still necessary for the broad acceptance and patient use of medical AI. Concerns about accountability and patients' beliefs that AI is less equipped to meet their specific requirements than human healthcare practitioners highlight the need for improved transparency and communication about AI's place in the medical field. As telehealth services gain traction and the demand for healthcare continues to rise, the significance of algorithmic-based healthcare services in ensuring accessible, high-quality care cannot be overstated. The journey towards widespread acceptance and trust in medical AI necessitates ongoing research and dialogue to mitigate concerns and highlight the tangible benefits AI brings to healthcare. The advancements made possible by AI in the medical field signal a promising future, yet achieving its full potential requires bridging the gap between technological capabilities and human trust and understanding.

Artificial Intelligence promises to revolutionize healthcare by improving diagnostic accuracy and patient care while raising important ethical and legal considerations. Its adoption in healthcare delivery has shown the potential to enhance patient safety and improve outcomes but introduces complex ethical dilemmas and legal challenges (Terranova C, Cestonaro C, Fava L and Cinquetti A, 2024). As AI systems become more integrated into healthcare, their impact on professional liability assessment becomes increasingly significant, necessitating new skills among judges, lawyers, and expert witnesses. The medico-legal landscape is evolving with the introduction of AI, requiring adaptations in the assessment of professional liability to accommodate the nuances introduced by AI technologies. These technologies, particularly those

integrated with human decision-making processes, offer a collaborative approach to healthcare that combines the strengths of AI analytics with human expertise and judgment. This integrated AI approach is becoming more accepted, reflecting a shift towards systems that support rather than replace human healthcare professionals. For example, AI can suggest potential diagnoses based on medical image analysis, yet final decisions on patient care remain with human physicians who consider AI outputs as part of their decision-making process. This approach emphasizes the importance of human involvement in healthcare, ensuring that AI serves as an augmenting tool rather than a replacement for human expertise (Terranova C, Cestonaro C, Fava L and Cinquetti A, 2024). However, these advances must be carefully balanced with concerns about data privacy and fairness in algorithmic decision-making.

AI technologies, particularly in diagnostics, have shown promise in accurately identifying diseases from medical imaging. A 2020 article discusses how AI models, trained on vast datasets, can surpass traditional methods in both speed and precision, offering significant advancements in detecting conditions like diabetic retinopathy and skin cancer. (Parfett, A., Townley, S. & Allerfeldt, K., 2021). However, the success of these technologies hinges on the quality and diversity of the training data. Issues of bias and fairness arise when the data does not adequately represent all patient demographics, potentially leading to poorer outcomes for underrepresented groups. Further, AI's role in supporting clinical decision-making illustrates the dual imperative of enhancing care while safeguarding patient autonomy and privacy. The integration of AI tools provides clinicians with more accurate diagnostic information, yet it also raises ethical concerns about the transparency of these tools and the security of patient data. (Parfett, A., Townley, S. & Allerfeldt, K., 2021) Ensuring that these systems are transparent

about their functioning and limitations is vital for maintaining trust and accountability in healthcare settings.

Ethical issues in AI deployment go beyond individual interactions and include greater social ramifications. For AI to actually improve the healthcare system, it must be created and applied in a manner that respects and advances society norms and values, as emphasized by the Social Construction of Technology (SCOT) paradigm. This concept gives a perspective through which to see AI as a socially integrated technology that must adhere to the ethical and sociocultural values of the communities it serves, rather than merely a collection of algorithms.

Furthermore, the incorporation of AI into healthcare settings provides a unique chance to rethink and maybe reinvent the duties of healthcare practitioners. By automating mundane activities, AI enables physicians to concentrate on parts of care that need human empathy and judgment, thus improving the patient-caregiver connection. This transition, however, must be carefully controlled to ensure that it improves rather than degrades the human aspects of healthcare. Future research should focus on building more complex AI systems that not only do jobs efficiently, but also function within a transparent and responsible ethical framework. Research should also study how AI may be built to complement and enhance the decision-making processes of healthcare professionals, rather than replace them, ensuring that AI remains a tool for boosting human talents, rather than substituting them.

As the study of AI in healthcare progresses, the importance of collaboration between human physicians and AI systems becomes clear. This collaborative method can greatly enhance patient outcomes by combining human intuition and empathy with AI precision and speed. However, for such integration to be successful, healthcare systems must emphasize medical staff training and support in order to use these technologies successfully. It is not enough to have

powerful AI tools; it is also important to ensure that the professionals who use them are well-equipped and confident in their deployment. It highlights a greater need for educational reforms in medical training programs to integrate AI literacy, ensuring that future healthcare professionals are equipped to collaborate with AI.

Patient education and public participation on AI's role in healthcare become essential. Healthcare systems may dispel widespread misconceptions and anxieties about AI by educating patients about its applications, advantages, and drawbacks. In addition to building trust, this openness gives patients the freedom to choose their course of care with knowledge. The scalability of AI solutions across many healthcare settings, especially under-resourced situations, is one of the major problems that still lie ahead. (Gerke, 2020) Global healthcare infrastructure disparities imply that, depending on how AI is used, health disparities may increase or decrease. Therefore, the goal of future research should be to develop scalable AI systems that can be applied successfully in a variety of healthcare contexts, including those with little resources as well as those with enough. This strategy will contribute to ensuring that everyone may benefit from AI in healthcare, irrespective of financial or geographical constraints. Continuous monitoring and review systems will be necessary to track how AI affects ethical norms and healthcare outcomes as the technology develops. These kinds of systems have to be flexible, ready to adjust to fresh difficulties and technological advancements. International cooperation may be essential in developing norms and regulations that guarantee the moral use of AI in healthcare everywhere.

The use of Artificial Intelligence in the healthcare sector presents significant opportunities to improve patient care and operational effectiveness. But the way forward needs to be chosen carefully, balancing creativity, morality, and inclusion. The healthcare sector can fully

utilize AI to build a more just, effective, and efficient healthcare system by establishing an atmosphere where human experience and technology coexist and ethical issues are prioritized when implementing new technologies. Insights from the Social Construction of Technology framework offer a useful viewpoint for comprehending and directing this integration, guaranteeing that technology developments in healthcare keep pace with social demands and human values.

Ethical Pathways for AI in Healthcare

Artificial Intelligence (AI) stands at the frontier of transforming healthcare, offering a beacon of hope for precision medicine and improved patient outcomes while navigating through the ethical landscapes of data privacy and algorithmic fairness. This study, through a meticulous review of literature and policy documents, champions a nuanced approach that intricately weaves technological advancements with ethical considerations. It underscores the necessity of embedding AI technologies within a framework of ethical integrity and societal consensus. As AI continues to redefine the paradigms of healthcare, this research emphasizes the importance of a multidisciplinary strategy, ensuring that the technological potential is realized in a manner that is both equitable and aligned with societal values. Thus, this exploration not only contributes to the ongoing dialogue on the ethical deployment of AI in healthcare but also highlights the imperative for establishing guidelines that encourage innovation while safeguarding the principles of justice and equity, paving the way for a healthcare future that benefits all.

Works Cited

- Davenport, T. H., & Kalakota, R. (2019). The potential for artificial intelligence in healthcare. *Future Healthcare Journal*, 6(2), 94–98. <https://doi.org/10.7861/futurehosp.6-2-94>
- Cadario, R., Longoni, C., & Morewedge, C. K. (2021). Understanding, explaining, and utilizing medical artificial intelligence. <https://doi.org/10.1038/s41562-021-01146-0>
- Padhi, A., Agarwal, A., Saxena, S. K., et al. (2023). Transforming clinical virology with AI, machine learning and deep learning: A comprehensive review and outlook. *Virus Disease*, 34, 345–355. <https://doi.org/10.1007/s13337-023-00841-y>
- Whittlestone, J., Nyrupe, R., Alexandrova, A., Dihal, K., & Cave, S. (2019). Ethical and societal implications of algorithms, data, and artificial intelligence: A roadmap for research. London: Nuffield Foundation.
- (2020). Privacy in the time of a pandemic. 13th CMI Conference on Cybersecurity and Privacy (CMI) - Digital Transformation - Potentials and Challenges(51275), 1-6. <https://doi.org/10.1109/CMI51275.2020.9322737>
- Johnson, K. B., Wei, W.-Q., Weeraratne, D., Frisse, M. E., Misulis, K., Rhee, K., Zhao, J., & Snowdon, J. L. (2021). Precision medicine, AI, and the future of personalized health care. *Clinical and Translational Science*, 14, 86-93. <https://doi.org/10.1111/cts.12884>
- Karimian, G., Petelos, E., & Evers, S. M. A. A. (2022). The ethical issues of the application of artificial intelligence in healthcare: A systematic scoping review. *AI Ethics*, 2, 539–551. <https://doi.org/10.1007/s43681-021-00131-7>
- Rockwern, B., Johnson, D., Snyder Sulmasy, L., et al. (2021). Health information privacy, protection, and use in the expanding digital health ecosystem: A position paper of the American College of Physicians. *Annals of Internal Medicine*, 174, 994-998. <https://doi.org/10.7326/M20-7639>
- Topol, E. J. (2019). High-performance medicine: The convergence of human and artificial intelligence. *Nature Medicine*, 25, 44–56. <https://doi.org/10.1038/s41591-018-0300-7>
- Gerke, S., Minssen, T., & Cohen, G. (2020). Ethical and legal challenges of artificial intelligence-driven healthcare. In *Artificial Intelligence in Healthcare* (pp. 295-336). Academic Press. <https://doi.org/10.1016/B978-0-12-818438-7.00012-5>

- Ueda, D., Kakinuma, T., Fujita, S., et al. (2024). Fairness of artificial intelligence in healthcare: Review and recommendations. *Japanese Journal of Radiology*, 42, 3–15.
<https://doi.org/10.1007/s11604-023-01474-3>
- Morley, J., Machado, C., Burr, C., Burr, C., Cows, J., Taddeo, M., & Floridi, L. (2019). The debate on the ethics of AI in health care: A reconstruction and critical review.
<https://ssrn.com/abstract=3486518> or <http://dx.doi.org/10.2139/ssrn.3486518>
- Terranova, C., Cestonaro, C., Fava, L., & Cinquetti, A. (2024). AI and professional liability assessment in healthcare. A revolution in legal medicine?. *Frontiers in Medicine*, 10:1337335. doi: 10.3389/fmed.2023.1337335
- Parfett, A., Townley, S., & Allerfeldt, K. (2021). AI-based healthcare: A new dawn or apartheid revisited?. *AI & Society*, 983–999. <https://doi.org/10.1007/s00146-020-01120-w>