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ChatGPT in complex adaptive healthcare systems: embrace with caution

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Abstract: The integration of artificial intelligence (AI) into healthcare, particularly through generative AI models like ChatGPT, presents both transformative opportunities and significant challenges. This discussion article explores the systemic impacts of generative AI, highlighting the ethical concerns, particularly around biases, and the shifts in patient-provider dynamics that could disrupt traditional healthcare. Democratising medical knowledge through ChatGPT tools offers new avenues for patient engagement, yet it may affect existing health disparities and erode trust if not responsibly implemented. As generative AI increasingly influences healthcare, it is critical to recognise the intricate feedback loops and dependencies within these complex adaptive systems so that innovations augment rather than destabilise the overall structure. This article advocates an 'embrace with caution' stance, calling for reflexive governance, heightened ethical oversight, and a nuanced appreciation of systemic complexity to harness generative AI's benefits while preserving the integrity of healthcare delivery.

Keywords: artificial intelligence; AI; complex adaptive systems; health equity; healthcare; health informatics; health information systems; informatics; nursing; patient education.

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1 Introduction

1.1 Generative artificial intelligence in healthcare

Generative artificial intelligence (AI) refers to advanced machine learning frameworks capable of producing genuinely original and contextually coherent outputs – such as text, images, or other digital media – by extrapolating intricate patterns from extensive datasets, rather than merely extracting or classifying pre-existing information. The rapid advancements in generative AI in healthcare have led to widespread enthusiasm as regards addressing long-standing challenges, including workforce shortages,

inefficiencies in clinical workflows, and gaps in patient care. However, this optimism may overshadow a more critical perspective, particularly when considering the complex, and often unpredictable, consequences of GAI implementation in healthcare (Almyranti et al., 2024). One of the most debated risks associated with GAI, including chat generative pre-trained transformer (ChatGPT), is its ability to generate convincingly realistic but factually incorrect content, thus GAIleading to the spread of misinformation and disinformation (Shoaib et al., 2023). The phenomenon of AI-generated 'hallucinations' – where models fabricate plausible-sounding but incorrect or misleading information – has raised concerns in clinical decision support and patient communication. In medical practice, misinformation from ChatGPT could lead to incorrect self-diagnosis among patients or errors in AI-assisted clinical decision-making. If not critically evaluated, there is a risk that such content will be integrated into medical records or influence treatment recommendations, leading to potential harm (Giuffrè et al., 2024).

Beyond concerns over misinformation, integrating ChatGPT into healthcare workflows challenges traditional models of care. While GAI can streamline administrative tasks, such as documentation and clinical summarisation, its growing role in patient interactions and diagnostic reasoning has led to concerns about role displacement among healthcare professionals (Zheng et al., 2024a). Unlike previous technological advancements, which primarily functioned as decision-support tools, GAI has begun to redefine care delivery (Morley et al., 2020).

The adoption of ChatGPT in healthcare also brings ethical and regulatory challenges, particularly regarding bias, transparency, and liability (Almyranti et al., 2024; Duffourc and Gerke, 2023; Giuffrè et al., 2024). As highlighted by Murphy et al. (2024), AI systems often rely on datasets that underrepresent marginalised communities, resulting in biased or inaccurate outputs that can exacerbate existing health disparities and lead to suboptimal performance across different demographic groups. In healthcare, bias in AI recommendations can have direct clinical consequences, such as incorrect risk stratification for minority patients or skewed diagnostic probabilities based on incomplete datasets (Murphy et al., 2024). While AI-driven tools hold the promise of improving efficiency, their integration must be accompanied by rigorous oversight to ensure they support rather than disrupt existing care systems. The speed at which AI is being integrated into healthcare raises concerns about AI preparedness among institutions and practitioners.

Healthcare institutions lack clear policies for AI integration, leading to inconsistent implementation strategies and uncertainty regarding liability when AI-generated recommendations are incorrect. As AI models continue to evolve, establishing governance structures that balance innovation with patient safety remains a pressing challenge (Nair et al., 2024). Thus, while ChatGPT and similar AI models offer opportunities to enhance efficiency and support decision-making, their disruptive impact on healthcare workflows, ethical considerations, and clinical roles must be critically examined. Rather than blindly embracing AI advancements, healthcare institutions must develop structured implementation strategies that ensure equity, safety, and human oversight at every stage of AI adoption.

In exploring the integration of ChatGPT into healthcare, it is crucial to recognise that healthcare systems function as interconnected, interdependent environments. Systems are defined by their complexity. They involve numerous interrelated components such that changes in one area can have cascading effects elsewhere; these are also known as complex adaptive systems (Braithwaite et al., 2017; Foster and Pyka, 2014; Göras et al.,

2023). Healthcare professionals, patients, and supporting stakeholders often adapt their behaviour to the system and others' activities, which adds greater complexity (Braithwaite et al., 2017). This perspective requires that we approach AI adoption using a nuanced understanding, recognising that while the potential benefits are vast, unforeseen consequences may arise if these technologies are adopted without considering the broader system. Rather than viewing ChatGPT as an isolated tool, it is essential to consider how it interacts with existing resources, workflows, and cultural norms. The discussion will delve into ChatGPT's broader implications, not merely as a tool but as a potentially disruptive force that tests the healthcare system's capacity to adapt, respond and learn from both expected and unexpected situations.

1.2 The rise of large language models

A large language model (LLM), a particular type of GAI, is specifically designed for natural language processing (NLP). LLMs use machine learning algorithms, trained on extensive volumes of human-generated text, to capture complex language patterns. NLP models have evolved, and they now generate significantly more coherent and context-aware text. A recent scoping review suggested that chatbots equipped with advanced NLP capabilities have demonstrated effectiveness in mental health support, featuring on-demand availability, privacy, and the provision of psychoeducation and coping strategies (Ahmed et al., 2023). While GAI offers benefits in healthcare, Möllmann et al. (2021) emphasised the need for the core principles of beneficence, non-maleficence, autonomy, justice, and explicability when using AI in clinical settings.

In 2022, the conversational abilities of ChatGPT quickly gained worldwide recognition. These capabilities hold promise for clinical decision support, as ChatGPT can simulate dynamic patient interactions (Kahambing, 2023), assist in summarising medical notes (Nguyen and Pepping, 2023), and provide initial recommendations for diagnostic or therapeutic considerations (Bhattacharya et al., 2023; Chauhan et al., 2023). Despite these promising cases of use in healthcare, concerns have been raised about potential drawbacks such as privacy concerns, academic integrity, and the possibility of bias (Alves de Castro, 2023; Kasneci et al., 2023; Tlili et al., 2023). The potential applications of ChatGPT in healthcare are numerous, yet full scope usage remains unexplored. Moreover, while LLMs can standardise and streamline communication in clinical settings, they may also increase system complexity by introducing non-linear dynamics into healthcare systems – where AI outputs influence care pathways in unpredictable ways. If the context-sensitivity of these systems is overlooked, unintended disruptions in patient care or operational efficiency may occur. Additionally, the integration of GAI into healthcare settings presents ethical dilemmas that directly affect patient-provider relationships. LLMs can offer detailed medical information or treatment suggestions, but they may also undermine the interpersonal dimension of care if used without professional oversight. In the present discussion article, we explore the specific challenges and opportunities of ChatGPT within healthcare, focusing on how it operates in the context of complex adaptive systems.

2 Exploring healthcare professionals' perspectives on utilisation of ChatGPT

2.1 Benefits

Knowledge about how healthcare professionals are using ChatGPT in their practice is still limited, and the broader application of GAI in healthcare remains largely unexplored (Johnson et al., 2023). Some studies have discussed the idea that, in hospitals, ChatGPT can support logistics and manage patient records, thereby freeing up time for direct patient care (Chen et al., 2024; Nguyen and Pepping, 2023; Sallam, 2023). For example, surgeons have reported that they could benefit from ChatGPT's assistance in choosing and planning procedures, identifying potential complications, and accessing relevant literature (Bhattacharya et al., 2023). In neuro-oncology, ChatGPT has been tested as a decision-support tool for stereotactic radiosurgery, assisting clinicians in deriving treatment doses and anticipating complications. However, concerns remain regarding AI hallucinations and the need for human oversight (Dayawansa et al., 2023). This indicates the potential for GAI to be developed further within the field, particularly with the integration of web search engines and electronic medical records to answer patient questions.

Moreover, when healthcare professionals begin integrating ChatGPT into their practice, they are not simply adopting a new tool; they are also navigating the introduction of a disruptive technology into a complex adaptive system. This integration requires rethinking workflows, professional roles, and the nature of patient-provider interactions. One study demonstrated that integrating ChatGPT into nursing information systems reduced documentation time from 15 to 5 minutes per patient without compromising record quality (Chen et al., 2024). Similarly, research into ChatGPT's role in progress note generation for chronic pain management has shown its potential to enhance documentation coherence and efficiency, provided that effective prompting techniques are used (Nguyen and Pepping, 2023).

2.2 Systemic impacts

One significant systemic impact is the shift in clinical decision-making dynamics. While ChatGPT can enhance efficiency by automating documentation and streamlining workflow processes, it may also alter the role of healthcare professionals from that of active diagnosticians to verifiers of AI-generated recommendations. This role transformation has already been observed in surgical practice, where ChatGPT-assisted tools provide preoperative planning guidance and suggest optimal surgical techniques (Bhattacharya et al., 2023). The challenge lies not just in using the technology effectively, but also in understanding and managing the broader systemic impacts. Beyond documentation, ChatGPT has been successfully tested in perinatal nursing care planning, where AI-generated care plans aligned well with standardised nursing terminologies and care priorities, demonstrating its potential as a clinical decision-support tool in structured nursing interventions (Johnson et al., 2023).

2.3 Challenges

Concerns about over-reliance remain. If professionals increasingly defer to ChatGPT for decision-making without critically assessing its recommendations, there is a risk of 'deskilling' – a phenomenon where reduced hands-on experience leads to a decline in independent clinical judgment and problem-solving skills (Draganic, 2023). In parallel, AI adoption in healthcare is not uniform; variations in AI competence significantly influence how effectively professionals can integrate ChatGPT into practice. Griewing et al. (2024) reported that healthcare professionals with greater abilities are more likely to utilise AI tools effectively and to critically evaluate their outputs, while those with limited digital competence may either avoid AI integration or use it uncritically, increasing the risk of misapplication. The extent to which healthcare professionals adopt and trust ChatGPT is strongly influenced by their perception of its competence and reliability. Those who regard ChatGPT as a capable and dependable source are more likely to integrate it into their clinical decision-making. Conversely, scepticism about its accuracy and security can result in hesitancy or selective use, which may shape both adoption rates and the quality of AI-supported care (Choudhury et al., 2024). Implementing AI requires significant resources – not only regarding having high-performance computing systems and data storage, but also regarding cultivating the necessary expertise among healthcare professionals. This suggests that variations in AI proficiency among clinicians could lead to disparities in how effectively the tool is utilised, ultimately influencing patient outcomes (Choudhury et al., 2024). However, it is essential to recognise that GAI cannot replace human empathy and compassion; it should be used as a complement to, not a replacement for, human emotions, critical thinking, and skills (Draganic, 2023).

3 Exploring patient perspectives on utilisation of ChatGPT

3.1 Benefits

Research to date has largely overlooked the voices of patients in examining the impact of ChatGPT, often treating them merely as case studies rather than active participants in their own care (Chauhan et al., 2023; McCormick and Chirila, 2023; Montagne et al., 2023; Sagalow et al., 2023; Seth et al., 2023; Tomar et al., 2023; Zamarud et al., 2023). This approach suggests a 'hidden' patient perspective, where the true experiences and concerns of patients remain insufficiently examined. Despite patients' increasing reliance on AI for medical information and guidance, patient perspectives are often marginalised in research. Patients can turn to ChatGPT for information about diagnosis and treatment, relying on these technologies to clarify complex medical jargon (Porter et al., 2023).

The accessibility of GAI can bridge the gap between complex medical discourse and lay understanding, enabling patients to engage more actively in their own healthcare. Several studies (Perlis, 2023; Ponzo et al., 2024; Zheng et al., 2024b) have demonstrated the effectiveness of ChatGPT in explaining rare diseases and medical conditions while offering medication recommendations for common issues such as depression. Beyond providing medical information, ChatGPT has been utilised in patient education by assisting with chronic disease management, promoting medication adherence through reminders and patient guidance, and offering post-treatment recovery support by

providing general self-care recommendations and monitoring progress after hospital discharge (Mosaiyebzadeh et al., 2023). Furthermore, use of ChatGPT in public health communication and as an intelligent patient companion illustrates the potential for AI to supplement traditional healthcare interactions (Kahambing, 2023). Patients interacting with ChatGPT may experience a greater sense of autonomy and engagement, particularly in treatment-related discussions where the AI employs more direct language, increased word usage, and expressions of concern. These effects appear most pronounced in mental health contexts, where ChatGPT's responses include frequent personal pronoun use, indicators of social connection, and concern-driven phrasing, fostering a more interactive and supportive dialogue (Biassoni and Gnerre, 2025).

3.2 Risks

Despite its potential benefits, using ChatGPT in patient decision-making is not without risks. One of the most pressing concerns is the spread of misinformation (Arslan, 2023; Porter et al., 2023). While GAI has the potential to make medical information more accessible, it also comes with significant limitations. For example, its inability to reference accurate sources may result in the promotion of alternative therapies over conventional treatments, which may mislead patients and delay proper diagnosis, for instance in fields such as obesity treatment (Arslan, 2023) and dermatology (Porter et al., 2023). This has been demonstrated in studies where patients following ChatGPT's recommendations altered their treatment plans without consulting their physician. Oviedo-Trespalacios et al. (2023) showed how ChatGPT's confident yet often misleading responses can cause patients to alter their treatment plans without consulting a physician, resulting in delays in necessary interventions. The study underscores how AI-generated advice – despite being persuasive – can lack accuracy, contributing to misdiagnosis and potentially harmful health decisions.

The use of ChatGPT in public health communication and as an intelligent patient companion highlights the delicate balance between the potential benefits and the risks associated with its implementation (Kahambing, 2023). One major concern is how AI-generated responses often appear authoritative regardless of their accuracy, which may contribute to suboptimal health decisions. Moreover, patients may struggle to differentiate between AI-generated advice and professional medical recommendations, particularly when ChatGPT presents responses with high confidence but does not supply references. These concerns extend to the potential for spreading misinformation, contributing to misdiagnosis, introducing biases, and disrupting the relationship between patients and healthcare providers (Dayawansa et al., 2023; Kahambing, 2023). This risk is further exacerbated by ChatGPT's tendency to generate responses that align with popular discourse rather than individualised medical accuracy, potentially failing to conform with best-practice clinical guidelines.

Despite these risks, several studies (Perlis, 2023; Ponzo et al., 2024; Zheng et al., 2024b) have demonstrated ChatGPT's capacity for explaining rare diseases and medical conditions while offering medication recommendations for common issues such as depression. However, its use in mental healthcare introduces significant ethical and clinical challenges. While AI-generated communication may appear compassionate and relatable, it lacks the depth of real human emotions and an authentic understanding of personal experiences (Carlbring et al., 2023). They stress that AI is limited in its ability to interpret non-verbal cues, tone, or subtle emotional nuances, which are crucial in

therapeutic settings. This limitation raises concerns about AI's ability to form meaningful therapeutic connections and effectively support individuals with complex emotional needs. This gap is particularly concerning in crisis situations, where AI-generated responses lack the contextual depth and professional oversight needed to replace the clinical judgment of a trained mental health professional who can assess suicidal ideation or severe distress. In specific areas such as surgical care, anaesthesia, and postoperative care, ChatGPT has been utilised for personalised pain management by analysing patients' medical histories, vital signs, and pain tolerance. For instance, Chauhan et al. (2023) used ChatGPT to explore treatment options for a 35-year-old male with chronic pain, identifying potential therapeutic pathways based on the patient's symptoms. This case highlights both the promise of ChatGPT in supporting complex decision-making and the inherent risks associated with relying on AI-generated recommendations without professional oversight.

3.3 Trust

Trust plays a fundamental role in how patients engage with AI-driven healthcare tools. ChatGPT's growing presence in medical contexts introduces a new dynamic into the patient-provider relationship, where AI is both a source of support and a potential disruptor of trust. Ensuring trust in AI-assisted healthcare requires prioritising patient autonomy and transparency. Patients should be informed about AI's role in decision-making, ensuring that AI recommendations support rather than replace individualised care (Lu et al., 2024). Choudhury et al. (2024) found that patients' trust in ChatGPT's competence and transparency significantly influences their reliance on its health recommendations. When perceived as competent, ChatGPT's responses may be accepted as accurate – even when they contain misinformation. Additionally, its persuasive nature can reinforce false health beliefs, potentially causing patients to take decisions that diverge from evidence-based medical guidance. This highlights the risk of misinformation in AI-generated healthcare advice, which can contribute to misdiagnosis, bias, and diminished trust in medical professionals. A study by Hopkins et al. (2023) compared Google's capabilities with those of ChatGPT, noting that ChatGPT provided more varied and supplementary information, especially for complex questions. However, concerns were raised about ChatGPT's lack of references and its potential to produce incorrect answers, leading to uncertainty regarding the reliability of AI-generated medical advice. This was further highlighted in Seth et al.'s (2023) study on breast augmentation, where ChatGPT was used to address frequently asked questions with similar mixed results. Carlbring et al. (2023) emphasised that transparency is essential when AI is incorporated into mental health interventions. Clients should be made aware when their support is coming from an AI system rather than a human therapist, as misrepresenting AI as a real person could create ethical and trust issues.

In addition, integration of ChatGPT into patient care reflects the intricate feedback loops inherent in complex adaptive systems. Introducing ChatGPT can create cascading effects throughout the healthcare system, where AI-generated decisions influence patient perceptions and behaviour, which in turn affect clinical practice and regulatory structures. These feedback loops can amplify both positive and negative outcomes. Understanding these dynamics is crucial, as small changes or decisions influenced by AI can reverberate through different system levels, leading to significant and sometimes unexpected shifts in patient care and system efficiency. This highlights the importance of approaching AI

integration with a deep appreciation for the interconnectedness of and sensitive dependence on initial conditions that define complex adaptive systems (Braithwaite et al., 2017; Foster and Pyka, 2014).

3.4 Bias and healthcare disparities

Using ChatGPT to take decisions about medical treatments – such as those for, e.g., obesity, chronic conditions, or infectious diseases – presents significant ethical challenges. One of the most pressing concerns is the potential for bias, particularly when AI systems are used to guide patient care decisions (Arslan, 2023; Biswas, 2023; Goodman et al., 2023). The question of responsibility arises in instances where AI provides incorrect or harmful advice. Alami et al. (2020) emphasised the need for robust monitoring systems to ensure responsibility and sustainability in AI development, especially for marginalised groups. They highlight how bias in AI algorithms–trained on data from high-income countries–may inadvertently reinforce inequalities in low- and middle-income countries. Likewise, AI systems often reflect biases rooted in their training data, which predominantly come from Western, industrialised societies. This limited dataset reduces the accuracy of diagnostic tools for underrepresented populations, leading to disparities in care access and quality (Abdulai, 2025). Specifically, studies have found that some AI-driven diagnostic tools struggle to detect medical conditions in Hispanic women, while mental health assessment models frequently overlook signs of psychological distress in non-native language speakers. For instance, Obermeyer et al. (2019) found that a predictive AI-driven risk stratification algorithm, used to allocate healthcare resources, systematically underestimated Black patients' care needs because it relied on future healthcare costs rather than actual health status, leading to racial disparities in access to high-risk care programmes. They showed that AI, after all, is a product of the data it is trained on, and if not carefully managed, it could reinforce existing inequalities or even introduce new ones. Beyond access to care, biased AI-generated recommendations can perpetuate harmful stereotypes, increasing lack of integrity in healthcare systems and discouraging patients from seeking necessary treatment (Abdulai, 2025). This risk is particularly acute when the data used to train AI systems lack sufficient representation of minority groups, resulting in inaccurate statistical patterns and biased outputs (Huang et al., 2022). The risk is further heightened if AI is deployed without transparency or accountability. Thus, the ethical implications are profound, especially when consider the balance between human expertise and machine intelligence.

3.5 Privacy and security

Furthermore, the security and privacy of patient information remain critical concerns that cannot be overlooked as regards the use of ChatGPT (Arslan, 2023). Although ChatGPT offers considerable potential, the ethical and security concerns associated with its use must be rigorously addressed. Without oversight, these risks could undermine the benefit of AI in healthcare, potentially exposing sensitive patient data or enabling unauthorised access to personal health records. Previous security breaches in healthcare have largely involved unauthorised external actors hacking into databases to steal patient information (Tertulino et al., 2024). These breaches have often exploited vulnerabilities in electronic health record systems, emphasising the need for robust encryption, access controls, and

audit mechanisms (Pool et al., 2024). Unlike traditional breaches, where the threat originates externally, GAI presents novel security risks, as sensitive data may be inadvertently exposed through AI-generated outputs or insufficiently controlled model training processes.

3.6 Accountability

Despite the gravity of these concerns, ethical considerations have frequently been overlooked in studies on AI in healthcare. One review of several case reports and studies involving patients revealed a troubling oversight: ethical considerations were often not mentioned or discussed (Chauhan et al., 2023; McCormick and Chirila, 2023; Montagne et al., 2023; Sagalow et al., 2023; Seth et al., 2023; Tomar et al., 2023; Zamarud et al., 2023). In the context of health education, particularly in nursing, use of GAI must be accompanied by a strong emphasis on ethical awareness. This includes concerns about academic integrity, plagiarism, and reliability of information. The need for responsible use of these technologies must also be considered (Irwin et al., 2023). Nursing is consistently ranked as the most trusted profession, which is a testament to the profession's integrity, honesty, and commitment to patient care (Olshansky, 2011). It is essential to actively nurture this trust capital and to ensure it remains intact. As AI technologies like ChatGPT become integrated into nursing, safeguarding this trust requires keeping ethical considerations at the forefront of their implementation. In a complex adaptive system, breaches in ethical standards can lead to cascading failures, which may erode trust, compromise patient safety, and damage the overall integrity of healthcare. The ethical challenges of implementing ChatGPT extend far beyond isolated incidents; they have the potential to emerge and impact the entire healthcare system. For this reason, ethical considerations must be at the forefront of any discussion on the integration of GAI technologies like ChatGPT.

One possible way to manage these risks is to establish rules for how AI systems should operate, including transparency measures, structured explainability models, and ongoing documentation updates. While broader AI governance frameworks emphasise these principles, applying them to healthcare requires additional safeguards to maintain trust and accountability in patient care. Transparency and explainability are particularly important when AI-generated decisions influence medical treatment, as unclear reasoning can weaken trust and complicate accountability. Ensuring that AI systems are designed with varying levels of interpretability for different stakeholders may help balance the need for openness with privacy concerns (Goktas, 2024; Lund et al., 2025).

4 Enforcement of ChatGPT in the context of health education

The integration of GAI into health education presents both opportunities and challenges. On one hand, GAI offers potential benefits such as personalised feedback, remote support, and the development of critical thinking and problem-solving skills (Draganic, 2023; Irwin et al., 2023). However, these opportunities must be balanced with serious concerns. Academic integrity, copyright laws, and the potential risk of compromising patient safety are all critical issues that need careful management when implementing GAI into education (Irwin et al., 2023). For instance, in the European exam in core cardiology (EECC), a post-graduate exam for cardiology specialty trainees, ChatGPT

demonstrated its capabilities by answering 340 out of 362 questions with an overall accuracy of 58.8%, achieving a score above or near the passing grade (Skalidis et al., 2023). Similarly, beyond standardised medical examinations, ChatGPT has also been evaluated in broader educational settings. Yang et al. (2024) systematically assessed ChatGPT-4's reasoning abilities using multiple evaluation tools, including the Watson-glaser critical thinking appraisal (WGCTA) and China's national teacher certificate examination (NTCE). Their findings revealed that while ChatGPT-4 demonstrated strong analytical and problem-solving skills – outperforming undergraduate students in critical thinking assessments – it struggled with complex inferential reasoning and exhibited limitations in creative problem-solving. These results underscore both the promise and constraints of GAI-driven education, reinforcing the need for human oversight in high-stakes learning environments. This aligns with the necessity of an 'AI ecological education policy framework' as suggested by Chan (2023), where AI adoption in education must be structured along pedagogical, governance, and operational dimensions to ensure responsible use and continuous evaluation.

4.1 Ensuring a human-in-the-loop approach

Beyond standardised assessments, the ethical implications of AI in education necessitate clearer regulatory frameworks. Goktas (2024) emphasised the importance of transparency and explainability in AI-driven learning environments, cautioning that over-reliance on GAI could lead to biases, misinterpretation of AI-generated content, and increased academic misconduct. Additionally, Goktas et al. (2023) introduced the concept of *Smart Prompt Learning*, advocating for an educational model where AI augments human expertise rather than replacing it. This is in line with the broader need to integrate AI into education in ways that enhance rather than disrupt traditional pedagogical approaches. In the context of nursing education, Draganic (2023) stressed the importance of not relying solely on GAI tools like ChatGPT.

Critical thinking remains essential, and educators are encouraged to integrate AI in a responsible way, always remembering that 'Technology should not replace human judgment and expertise' [Draganic, (2023), p.6]. Similarly, Chan (2023) stressed that universities must not only teach students how to use AI, but also provide ethical training on its limitations and potential biases, fostering a balanced and informed approach. Ensuring a *Human-in-the-Loop* approach is crucial in healthcare education, where AI should function as a complementary tool rather than an authoritative source. This necessitates ongoing AI literacy training for educators and students, allowing them to critically assess AI-generated content. As Goktas et al. (2024) pointed out, transparency mechanisms – such as explainability models and audit frameworks – should be embedded in AI systems to uphold academic integrity and safeguard educational outcomes. In this regard, AI policies should be developed collaboratively with students and faculty, ensuring that ethical AI integration aligns with broader educational goals (Chan, 2023). This perspective highlights the importance of combining AI with the irreplaceable human elements of compassion, judgment, and critical analysis.

4.2 Risk mitigation and system safety in health education

Teaching healthcare professionals to work with AI like ChatGPT goes beyond mere technical training; it requires a deep understanding of the complex adaptive system in

which they operate. As these professionals learn to integrate AI into their practice, they must also be prepared to navigate the broader systemic changes that AI brings with it. Their decisions should aim to enhance, rather than disrupt, the delicate balance of healthcare systems. However, in the contemporary 'landscape' of healthcare education, there remains a lack of training on AI's systemic risk and ethical constraints. Thus, the push towards AI integration requires ongoing education and training, ensuring that these technologies are used effectively and safely. As highlighted by Goktas et al. (2024), preventing the generation of non-existent sources and mitigating AI hallucinations are critical to maintaining the credibility of AI-assisted education. From a complexity science perspective, the interactions between the education system, healthcare system, and broader societal structures create feedback loops that can either reinforce positive outcomes or exacerbate negative ones.

5 Towards responsible ChatGPT integration in healthcare

The integration of ChatGPT and other GAI models into healthcare represents a systemic transformation within a complex adaptive system. Healthcare, as a complex adaptive system, is non-linear, emergent, and interdependent, meaning even well-intended innovations can trigger unpredictable consequences (Braithwaite et al., 2017; Wilson et al., 2023). Unlike conventional tools that fit within pre-existing workflows, ChatGPT actively reshapes the system in which it operates, influencing professional roles, decision-making hierarchies, and institutional structures (Plsek and Greenhalgh, 2001). Previous research on complex adaptive system has shown that healthcare systems cannot be fully governed by static regulatory models, as their adaptive nature requires iterative, flexible governance structures (Snowden and Boone, 2007). AI, as an emergent actor in this system, necessitates a similar reflexive approach, by continuously adjusting to evolving interactions across professionals, patients, and institutions (Wilson et al., 2023). As the healthcare system stands at the threshold of widespread AI adoption, it is necessary to embrace these technologies with caution. The complex adaptive system framework reminds us that seemingly beneficial innovations can produce unintended vulnerabilities when implemented in complex, interdependent environments (Braithwaite et al., 2017).

Imposing rigid, pre-emptive regulations entails the risk of constraining AI's adaptability, while having uncontrolled AI adoption entails the risk of destabilising critical decision-making structures (Snowden and Boone, 2007). Taking a reflexive governance approach – one that continuously monitors and recalibrates AI's evolving role – is essential to maintaining system resilience while allowing AI to develop in a responsible manner (Wilson et al., 2023). While ChatGPT and other GAI models hold transformative potential, their impact will not be determined solely by technological advancements, but also by the frameworks in which they are embedded (Braithwaite et al., 2017). By embracing AI with caution – balancing innovation with ethical oversight, and adaptability with patient safety – healthcare institutions can harness AI's transformative power while safeguarding the fundamental principles that define high-quality, equitable care (Sturmberg et al., 2012).

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Ethics and consent statements

There are no human participants in this article, and informed consent is not applicable.

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