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Key Challenges and Limitations of AI in Healthcare

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Abstract: Artificial Intelligence (AI) has become a critical catalyst in transforming healthcare through improved diagnostics, predictive analytics, and clinical decision support. However, the path toward effective integration of AI in clinical and organizational contexts is riddled with significant challenges and inherent limitations. This research critically examines the multifaceted barriers that shape AI's implementation and reliability in healthcare systems. The study identifies key challenges across seven domains—data integrity and availability, technical and systemic integration, economic and resource constraints, human and ethical considerations, organizational and innovation barriers, regulatory and governance complexities, and emerging operational difficulties. Beyond these external challenges, it explores intrinsic limitations categorized as cognitive and algorithmic, ethical and humanistic, regulatory and socio-structural, and environmental and generative. Through this comprehensive analysis, the paper underscores that while AI holds immense potential to enhance the precision, efficiency, and accessibility of healthcare, its success ultimately depends on addressing these layered constraints through transparent design, inclusive policy frameworks, and sustained human oversight.

Keywords: Artificial Intelligence, Healthcare, Machine Learning, Challenges, Limitations, Ethics, Regulation.

I. INTRODUCTION

Healthcare sector is intrinsically complex, involving varied stakeholders, elaborate workflows, and critical decision-making. In recent time, artificial intelligence has emerged as a influential force in a variety of fields specially healthcare. Thus offering the potential to greatly enhance overall quality of life, streamline surgical operations, and improve the treatment of patients[1,2,4]. AI holds great promise to address long-standing shortcomings and improve the standard of care, through robotic-assisted operations and individualized suggestions for treatment for early detection of diseases and quicker pharmaceutical research development. Natural language processing, machine learning, deep learning, and generative models have all shown remarkable accuracy and efficiency, occasionally outperforming human performance in specific activities[2].

The application of AI in healthcare still faces significant challenges in spite of these advancements [3]. The increasing integration of AI systems into clinical decision-making and patient management has raised questions about safety, data privacy, accountability, equality, and ethical integrity. Biases in training data, lack of transparency in AI algorithms, regulatory gaps, and the possibility for over-reliance on automated systems are all significant dangers to both patient welfare and the integrity of medical practice. Furthermore, the speed at which technology is being used, which frequently surpasses the creation of suitable protections and control procedures, exacerbates these concerns.

While the goal of AI in medicine is to promote human well-being, ensure fairness, and protect patient autonomy, its deployment without adequate regulation and critical scrutiny could undermine these very principles. Therefore, understanding the limitations and dangers associated with AI is essential—not only to mitigate harm, but to ensure that its integration truly enhances, rather than compromises, the future of healthcare.

Although artificial intelligence (AI) has the potential for transforming healthcare, its adoption raises serious issues. The introduction of AI in medicine must be handled carefully to prevent exacerbating already-existing problems in clinical practice and healthcare delivery, as researchers in [5] emphasized. As highlighted by [5,6], the development of AI technologies must be firmly governed by careful governance, risk assessment, and a commitment to transparent, explainable, reliable usage.

This work contributes to the current discussion on risk of AI in healthcare by systematically categorizing the barriers into two major domains. First one is key challenges which represents external and systemic obstacles, and second one is inherent limitations which reflects the intrinsic and technical constraints of AI technology. Figure 1 illustrates different categories of AI risks as outlined in this chapter.

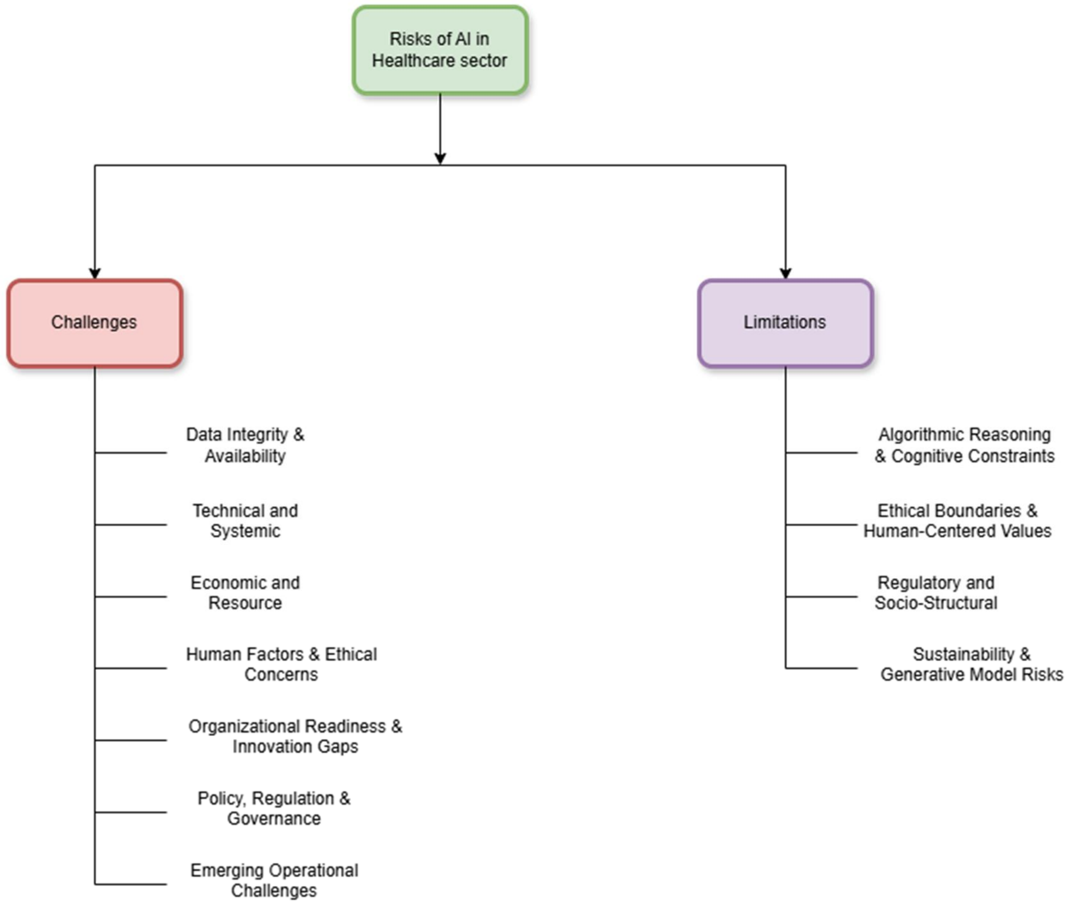

Figure 1: pitfalls of using AI in sensitive health domains

II. KEY CHALLENGES IN THE INTEGRATION OF AI IN HEALTHCARE

The challenges faced by AI in healthcare are inherently multi-faceted and highly interconnected, encompassing technical, ethical, infrastructural, and policy aspects. On the one hand, they pose major challenges to effective integration into real-world clinical settings, such as inadequate data integrity, fragmented digital frameworks, limited financial and human resources, and regulatory ambiguity. However, AI systems also have intrinsic drawbacks that are more basic in nature, like algorithmic opacity, a lack of contextual reasoning that is similar to that of humans, and challenges in coordinating machine outputs with complex legal and social principles. These fundamental limitations raise doubt on the long-term reliability of AI-driven medical decision-making as well as transparency and trust.

These overlapping limitations are categorized into seven broad thematic areas based on the categorization shown in Table 1 to make it easier a structured analysis. A comprehensive description of each is given in the section that follow.

A. Data-Centric Challenges

Although data is frequently referred to as artificial intelligence's (AI) lifeline, it also represents one of AI's greatest weaknesses in the healthcare industry. To guarantee high accuracy, sensitivity, and generalizability, AI systems rely significantly on sizable, varied, and properly labeled datasets. However, real-world healthcare data is often stored in incompatible formats, dispersed across several systems, and subject to stringent data governance regulations that make it difficult to share and train models. [7].

Despite being widely used, Electronic Health Records (EHRs) lack standards and semantic interoperability, which results in disparities in data that prevent the development of comprehensive, long-term patient datasets [8]. This is especially problematic in cross-border or multi-center AI applications, because inconsistent documentation procedures compromise integration and consistency. Furthermore, strict data protection regulations like the GDPR in Europe and HIPAA in the US, while necessary for patient privacy, frequently make cross-border cooperation more difficult and restrict access to datasets that are vital for AI research and implementation [9].The problems facing emerging economies are significantly more severe. Many patient records in low-resource settings are either handwritten or updated irregularly, and digitization is still ongoing. The training and validation of AI models for different populations is significantly hampered by the lack of structured data, which raises questions around bias and fairness.

Data security is an increasing problem in addition to quality and accessibility. Because medical data is so valuable to insurers, pharmaceutical companies, and even state actors, the healthcare industry has become a top target for cyberattacks, according to academics [10,11]. Health data breaches now have national security ramifications in addition to patient privacy concerns. Furthermore, hostile actors might subtly skew AI results and jeopardize healthcare decision-making, insurance fraud detection, and even the integrity of clinical trials by introducing modified data into training sets through data poisoning assaults [12].

B. Technical and Systemic Challenges

The majority of hospitals continue to use antiquated IT systems that were never intended for real-time analytics. Public hospitals frequently lack the advanced middleware, cross-platform APIs, and secure data pipelines needed to integrate AI tools with current EHR systems [13].

The inability of AI outputs to be explained is another serious problem. Deep neural networks in particular are examples of high-performing models that function as "black boxes," producing outcomes devoid of any discernible logic. When judgments result in unfavorable consequences, this opacity erodes physician confidence and makes accountability more difficult [14]. Furthermore, it is difficult to evaluate AI technologies tested in one context in another due to the lack of consistent evaluation methodologies. Reproducibility becomes a significant technical difficulty when the demographic makeup and illness prevalence of healthcare systems vary greatly. These problems are made worse by the quick speed at which AI is developing since ongoing improvements necessitate ongoing funding and staff retraining.

By decentralizing model training, emerging paradigms like federated learning and edge AI seek to overcome privacy and scalability issues. They do, however, present a unique set of hurdles, including as latency, computing needs, and synchronization issues in real-time clinical contexts[15].

C. Economic and Resource Challenges

There are significant resource and economic barriers to implementing AI in healthcare. Adoption is challenging for small and medium-sized hospitals due to the initial setup, which includes the acquisition of high-performance servers and cloud contracts, as well as ongoing maintenance and cybersecurity expenses. Furthermore, because healthcare providers sometimes lack clear reimbursement policies or ROI models for AI-based diagnostics and robotic operations, ambiguity regarding economic returns deters investment[16]. The digital divide contributes to this financial burden; as under-resourced areas struggle with inadequate infrastructure, wealthy nations quickly integrate AI into imaging and prediction systems, increasing healthcare disparities worldwide. Moreover, environmental issues give this problem an additional complexity. Large AI model deployment and training require a lot of energy, which raises sustainability concerns and increases the carbon footprint[17]. Some researchers further stress the connection between these economic and environmental issues, arguing that developing AI technology cannot come at the price of ecological stability or global equality. AI must be used sustainably and responsibly if it is to live up to its promise of enhancing healthcare without endangering the economy's stability[17].

D. Human and Ethical Challenges

Healthcare is based on trust, but AI makes this relationship more difficult. The adoption of useful AI technology is being slowed by patients' fears about data misuse and clinicians' concerns about losing their independence and professional identity. Lack of transparency breeds mistrust since patients frequently don't comprehend how AI systems utilize their data, and clinicians can't always understand decisions made by AI, which puts informed consent and explainability at danger. Results are worsened by algorithmic bias, which results in uneven diagnosis accuracy, particularly for disadvantaged populations[18]. Although clinician approval is crucial, many clinicians oppose interpretable systems out of concern for changes in ethical accountability. When AI mistakes happen, the issue of who is at fault—the developer, the organization, or the practitioner—remains open. In order to ensure that AI improves rather than damages healthcare relationships, recent research emphasizes the necessity of legal frameworks, algorithmic fairness, and embedded ethics guidelines to promote trust and define accountability[18].

E. Organizational and Innovation Challenges

Healthcare organizations are intricate systems that are influenced by workflow, culture, and hierarchy. AI integration calls for organizational change in addition to technological advancements. Lack of leadership commitment, low AI literacy among medical professionals, and staff members' fear of layoffs are frequently the causes of resistance[21]. There is frequently little cooperation between data scientists and medical specialists, which results in goals that are not aligned. Developers might, for instance, optimize algorithms for accuracy at the expense of clinical interpretability or usability. The necessity of transdisciplinary ecosystems where physicians co-design AI technologies is not widely emphasized by researchers.

Large language models (LLMs), generative adversarial networks (GANs), and deep reinforcement learning are examples of new-generation AI techniques that offer both institutional difficulties and potential. To avoid abuse or over-reliance, their implementation necessitates new governance frameworks, open data pipelines, and regular ethical audits [19–20].

F. Regulatory and Governance Challenges

There are major regulatory challenges since the quick growth of AI in healthcare has outpaced the creation of appropriate rules. Global collaborations are made more difficult by regulatory agencies' inability to provide clear criteria for the development, testing, and certification of AI systems. This lack of international consensus leads to different compliance standards across jurisdictions. Because regulators try to apply conventional medical device frameworks to adaptive AI models that are always learning, approval processes are frequently laborious and time-consuming, leading to oversight gaps. Startups are discouraged from innovating in the healthcare industry by the high expenses of compliance, which include legal counsel, data audits, and documentation. Governance is further complicated by the lack of international ethical norms and data sovereignty concerns, particularly in international clinical trials and cross-border telemedicine[22].

G. Emerging Operational Challenges

Healthcare companies are facing a growing number of new operational hazards as artificial intelligence (AI) systems advance toward the ability to make decisions in real time and perform creative tasks. The use of chatbot-based symptom checkers, AI-assisted triage platforms, and generative diagnostic models reveals information-related vulnerabilities, such as the potential for "hallucinated" or erroneous outputs that could impair the accuracy of clinical decisions. These occurrences highlight a persistent issue in which healthcare systems have not yet completely developed standardized procedures for verifying, tracking, and dynamically adjusting AI models while they are being used in clinical settings.

The intricacy of AI models and their "black box" status create further barriers to clinician supervision and trust, which may lead to an excessive dependence on subpar AI results that increase patient safety hazards. Additionally, the application of strong safeguards is hampered by fragmented regulatory and governance frameworks, which add to uncertainty in operational accountability and ethical monitoring.

Table 1: AI challenges in healthcare

Perspective	Challenges	Nature
1. Data-Centric Challenges	• Fragmented, siloed health data. • Poor interoperability across EHR systems. • Data-sharing restrictions and privacy compliance barriers. • Inconsistent data quality and governance.	Structural and regulatory barriers that prevent comprehensive, high-quality datasets essential for reliable AI modelling.
2. Technical and Systemic Challenges	• Integration with legacy hospital IT systems. • Lack of standardized evaluation protocols. • Limited real-world validation and scalability. • Inter-vendor incompatibility.	Operational hurdles in deploying AI safely and uniformly within heterogeneous clinical infrastructures.
3. Economic and Resource Challenges	• High implementation and maintenance costs. • Unclear Return on Investment (ROI). • Reimbursement and funding uncertainty. • Digital divide between rich and resource-poor regions.	Financial and infrastructural inequities restricting large-scale AI adoption and sustainability.
4. Human and Ethical Challenges (Social Perspective)	• Public mistrust and privacy concerns. • Resistance to change among clinicians. • Inadequate AI literacy and training. • Unclear liability and legal accountability.	Behavioral, social, and ethical barriers affecting trust, acceptance, and accountability in AI-driven healthcare.

5. Organizational and Innovation Challenges	• Weak leadership and limited strategic vision. • Institutional resistance and culture barriers. • Skill gaps among health professionals. • Low collaboration between clinicians and technologists.	Management and innovation-readiness issues hindering AI integration and cross-disciplinary implementation.
6. Regulatory and Governance Challenges	• Rapidly changing and fragmented AI regulations. • Lengthy approval processes for AI devices. • High compliance cost and limited expertise. • Lack of international consensus and data sovereignty issues.	Policy and governance uncertainties that delay safe implementation and reduce cross-border interoperability.
7. Emerging Operational Challenges	• Integration of next-generation tools (LLMs, GANs, federated learning). • Low readiness for adopting AI in real-time clinical workflows. • Ethical governance of AI chatbots and virtual assistants.	New barriers arising from deployment of advanced AI technologies without robust training or regulatory oversight.

III. LIMITATIONS OF AI

The four broad categories of limits that may be identified by a broad review of current literature and emerging technologies are: (i) algorithmic and cognitive, (ii) humanist and ethical, (iii) socio-structural and regulative, and (iv) environmental and generative. As a whole, they define the existential and ethical limits of AI as much as its technical limits.

A. Algorithmic and Cognitive Constraints — Knowledge Limits

While the models of AI are great for recognizing patterns, their understanding is minimal. While they cannot offer a human-level description, they are however able to predict patterns of relations between results and symptoms. The cognitive limit of AI is encapsulated by this distinction between causation and correlation.

1) The black-box problem: It manifests in healthcare in several ways. Despite their ability to predict risk scores with great precision, predictive models for diabetes, heart failure, or sepsis offer scarce interpretability regarding the underlying mechanisms of disease progression. The black-box problem is the description for their black-box-like reasoning procedure that is entangled in millions of weighted parameters that are not fully understood by even programmers. Its ethical and therapeutic impacts are further illuminated by new studies. Study in [24] stated that this type of obscurity creates epistemic uncertainty, where the physicians understand the outputs of the algorithm but are incapable of understanding the logic that led to the conclusions. This obscurity may breach the medical principle of non-maleficence or "do no harm" by constraining a practising clinician's ability to defend or dispute AI-produced predictions. Likewise, authors in [25] argues that patient autonomy and informed consent are compromised when physicians are incapable of understanding or explaining algorithmic conclusions because confidence in the provision of medical opinion deteriorates. Both studies underscore that while AI enhances the accuracy in diagnostics, its obscurity demands additional ethical regulation and the establishment of explainable AI (XAI) methods so that the decision-making processes are transparent, responsible, and in accord with fundamental medical ethics.

2) Algorithmic bias: This perpetuates systemic injustices in healthcare. The model will perpetuate biases if the dataset is biased towards specific demographics, making it difficult to diagnose underrepresented groups. This limitation is a byproduct of AI's statistical learning from erroneous human data instead of a bug in the code. According to work in [26] researchers argued that these biases change and become worse throughout all phases of the AI building process, from data labeling and generation to model release, finally influencing clinical judgment and perpetuating already-present healthcare inequities. Biased labels, incomplete patient information, and inadequate sample numbers for underrepresented groups may all result in suboptimal outcomes and unfair recommendations for treatment. Similarly, algorithmic bias disproportionately affects impoverished persons and often has the result of systematic under-diagnosis or over-estimation of the risk for illness as revealed in [27]. They emphasize that models created primarily with data from specific geographic or ethnic groups may perform poorly when employed using a wide variety of patient groups, thereby perpetuating disparities in outcomes and access. Both research studies recommend stringent bias detection, the utilization of representative and varied datasets, and the addition of bias-mitigation methods, such as re-sampling, transparency requirements, and continuous monitoring, to combat these dangers and ensure fairness and accountability for AI-based healthcare systems.

3) Model Drift: Finally, model drift makes these systems' predictive powers fade when population health patterns or clinical practices shift. Whereas retraining may mitigate drift, it will never fully eliminate it. Hence, the algorithmic and epistemic constraints of AI remind us that computational intelligence remains distinct from the interpretive causal understanding of human doctors. Model drift or concept drift happens when the statistical properties of healthcare data streams change over time such that the statistical patterns become misclassifications and prediction accuracy falls even when the model structure doesn't change [28]. Such drift in the healthcare context may be triggered by evolving clinical practices, shifts in the prevalence of diseases, or new patient cohorts that diverge from training distributions. Additionally, authors in [29] emphasized that model drift (corruption of internal parameters or calibration) and data drift (shifts in patient attributes, imaging devices, or clinical protocols) interact to destroy long-term AI reliability in evolving clinical scenarios. Analysis highlights how feedback loops and staleness of information exacerbate predictive deterioration while calibration drift subtly biases risk assessment.

Thus, long-term reliability for medical AI involves continuous monitoring, adaptive recalibration, and retraining methods such as continuous learning and domain adaptation. Such findings also emphasize the importance of intentional retention of algorithmic intelligence for preservation of clinical trust and performance integrity where it has no contextual awareness in comparison to human cognition.

B. Humanistic and Ethical Constraints

Founded upon the principles of kindness, morality, and the healing touch, medicine is a science and an art. Lacking a few basic human skills, AI has nothing in it that it doesn't have.

1) Contextual judgment and empathy: An AI chatbot that provides end-of-life counsel, for example, may offer medically accurate facts but be lacking in conveying empathy or sensitivity. At the very moments when patients most need to be understood, such interactions risk alienating them. Likewise, morally neutral choices provided by AI-based triage technologies may unwittingly omit the most vulnerable. Study in [30] strongly recommended that artificial intelligence has no conscious attention or emotional resonance to afford true empathy. AI may mimic the cognitive empathy of recognizing and responding to emotional stimulation but cannot experience or convey emotional empathy, that aspect of human consciousness that has evolved through biology and civil society. The authors argue that the potential for AI to provide real care is constrained by its inability to offer experienced empathy, particularly in the emotional intensity of moments such as conveying trauma or terminal illness. The end result is a kind of "empathy", or constructed empathy that may appear benevolent but runs the risk of being misconstrued, subverting the moral accountability and trust that are crucial to patient-clinician relations. Relational aspects of care—those that demand emotional sensitivity, moral discernment, and a presentational empathic understanding—are necessarily human and irreplaceable in a world where AI may supplement the delivery of healthcare.

2) Moral Displacement: Clinicians also risk morally distancing themselves by technology taking the place of human judgment, such that they believe "the system decided." Complacent clinical groups may become similarly affected by this denigration of moral agency. Laying emotionally and morally challenging work before AI systems has the potential for physicians' feelings of obligation and moral investment to dwindle as stated in [30]. Health practitioners may come to see themselves as masters of automated protocols rather than morally active beings when computers are in charge of exercising the virtue of empathizing and making the sorts of decisions that involve moral thinking. This problem threatens the relationships of trust that lie at the heart of patient care and the ethical foundations of the profession. Similarly authors of work in [29] pointed out that the undue reliance on automated diagnostic or predictive models may create a "responsibility gap" where the AI system and the physician are not directly responsible for a poor judgment. Because algorithmic authority takes the place of the exercise of moral judgment, this diffusion of obligation threatens ethical integrity. Accompanying technology efficiency by ensuring human oversight and incorporating moral reasoning frameworks into AI governance and making physicians' ethical consciousness a priority, prevents technology efficiency from crowding professional accountability.

3) Clinician deskilling—An unanticipated psychological effect of AI integration is the progressive loss of diagnostic intuition brought on by an excessive dependence on automation. Since the healing relationship depends on intuition and empathy, it cannot be measured or controlled. These drawbacks highlight the fact that, although AI can assist in medical decision-making, it is unable to represent the moral awareness that characterizes care. Real empathy and moral sensitivity, according to Montemayor, Halpern, and Fairweather (2022) [30], are based on human consciousness, biological feeling, and attentional engagement—elements that no computer can duplicate. Clinicians run the risk of losing touch with the interpretative and emotional aspects of medicine, which are crucial for patient trust and precise contextual knowledge, when they start to rely too much on machine-generated advice. As therapists[29] increasingly submit to algorithmic authority instead of using reflective judgment, the outcome is not only cognitive deskilling but also moral detachment. Therefore, retaining the moral and compassionate foundation of medical practice requires striking a balance between AI-assisted efficiency and human-centered intuition.

C. Regulatory and Socio-Structural Constraints — Governance and Equity Bounds

1) Paradox of Regulation: The growth of AI has far overshadowed that of institutional and legal infrastructure. Dynamic, self-updating technologies are challenging current regulatory structures because they were designed for fixed medical devices. An AI diagnostic system is retrained after approval, causing a regulatory paradox where the approved version may already be outdated. Pre-existing schemes, such as the FDA's Software as a Medical Device (SaMD) architecture and its Predetermined Change Control Plan (PCCP), attempt to manage emerging algorithms but are still limited in scope for models that are always learning [31]. The authors emphasize that traditional premarket approval processes were never meant for autonomously transforming systems post-release, potentially causing flaws in supervision and dangers in terms of safety. The European Union's AI Act (2024) is pioneering but has challenges putting forth consistent post-market monitoring and accountability for high-risk Medical AI technologies [32]. Local variation in the level of safety standards and patchy administration may be the result of variation between national oversight entities and confusion regarding algorithmic change. Considered collectively, these evaluations point to the urgent necessity for changeable, transparent, and harmonious global policy able to keep pace with AI while keeping patient safety, fairness, and accountability for healthcare innovation.
2) Accountability**:** Whose fault is it, when a dangerous recommendation is given by an AI or when a patient is misdiagnosed—the hospital, the inventor, or the practitioner who used it. It's difficult to apply traditional negligence doctrines to distributed data-based systems. The European Union's AI Act attempts to resolve accountability by placing primary accountability on distributors and providers of high-risk AI systems [32]. But it doesn't do anything to address important issues related to the shift of liability between developers, healthcare organizations, and clinicians. How accountability is to be apportioned is by no means clear in cases where a diagnostic algorithm goes wrong unless the AI model's been retrained and has developed beyond its originally certified form. The authors warn that because institutions are feared of legal risk where they perceive no clear protections in place, this very possibility may have a chilling impact upon adoption. Also, it has been observed that self-learning systems whose behavior may alter once deployed are poorly matched to current regulatory ideologies such as the FDA's Software as a Medical Device (SaMD) framework[31]. For purposes of attributing blame better, they recommend flexible legislative frameworks, ongoing post-market surveillance, and transparent publication of algorithmic alterations. Each of these studies indicates that AI-enabled healthcare bodes a generation of "liability vacuum" where clear accountability structures are absent that will impede patient protection and innovation.
3) Socio-economic inequality: On a greater level, socioeconomic inequality impacts whom the benefits of AI are accruing to. Advanced AI technologies are deployed by better-off institutions with stronger infrastructure, but smaller hospitals or impoverished countries are excluded. A new digital divide in the field of medicine where the geography of the data determines the geography of health may be the end result of this unequal access. Because under-resourced healthcare environments are lacking the computational power and diversified high-quality datasets required to train or test powerful AI models themselves, algorithmic systems often perpetuate pre-existent imbalances [27]. Also, territorial discrepancies in digital infrastructure and regulation capabilities create unequal utilization of AI legislation by law that further expands the technology gap. Equitable values such as fairness, inclusivity, and representativeness are key principles for the ethical implementation of medical AI because, absent fair data-sharing protocols and global standards for access, AI may perpetuate and exacerbate healthcare inequality instead of reducing it[31].
4) Data sovereignty and knowledge ownership: Again, data sovereignty and knowledge ownership issues are raised by the centralization of medical data and processing power in a few private companies. Hence, the employment of AI in healthcare challenges not merely legal or technical limits but also the very foundation of justice, accountability, and fairness in global health systems. Such corporate centralization has the risk of building monopolies over medical creativity so that access and transparency are denied to public institutions [32]. Some researchers [27] also warned that the benefits of AI become unequally distributed and entrench global health inequities when algorithmic invention is guided by proprietary datasets. For the preservation of justice and mutual progress in the science of medicine, it is important to ensure open data governance, ethical oversight, and equitable access to the benefits of AI.

D. Environmental and Generative Limitations — Boundaries of Sustainability and Authenticity

1) Carbon Footprints: There is a latent environmental cost of AI's computational thirst. Huge energy and hardware infrastructure are required to train large diagnostic models, which creates extensive carbon footprints. It has been observed in some researches that during the lifetime of a single deep learning model, it has the potential to emit more CO_2 than a large number of automobiles. Such environmental externalities contradict the ethical obligation of healthcare to "do no harm" in a business for

human wellness. Because healthcare AI models often depend on high-performance computation clusters running on fossil fuels it has been noticed that the carbon intensity of training and running deep neural networks has become a major sustainability issue[33]. Some researchers have cautioned that greater data center and GPU dependence for real-time model refreshes significantly expands energy usage and electronic waste in clinical informatics[31]. The findings emphasize the way that the tacit environmental harm of AI offsets the ethical mandate of medicine not to harm while it also holds the potential for efficiency and accuracy. For this reason, energy-efficient model design must be incorporated along with green principles of AI and responsible end-of-life disposal of hardware in a drive towards making healthcare innovation congruent with international sustainability objectives.

2) Electronic trash: Environmental degradation is added to by the generation of e-waste from periodic server cooling and hardware replacements. Such environmental constraints foster awareness of the sustainability of AI as a long-term objective for healthcare. The rapid obsolescence of GPUs, TPUs, and other AI-specialized hardware accelerates a growing cycle of electronic trash, much of which is shipped to poverty-level communities lacking proper safe recycling facilities or goes to a landfill[34]. Likewise, some researchers also observed that commercial-grade medical AI systems rely on data centers that burn enormous energy for around-the-clock operation and cooling purposes, thereby escalating their carbon and material impact. The objectives of sustainable healthcare, namely the reduction of environmental impact while patient benefit is increased, are incompatible with these activities[31]. As a way of surmounting this roadblock, AI research pipelines need to integrate green technology methods, extend hardware lifetimes, and implement proper e-waste disposal guidelines to ensure that environmental stewardship is aligned with medical ethics.

3) Generative AI: There are new epistemic challenges associated with the building of generative AI. There is a potential for image-generation models and large language models (LLMs) to generate "hallucinated" outputs that are realistic but factually incorrect. There is a risk for such errors to result in incorrect information, imprecise diagnoses, or even harm when embedded into healthcare processes. The accuracy of clinical documentation and research datasets is jeopardized because it is hard to differentiate between real and phantom medical images or text. There are algorithms that generate citations, clinical summaries, or radiologic images that are credible-looking but poor in terms of empirical validity, says the NCBI Bookshelf paper (2024) for Generative Artificial Intelligence in Health Care [35]. Such hallucinations risk the spreading of false information about medicine and diluting the credibility of practitioners. Likewise, some authors [31] pointed to the fact that it is challenging to guarantee the validity of AI-generated medical information because of the lack of standard verification and provenance-tracking mechanisms. Both publications recommend the use of AI audit trails, synthetic data watermarking, and strict human-in-the-loop verification to ensure patient safety and research reliability. This ensures that generative models become decision-support tools but no autonomous authority in the healthcare sectors.

The future of health AI will need to balance the innovative and the sustainable with the automated and the true, all illuminated by these environmental and generative edges.

IV. CONCLUSION AND FUTURE WORK

Instead of existing as distinct issues, the difficulties and constraints posed by AI in healthcare are part of a continuum. Adoption is slowed by issues like data fragmentation, expenses, and legal restrictions, yet AI's inherent potential and bounds are defined by its limits. Realistic expectations and responsible use are made possible by acknowledging this continuum. For instance, explainability tools and hybrid human-AI decision models can help reduce black-box opacity, even though it cannot be completely removed. While algorithmic solutions cannot address AI's lack of empathy, human-AI cooperation can maintain clinical compassion. Every medical development calls for new ethical frameworks; technological advancement by itself does not guarantee ethical advancement. Resilient AI systems that value accountability, transparency, and human supervision should thus be given top priority in the healthcare industry. Adaptive governance, explainable algorithms, digital integrity, environmental sustainability, and inclusive international cooperation are necessary for future paths. The ultimate objective is a mutually beneficial collaboration in which AI enhances human judgment while remaining grounded in moral obligation and compassion, promoting medical treatment that upholds both technology advancement and human dignity.

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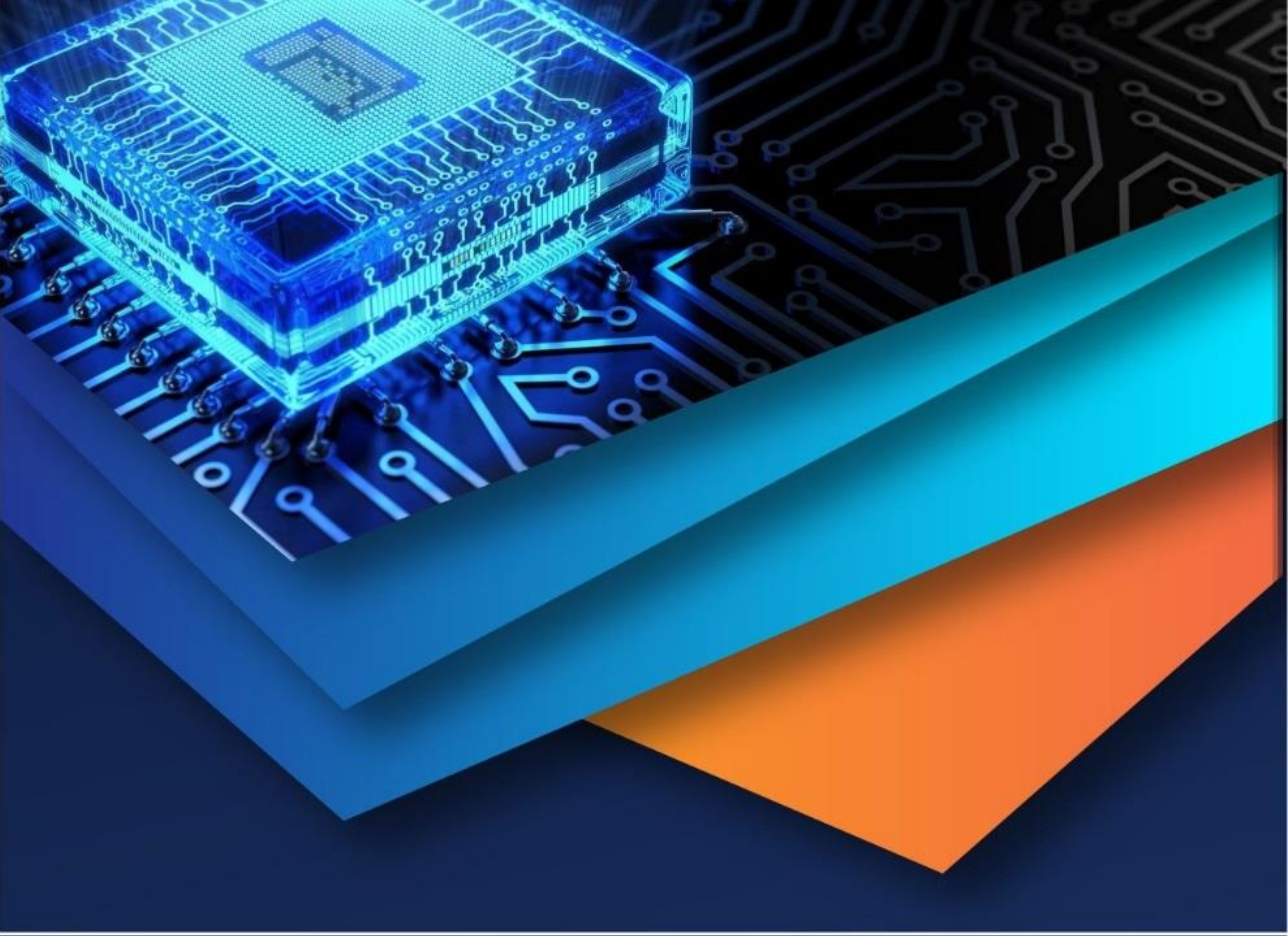

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