

Revolutionizing Patient Care: The Impact of ChatGPT and Generative AI in Healthcare

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Abstract:- Generative AI, a subset of artificial intelligence (AI), possesses the ability to produce diverse forms of data, including images, videos, audio, text, and 3D models. It achieves this by analyzing existing data patterns and leveraging this knowledge to generate fresh and distinct outputs. Noteworthy advancements in the field, exemplified by OpenAI's ChatGPT, have substantially enhanced the potential of generative AI. These breakthroughs have unlocked novel opportunities for applying generative AI in addressing intricate challenges within the healthcare domain. The advent of ChatGPT has provided a progressively clearer glimpse into how generative AI might reshape the healthcare industry. Fueled by large language models (LLMs), generative AI, like ChatGPT, possesses the potential to revolutionize multiple facets of healthcare, encompassing patient interactions, clinical diagnostic assistance, telehealth services, health education, health advisory services, and health promotion. This research paper presents a curated selection of representative instances where generative AI finds application in the realms of healthcare. Despite the promising capabilities of ChatGPT and similar technologies, they also raise a plethora of ethical and privacy concerns, which are meticulously scrutinized within this document. Furthermore, we engage ChatGPT to provide its perspective and articulate responses to several questions that we endeavor to answer. In conclusion, we assert that generative AI will assume an increasingly pivotal role in healthcare as it evolves and becomes more finely tuned to the unique requisites of the medical field, and as legal, regulatory, and policy frameworks governing its usage take shape.

Keywords: *Generative AI, Large Language Models, ChatGPT, Artificial Intelligence, Healthcare.*

1. Introduction

Over the years, artificial intelligence (AI) has driven transformative progress across various sectors, and its impact on healthcare holds significant promise. In November 2022, OpenAI introduced an innovative AI-powered chatbot named ChatGPT, which quickly garnered substantial public attention. Setting itself apart from previous chatbots, ChatGPT exhibited exceptional proficiency in generating coherent responses to a wide spectrum of inquiries. The ChatGPT model has garnered considerable attention and emerged as a potent tool with the potential to reshape the healthcare landscape due to its remarkable natural language processing (NLP) capabilities [1,2]. These advanced language models display a remarkable ability to comprehend and generate text that resembles human language, rendering them highly suitable for numerous applications, particularly in the fields of medicine and healthcare.

However, the utility of generative AI extends beyond healthcare. For instance, AI is already being employed to create movies, and it is conceivable that in the near future, generative AI could produce entire shows based on user directives [5A]. Similarly, AI is proficient in generating music and voice content, and the combination of existing techniques enables the creation of multi-modal media. In higher education, educators and administrators are grappling with the impact of ChatGPT. Considerations must be made regarding take-home exams, as students can readily employ generative AI to compose entire essays or sections of their assignments, with no reliable means of detecting ChatGPT-generated content. Some individuals view this disruption with apprehension and frustration, while others are already incorporating it into their teaching methods, encouraging students to use it in novel and creative ways. The precise transformation that higher education will undergo due to ChatGPT remains uncertain, but it is indisputable that change is on the horizon.

By harnessing extensive medical data and knowledge, GPT models can revolutionize various aspects of the healthcare sector, ushering in a new era of clinical decision support, patient communication, and data management. Their ability to process and interpret complex medical information has generated optimism regarding their transformative potential in healthcare practices. GPT models can aid healthcare professionals in formulating recommendations to enhance their decision-making, leading to improved patient outcomes and overall healthcare service quality [26]. For example, by analyzing extensive medical datasets, GPT models

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can assist in disease diagnosis and prognosis, identifying and predicting various medical conditions, thereby enabling earlier detection and personalized treatment strategies. Additionally, when equipped with sophisticated tools, GPT models can aid radiologists in clinical diagnosis by interpreting medical images, enhancing diagnostic accuracy and reducing interpretation time [37]. Leveraging their capacity to comprehend intricate molecular interactions, GPT models can also revolutionize the drug discovery process by predicting potential drug candidates with higher efficacy and safety probabilities, expediting the development of innovative therapies and treatments [44].

Beyond enhancing the efficiency and quality of medical services, GPT models hold the potential to transform patient communication. As interactive AI language models, GPT models can engage with patients, offer educational resources, and address medical inquiries, fostering increased patient engagement and empowerment in managing their health [45]. Furthermore, their ability to streamline the management of electronic health records (EHR) and clinical documentation offers a promising avenue for reducing administrative burdens, allowing healthcare practitioners to devote more time to patient care [47].

Table 1. Chat with ChatGPT – Uses in Healthcare

<p>Question: <i>In what ways can you be used in healthcare?</i></p> <p>ChatGPT: <i>As an AI language model, I have some limitations, some of which include:</i></p> <p><i>I can be used in various ways in healthcare to enhance processes, support medical professionals, and improve patient care. Here are some ways in which I can be applied:</i></p> <p><i>Clinical Decision Support: I can assist healthcare providers by offering information and insights from medical literature and databases. This can help doctors make more informed decisions about diagnoses, treatments, and medications.</i></p> <p><i>Medical Research: Researchers can use me to analyze large datasets, identify trends, and generate hypotheses. This can accelerate the discovery of new treatments and medical breakthroughs.</i></p> <p><i>Patient Education: I can provide patients with understandable information about their medical conditions, treatment options, and post-care instructions. This can improve patient comprehension and adherence to treatment plans.</i></p> <p><i>Telemedicine: I can facilitate telehealth consultations by helping doctors and patients communicate effectively, even when they are not in the same location.</i></p> <p><i>Electronic Health Records (EHR) Management: Healthcare organizations can use me to streamline EHR documentation, reducing administrative burdens on healthcare providers and improving data accuracy.</i></p> <p><i>Administrative Tasks: I can assist with appointment scheduling, billing inquiries, and other administrative tasks, allowing healthcare staff to focus more on patient care.</i></p> <p><i>Medical Imaging: I can assist radiologists in analyzing medical images such as X-rays, MRIs, and CT scans, helping to detect abnormalities and improve diagnostic accuracy.</i></p> <p><i>Health Monitoring: Wearable devices and IoT sensors can transmit data to me for analysis. I can then provide insights into a patient's health status and notify healthcare providers of any concerning changes.</i></p> <p><i>Drug Discovery: I can help researchers in drug discovery by predicting potential drug candidates, simulating molecular interactions, and expediting the identification of novel therapies.</i></p> <p><i>Mental Health Support: I can provide mental health assistance by offering resources, suggestions, and coping strategies to individuals dealing with mental health challenges.</i></p> <p><i>Language Translation: I can assist in overcoming language barriers by providing real-time translation services for healthcare providers and patients who speak different languages.</i></p> <p><i>Healthcare Chatbots: Chatbots powered by my technology can be used on healthcare websites and applications to answer common questions, schedule appointments, and provide general medical information.</i></p> <p><i>Healthcare Education: I can be used to create educational materials and training programs for medical professionals and students.</i></p> <p><i>It's important to note that while I can provide valuable support in healthcare, my responses should be used as supplementary information and not as a replacement for the expertise of qualified healthcare professionals. Additionally, privacy and security considerations are crucial when using AI in healthcare to ensure the protection of sensitive patient data.</i></p>
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Responses generated by ChatGPT in Table 1. demonstrates remarkable coherence, engagement, and precise grammatical structure. In spite of the potential for transformative change that generative models offer, their incorporation into the field of medicine and healthcare presents a set of challenges and ethical dilemmas. One of the foremost concerns is the assurance of accuracy and dependability in AI-driven decisions, especially in critical medical scenarios. The 'black box' nature observed in certain AI models, including generative ones, gives rise to inquiries about the interpretability of the decisions they produce, underscoring the need for increased transparency and comprehensibility in AI systems employed within healthcare settings. Furthermore, ethical considerations relating to data privacy, patient confidentiality, and the possibility of biases inherent in AI models demand meticulous

scrutiny [48]. Given that these models interact with sensitive medical data, safeguarding patient privacy and upholding data security are paramount to preserving public trust in AI-facilitated healthcare solutions.

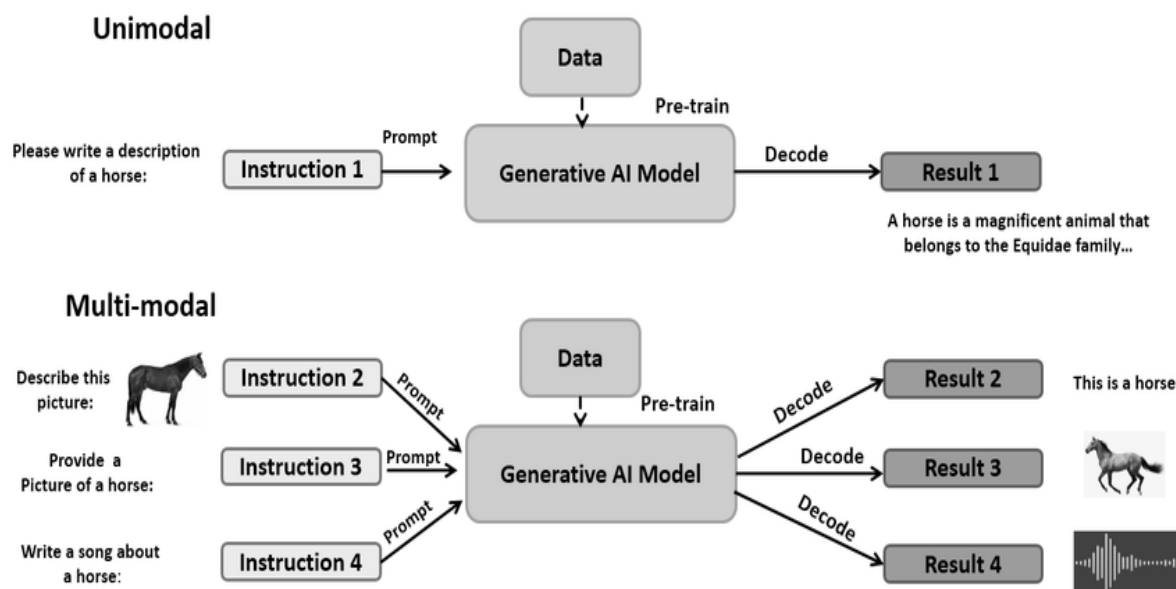


Figure. 1. Generative AI Model

In light of recent advancements, this comprehensive review article offers an overview of the current landscape in both industry and research regarding the utilization of generative AI models within the realms of medicine and healthcare. By shedding light on their extensive potential, advantages, challenges, and ethical considerations, this research endeavor aims to contribute to the ongoing discourse regarding the responsible deployment of AI's transformative capacities to enhance medical practice and patient well-being. As we delve into the impact of generative models on the fields of healthcare and medicine, it becomes imperative to navigate the continually evolving AI terrain with an unwavering commitment to ethical principles, patient-centric care, and a collaborative partnership between AI developers, healthcare professionals, and policymakers.

2. Generative AI Technology

Large Language Models (LLMs), as a pivotal subfield within the domain of artificial intelligence (AI), centers its focus on the interaction between computers and human language. Its primary objective is to empower machines with the capability to comprehend, interpret, and generate human language in a manner that is both meaningful and contextually relevant. NLP encompasses a diverse array of tasks, ranging from language translation, sentiment analysis, speech recognition, text summarization, to question answering, among others. These tasks are meticulously designed to bridge the divide between human communication and computational understanding [49]. The implementation of NLP within the healthcare sector has been extensive, showcasing its remarkable aptitude for extracting and analyzing valuable insights from vast volumes of unstructured clinical data. This data encompasses electronic health records (EHRs), medical literature, and content generated by patients [4]. Particularly noteworthy is NLP's capacity to convert unstructured clinical notes into structured data, aiding in the identification of medical conditions, medications, and laboratory test names through processes like named entity recognition [11,6]. Likewise, NLP has been effectively applied to unstructured EHR data, facilitating the identification and detection of adverse drug events by discerning relevant drugs and their interactions [7]. NLP-driven models have also played a pivotal role in early disease detection, enabling timely interventions and resulting in improved patient outcomes [8].

Within the domain of NLP, GPT models have emerged as a significant development, pioneered by OpenAI. GPT models constitute a family of sophisticated language models meticulously designed to leverage the potential of deep-learning neural networks. At the core of GPT models lies the transformer architecture, initially introduced by Vaswani et al. in 2017 [9]. This neural network architecture excels in processing sequential data, especially text, by deploying a mechanism known as 'self-attention.' Self-attention empowers the model to discern the significance of individual words within a sentence during processing, enabling it to allocate greater attention to semantically related words and carry more contextual information. The revolutionary aspect of transformers lies in their proficiency in handling long-range dependencies within language sequences, thereby enhancing their ability to grasp contextual language nuances and semantic comprehension.

Since their inception, the development and evolution of GPT models have progressed rapidly over a relatively brief period. The chronicle of GPT models commences with the introduction of the original GPT-1 by OpenAI in June 2018. GPT-1 served as a testament to the potential of pre-training large-scale Transformer models on extensive textual data, resulting in the generation of coherent and contextually relevant language. Building upon the success of GPT-1, OpenAI unveiled GPT-2 in February 2019. GPT-

2 marked a significant leap, boasting an impressive 1.5 billion parameters. However, its release raised concerns regarding potential misuse due to its ability to generate human-like text, including fictitious news and misinformation. As a precautionary measure, OpenAI initially restricted access to the full GPT-2 model, providing access only to scaled-down versions. In November 2019, OpenAI fully released the GPT-2 model, making it widely accessible to researchers and developers. This decision sparked a surge in research and experimentation, propelling the rapid development and fine-tuning of GPT-2 across diverse domains, including text generation, chatbots, language translation, and more [1,10].

The timeline embarked on another substantial leap in June 2020 with the introduction of GPT-3. This model represented a monumental achievement, comprising a staggering 175 billion parameters, thus establishing itself as the largest language model in existence at the time. GPT-3 demonstrated unparalleled language generation capabilities, encompassing the ability to perform tasks such as translation, summarization, question-answering, and even creative writing. GPT-3's success ignited heightened interest in Large Language Models (LLMs), subsequently leading to numerous research breakthroughs and commercial applications [2]. In November 2022, OpenAI unveiled ChatGPT, another revolutionary model powered by the GPT-3.5 architecture, designed as an advanced conversational AI. ChatGPT is engineered to engage in natural and dynamic conversations, rendering it a versatile and invaluable tool for a plethora of applications. Users can interact with ChatGPT by providing text prompts or questions, to which it responds by generating coherent and contextually relevant answers, drawing upon its acquired knowledge from the pre-training data. Five months later, in March 2023, GPT-4 was introduced, characterized as a large multimodal model capable of processing both image and textual inputs, and boasting even further improved performance over ChatGPT. Given the extensive pre-training process, these trained models are collectively referred to as Large Language Models (LLMs) [16].

Table 2. Chat with ChatGPT - Generative AI Technology

<p>Question: What is Generative AI Technology?</p> <p>ChatGPT: Generative AI technology, often referred to as Generative Adversarial Networks (GANs) or generative models, is a subset of artificial intelligence (AI) that focuses on creating new data, such as images, text, audio, or other forms of content, rather than analyzing or interpreting existing data. It is designed to generate data that is similar to, or even indistinguishable from, data that could be produced by humans.</p> <p>Here are some key characteristics and components of Generative AI Technology:</p> <p>Generative Models: These are the core algorithms and neural networks that power generative AI. They learn patterns and structures from large datasets and use that knowledge to generate new data. Some popular generative models include Variational Autoencoders (VAEs), Recurrent Neural Networks (RNNs), and GANs.</p> <p>Generative Adversarial Networks (GANs): GANs are a specific type of generative model that consists of two neural networks – a generator and a discriminator. The generator creates data, while the discriminator tries to distinguish between real data and data generated by the generator. These two networks are trained simultaneously in a competitive manner, resulting in the generator getting better at creating realistic data over time.</p> <p>Variety of Data Types: Generative AI technology can be applied to various types of data, including images, text, audio, video, and more. This versatility makes it valuable across different domains and industries.</p> <p>Creative Outputs: One of the most exciting aspects of generative AI is its ability to produce creative and novel content. This can range from generating realistic images of nonexistent faces to composing music or generating human-like text.</p> <p>Data Augmentation: Generative AI can be used to augment datasets for training other machine learning models. For example, in computer vision, it can generate additional images to improve the performance of object recognition models.</p> <p>Simulation and Prediction: It can simulate scenarios or predict future events based on learned patterns. In fields like healthcare, it can simulate the behavior of diseases, which can aid in treatment planning and drug discovery.</p> <p>Challenges and Ethical Concerns: While generative AI has immense potential, it also raises ethical concerns related to deepfakes (fake but highly realistic media), misinformation, and privacy. Ensuring the responsible and ethical use of this technology is crucial.</p> <p>Generative AI technology has found applications in a wide range of industries, including art, entertainment, healthcare, finance, and more. Its ability to mimic and create human-like content makes it a powerful tool for tasks that involve creativity, simulation, or generating new insights from data. However, as with any advanced technology, it requires careful consideration of ethical and societal implications as it continues to evolve and expand its capabilities.</p>

The intrinsic "generative" capability of these models endows them with the remarkable capacity to autonomously generate human-like text. This feature bears significant implications across a wide spectrum of domains, healthcare included. The pre-training phase plays a pivotal role in the creation of GPT models. During this phase, the model is exposed to a massive corpus of diverse textual data and datasets, enabling it to acquire a robust understanding of language patterns and structures. The fusion of pre-training with

the transformer architecture equips GPT models with the ability to excel in various NLP tasks, facilitating text generation with a high degree of fluency and contextual coherence, akin to human language [17]. Pre-training mirrors the initial phase of knowledge acquisition, wherein GPT learns from vast quantities of unlabeled text data to cultivate a robust language understanding. Subsequently, fine-tuning, the subsequent phase in GPT model training, ensues, utilizing task-specific labeled data, including data in healthcare. This process tailors the pre-trained model to perform specific NLP tasks pertinent to the healthcare domain, such as medical question answering, clinical text classification, or the translation of medical records.

The convergence of GPT's language comprehension capabilities, in conjunction with pre-training and fine-tuning, empowers the model's acquired medical language knowledge to excel in a broad spectrum of downstream healthcare NLP tasks. This culminates in enhanced model performance and reduces the time and resources requisite for comprehensive model training. By generating text resembling human language and capitalizing on their language proficiency within healthcare-specific tasks, LLMs have showcased immense potential in advancing AI-driven healthcare solutions. The integration of generative AI into the realm of healthcare holds promise for augmenting clinical decision support, enhancing patient communication, and expediting disease diagnosis, ultimately paving the way for AI-driven healthcare solutions that can aid medical professionals in making well-informed decisions and elevating the quality of patient care [47].

3. Generative AI applications

Although ChatGPT has been made available to the public only recently, it has already garnered substantial research attention. In this section, we present recent studies that explore the utilization of ChatGPT in various research endeavors and applications. This article employs a scoping review methodology to delve into recent research that focuses on the utilization of ChatGPT across diverse domains. This approach is particularly fitting given the rapid pace of advancements in the field of AI, allowing us to encompass a wide range of research on the subject and gain insights into emerging evidence while pinpointing gaps in the existing knowledge base. To conduct a comprehensive exploration of the literature, we primarily relied on Google Scholar as our chosen search engine. Google Scholar was selected due to its extensive coverage of scholarly literature spanning various disciplines and formats. Our search encompassed a combination of keywords such as "ChatGPT," "ChatGPT Applications in Healthcare," and "Large Language Models (LLMs)" to ensure the inclusion of all potentially relevant publications.

Table 3. Chat with ChatGPT – Most Famous Applications in Healthcare

<p>Question: <i>What are your most famous applications in healthcare?</i></p> <p>ChatGPT: <i>As of my last knowledge update in September 2021, there were several notable applications of AI in healthcare, some of which gained prominence due to their potential to transform the healthcare industry. However, it's important to note that the landscape of AI applications in healthcare continues to evolve rapidly. Here are some of the famous applications:</i></p> <p>Medical Imaging Analysis: <i>AI has been widely used for the interpretation of medical images, such as X-rays, CT scans, and MRIs. AI algorithms can assist radiologists in detecting abnormalities, tumors, and other medical conditions more accurately and quickly.</i></p> <p>Disease Diagnosis: <i>AI-powered tools can aid in diagnosing diseases by analyzing patient data, including medical records, lab results, and symptoms. These tools can provide doctors with diagnostic insights and suggest potential treatment options.</i></p> <p>Drug Discovery: <i>AI can significantly accelerate the drug discovery process by analyzing vast datasets of molecular structures, genetic information, and clinical trial data. It can help identify potential drug candidates and predict their efficacy.</i></p> <p>Personalized Treatment Plans: <i>AI can create personalized treatment plans based on a patient's unique genetic makeup and medical history. This approach, known as precision medicine, aims to optimize treatment outcomes and minimize side effects.</i></p> <p>Telehealth and Remote Monitoring: <i>AI-powered telehealth platforms enable remote consultations between patients and healthcare providers. Additionally, wearable devices and sensors can collect patient data and send it to healthcare providers for continuous monitoring.</i></p> <p>Natural Language Processing (NLP): <i>NLP techniques are used for analyzing unstructured clinical notes, medical literature, and patient-generated content. AI-driven NLP can assist in extracting valuable insights from these sources.</i></p> <p>Chatbots and Virtual Health Assistants: <i>AI-driven chatbots and virtual assistants like ChatGPT can provide information, answer health-related questions, and even offer basic diagnostic guidance. They enhance patient engagement and provide support.</i></p> <p>Robot-Assisted Surgery: <i>Surgical robots, guided by AI algorithms, assist surgeons during complex procedures, increasing precision and minimizing invasiveness. These robots can perform procedures with greater accuracy.</i></p>

Drug Adverse Event Monitoring: AI can help monitor adverse events related to medication by analyzing patient reports and identifying potential safety concerns.
Clinical Trial Optimization: AI can help design more efficient and cost-effective clinical trials by identifying suitable patient populations, optimizing trial protocols, and predicting patient outcomes.
Healthcare Fraud Detection: AI algorithms are used to detect fraudulent activities in healthcare, such as insurance fraud and inappropriate billing, saving costs for healthcare providers and insurers.
Population Health Management: AI-driven analytics can analyze population health data to identify at-risk individuals, monitor disease trends, and allocate healthcare resources more efficiently.
Please note that advancements in AI and healthcare applications have likely continued since my last update in September 2021. New applications and breakthroughs may have emerged, so I recommend checking the latest sources and developments in the field for the most up-to-date information on AI in healthcare.
Source: OpenAI. (2023). ChatGPT (September 25 Version) [Large language model]. <https://chat.openai.com>

De Angelis et al. (De Angelis et al., 2023) examined the assessment of language models concerning ChatGPT and illuminated potential ethical and practical challenges within the realms of medicine and public health. The primary challenges highlighted encompass the risk of AI-driven misinformation or the emergence of an "infodemic," which is often challenging to discern. In the field of medicine and public health, ChatGPT has already undergone exploration for a variety of applications. Khan et al. (Khan et al., 2023) deliberated on several prospective applications of ChatGPT in medical education, including personalized learning and the generation of case studies. The authors also underscored ChatGPT's utility in clinical management for tasks such as documentation and decision support. Rao et al. (Rao et al., 2023) conducted an evaluation of ChatGPT's effectiveness in delivering clinical decision support within the domain of radiology. The authors provided ChatGPT with text prompts, such as "For the variant 'Breast cancer screening. Average-risk women: women with <15% lifetime risk of breast cancer,' determine the single most appropriate imaging procedure," to assess its performance in breast cancer screening and the detection of breast pain. ChatGPT exhibited relatively commendable performance for the former task, with an accuracy rate of 88.9%, while achieving a 58.3% accuracy rate for breast pain detection. The role of ChatGPT and generative AI in assisting urologists has also been examined (Gabrielson et al., 2023). ChatGPT demonstrates its primary value in aiding urologists with low-complexity tasks, thereby affording them more time to devote to patient care. Hulman et al. (Hulman et al., 2023) employed ChatGPT to respond to frequently asked questions about diabetes and tasked healthcare professionals with distinguishing between responses generated by ChatGPT and those created by humans. The evaluators correctly identified ChatGPT-generated responses 59.5% of the time. Additionally, the authors concluded that despite ChatGPT not being exclusively trained on medical data, it possesses clinical knowledge and can recognize information pertaining to disease management. Generating a medical report on a specific topic could prove beneficial in pharmaceutical education. To this end, Zhu et al. (Zhu et al., 2023) prompted ChatGPT to generate a concise review on "lipid-based drug delivery systems." The authors determined that ChatGPT effectively structured the topic and offered meaningful conclusions for readers. However, concerns arose regarding accuracy due to the absence of reliable citations. Shen et al. (Shen et al., 2023) summarized potential use cases and implications of ChatGPT in medicine while addressing various other aspects of its application.

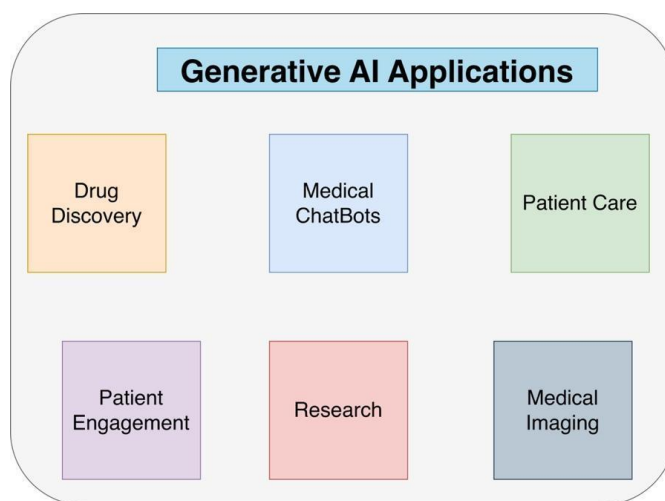


Figure. 2. Generative AI Common Applications in Healthcare

3.1. Most Prevalent Categories

Language: Text serves as the foundational element for numerous generative AI models, representing one of the most advanced domains. A prominent example within this category is large language models (LLMs). These expansive language models find application in a diverse array of tasks, including essay composition, code generation, language translation, and even the comprehension of genetic sequences.

Audio: Within generative AI, the realms of music, audio, and speech are gaining prominence. Models have demonstrated their capacity to craft musical compositions and generate audio clips from textual inputs. They can identify objects within videos and generate corresponding sound elements for different video content. Additionally, they can compose customized music tracks.

Visual: Among the most prevalent applications of generative AI lies the domain of visual content. This encompasses the generation of 3D images, avatars, videos, charts, and other visual representations. Generative AI exhibits flexibility in crafting visuals with distinct aesthetic styles. These models possess the capability to modify and enhance generated visuals. In practical terms, generative AI can construct graphs illustrating novel chemical compounds and molecules for drug discovery, generate lifelike images for virtual and augmented reality, create 3D models for video games, design logos, and perform various image editing tasks.

Synthetic Data: Synthetic data proves invaluable for training AI models when authentic data is lacking, constrained, or insufficient for addressing specialized scenarios with optimal precision. The creation of synthetic data through generative models stands as a highly impactful solution for surmounting data-related challenges across enterprises. This approach spans diverse modalities and use cases and can be achieved through a process known as label-efficient learning. Generative AI models facilitate cost reduction in data labeling by autonomously generating augmented training data or by acquiring an internal data representation that streamlines AI model training with reduced reliance on labeled data.

3.2 Applications in Healthcare

This section examines ongoing endeavors and research initiatives focused on harnessing Generative AI and LLMs to enhance various facets of medical practice. These applications encompass clinical administrative support, educational resources for healthcare professionals and patients alike, with the overarching goal of enhancing patient care, advancing medical research, and alleviating the workload of healthcare providers. By delving into the latest developments in this field, we aim to uncover the transformative potential of cutting-edge AI language models in shaping the future landscape of healthcare. Table 1 outlines specific applications of ChatGPT within the Healthcare Domain.

Table 4. Chat with ChatGPT - List few Healthcare Applications

<p>Question: List few healthcare applications using ChatGPT</p> <p>ChatGPT: Certainly, here are a few healthcare applications using ChatGPT:</p> <p>Clinical Decision Support: ChatGPT can assist healthcare professionals by providing information and recommendations based on patient data and medical knowledge. It can help doctors make informed decisions about treatment options, drug interactions, and diagnostic considerations.</p> <p>Patient Education: ChatGPT can serve as a virtual health assistant to educate patients about their medical conditions, treatment plans, and medication instructions. It can answer patient queries and provide clear explanations in plain language.</p> <p>Medical Documentation: Healthcare providers can use ChatGPT to assist in the documentation of patient records, including clinical notes, medical history, and treatment plans. This can save time and reduce the administrative burden on medical staff.</p> <p>Telehealth Services: ChatGPT can facilitate telehealth consultations by interacting with patients, collecting preliminary information, and assisting in appointment scheduling. It can also provide follow-up guidance after virtual visits.</p> <p>Health Information Chatbots: Healthcare organizations can deploy ChatGPT-powered chatbots on their websites or apps to answer general health-related questions, offer first-aid advice, and direct users to appropriate resources.</p> <p>Pharmaceutical Information: Patients and healthcare professionals can use ChatGPT to access information about medications, including dosage instructions, potential side effects, and drug interactions.</p> <p>Disease Awareness Campaigns: ChatGPT can be used to disseminate information about specific diseases, preventive measures, and public health campaigns. It can engage with the public and provide relevant insights.</p> <p>Health Promotion: ChatGPT can offer guidance on healthy living, nutrition, fitness, and lifestyle choices. It can help individuals make informed decisions to improve their overall well-being.</p> <p>Medical Literature Summarization: Researchers and medical professionals can use ChatGPT to summarize complex medical literature and research papers, making it easier to stay updated with the latest advancements in healthcare.</p> <p>Mental Health Support: ChatGPT can provide emotional support and resources for individuals dealing with mental health issues. It can offer coping strategies, relaxation techniques, and information about available mental health services.</p> <p>These are just a few examples of how ChatGPT can be applied in the healthcare sector. Its natural language understanding capabilities make it a versatile tool for improving patient care, medical education, and healthcare administration.</p>
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3.2.1. Virtual Health Assistant

The utilization of ChatGPT in healthcare extends to the development of virtual health assistants, which play a vital role in aiding patients in managing their well-being. These virtual assistants are equipped to automatically generate concise summaries of patient interactions and medical histories, thereby streamlining the medical record-keeping process for healthcare providers. Medical professionals can leverage ChatGPT by dictating their notes, enabling the automatic summarization of critical details such as symptoms, diagnoses, treatments, and the extraction of pertinent information from patient records, including lab results and imaging reports. Furthermore, ChatGPT proves valuable in the realm of clinical trial recruitment. By analyzing extensive sets of patient data, it can identify individuals who meet the eligibility criteria for clinical trials, potentially accelerating the recruitment process. Additionally, ChatGPT assists patients in managing their medication regimens, offering reminders, precise dosage instructions, and information concerning potential side effects, drug interactions, and other essential considerations. A recent article highlighting the advantages of artificial intelligence in managing sickle cell disease underscores ChatGPT's role as a dependable conversational agent capable of gathering information from patients with a diverse array of medical conditions.

3.2.2. Research, Drug Discovery, and Health Education

ChatGPT serves as an invaluable tool for the continual learning of medical students, doctors, nurses, and healthcare professionals, keeping them abreast of the latest updates and developments in their respective fields. Additionally, it can be employed as an assessment tool to evaluate clinical skills, playing a pivotal role in medical education. In the realm of health literacy, Chatbots like ChatGPT can effectively enhance knowledge, particularly among students and young adults. Generative AI, furthermore, has the potential to expedite the drug discovery process. Traditional drug discovery is both time-consuming and expensive, with many drugs taking decades to develop. Generative AI offers the capability to accelerate this process by generating new drug molecules that hold promise for future drug development. Deep learning algorithms enable the identification of potential drug candidates based on a vast dataset of compounds and their properties, ultimately leading to the creation of new molecules that can undergo laboratory testing for their potential as novel drugs.

3.2.3. Diagnostic Support

ChatGPT's application extends to diagnostic support. Recent interest has surged in AI-powered chatbot-based symptom checker (CSC) applications that employ natural, human-like interactions to provide potential diagnoses and assist users in self-triaging based on an Artificial Intelligence (AI) approach. Moreover, ChatGPT finds utility in clinical decision support and patient monitoring, suggesting consultations with healthcare professionals based on the recognition of warning signs and symptoms.

Table 5 Chat with ChatGPT - Diagnostic

<p>Question: A patient presents with fatigue, weight loss, and dizziness. What are some possible causes for these symptoms?</p> <p>ChatGPT: Fatigue, weight loss, and dizziness can be indicative of various underlying medical conditions. While these symptoms are nonspecific and could be linked to numerous factors, here are some possible causes to consider:</p> <p>Anemia: Anemia, a condition characterized by a deficiency in red blood cells or hemoglobin, can lead to fatigue and dizziness due to reduced oxygen-carrying capacity in the blood. Unexplained weight loss may also occur.</p> <p>Thyroid Disorders: Conditions like hyperthyroidism (overactive thyroid) can result in weight loss, fatigue, and dizziness. Thyroid hormones play a crucial role in metabolism and energy levels.</p> <p>Diabetes: Uncontrolled diabetes can lead to fluctuations in blood sugar levels, potentially causing fatigue and dizziness. Weight loss may occur in some cases.</p> <p>Infections: Certain infections, such as viral illnesses or chronic infections, can manifest with fatigue, weight loss, and dizziness as part of their symptom profile.</p> <p>Depression: Mental health conditions like depression can lead to a range of physical symptoms, including fatigue, changes in appetite leading to weight loss, and a sense of dizziness or lightheadedness.</p> <p>Cardiovascular Issues: Conditions like heart failure or arrhythmias can result in decreased blood flow to vital organs, leading to fatigue and dizziness. Weight loss may occur as a result of fluid retention.</p> <p>Nutritional Deficiencies: Deficiencies in essential nutrients, such as vitamin B12 or iron, can lead to anemia, fatigue, and dizziness. These deficiencies may also contribute to unexplained weight loss.</p> <p>Gastrointestinal Disorders: Conditions like celiac disease, Crohn's disease, or chronic gastritis can affect nutrient absorption and lead to weight loss, along with symptoms like fatigue and dizziness.</p> <p>Medication Side Effects: Some medications may cause side effects like fatigue, dizziness, and changes in appetite or weight.</p> <p>Autoimmune Disorders: Certain autoimmune diseases, such as lupus or rheumatoid arthritis, can cause fatigue and weight loss as part of their symptom profile.</p>

It's important to emphasize that these symptoms are not specific to a single condition, and a comprehensive medical evaluation by a healthcare professional is essential to determine the underlying cause. A thorough medical history, physical examination, and potentially additional diagnostic tests may be necessary to reach a diagnosis and develop an appropriate treatment plan. If someone is experiencing these symptoms, it is advisable to seek prompt medical attention.

3.2.2. Clinical Documentation Enhancement

Generative AI models offer a significant advancement in healthcare by streamlining the process of clinical documentation. Healthcare professionals, often faced with the time-consuming task of note-taking, can harness the capabilities of ChatGPT and similar models to swiftly and accurately generate preliminary clinical notes. By providing a concise verbal summary (referred to as a "prompt") or relevant patient data (while ensuring data privacy compliance), these models can generate comprehensive and contextually relevant clinical documentation, thereby saving valuable time for clinicians. An example of such integration is Microsoft Copilot [54], an enterprise tool that seamlessly incorporates generative AI into everyday productivity tools like Word, PowerPoint, and Teams. This integration has the potential to greatly enhance collaboration among multidisciplinary healthcare teams. For instance, in cases involving complex medical conditions that require input from multiple specialties, a generative AI-based meeting tool can assist in creating meeting agendas, identifying suitable team members for follow-up actions, and summarizing key meeting points.

Google Bard [3], powered by Med-PaLM 2, introduces exciting applications in healthcare, particularly in providing around-the-clock patient support and assisting healthcare providers. Trained on a wide range of medical information sources, including journals, textbooks, clinical notes, and patient records, Med-PaLM 2 enhances Google Bard's capabilities in generating medical content. This tool can assist in answering patient queries, suggesting potential diagnoses, and providing support for treatment plans. In the field of hematology, it can offer valuable information and assistance to patients with blood disorders, providing immediate responses and recommending professional medical attention when necessary. It is crucial to emphasize that AI-generated responses should be used for informational purposes only and not as a replacement for professional medical advice. As Google Bard continues to evolve, its potential to transform healthcare interactions and enhance patient care remains highly promising.

3.2.2. Decision Support

With their advanced language comprehension and domain-specific knowledge, GPT models also hold the potential to support clinical decision-making processes. Glass AI [1] is an experimental tool powered by a Large Language Model (LLM) that provides clinical decision support. It functions as a diagnostic assistant, generating a list of possible diagnoses and tailored treatment plans for a clinical audience. For instance, when presented with a patient exhibiting symptoms such as fatigue, shortness of breath, and paleness, a healthcare provider can input these symptoms into Glass AI [8]. The system can then generate a comprehensive list of potential differential diagnoses, which may include conditions such as anemia, leukemia, or myelodysplastic syndromes. Additionally, Glass AI can assist in formulating a clinical plan, guiding hematologists and other healthcare professionals in determining the next steps for further tests or treatment.

Kahun [16] is a symptom checker tool equipped with a conversational chatbot integrated with the Electronic Health Record (EHR) system. This tool conducts clinical assessments of patients by producing ranked lists of potential differential diagnoses and recommended workup options based on patient input and medical knowledge. Kahun's AI inference engine delivers a prioritized list of potential diagnoses, expediting the diagnostic process and saving valuable time. Ben-Shabat et al. demonstrated the superior performance of Kahun compared to a selected set of similar AI symptom checkers [20]. Additionally, Kahun suggests further workup options for a comprehensive patient evaluation. Its expanding network of relationships between disorders, complications, and findings ensures that healthcare professionals stay updated with the latest medical knowledge.

Table 6 Applications of ChatGPT in Healthcare Domain

Application	Method	Results
Clinical decision support in radiology (Rao et al., 2023)	Provided text prompts and evaluated diagnosis response for breast cancer screening	Effective in breast cancer screening (88.9%) but not in breast pain detection (58.3%)
Improving efficiency in Urology (Gabrielson et al., 2023)	Discussed the role of generative AI in helping urologists	N/A

Answer frequently asked medical questions (Hulman et al., 2023)	Asked human evaluators to distinguish between ChatGPT and human answers to diabetes related questions	The evaluators could only identify answers to be generated by ChatGPT 59.5% of the time
Write a short review on a medical topic (Zhu et al., 2023)	ChatGPT was asked to write a mini review on lipid-based drug delivery systems	ChatGPT can benefit readers with general knowledge, but the accuracy of analysis is questionable due a lack of reliable citations
Take on medical exam (Kung et al., 2023)	Asked ChatGPT questions from US medical licensing exam after removing questions with visual information	ChatGPT performed near the passing threshold of 60% accuracy
Take on a medical exam in Chinese (Wang et al., 2023)	Asked ChatGPT questions from the Chinese national medical licensing exam	ChatGPT performed considerably lower, with 45.8% correct answers

3.2.3. Patient Interaction Enhancement

Gridspace [15] represents an enterprise solution harnessing the power of generative AI to automate patient engagement through phone calls, query responses, and administrative tasks. It enables scalable, 24/7 accessible, and cost-effective patient interaction, handling both inbound calls and outbound patient communications. Gridspace automates routine administrative duties like appointment scheduling, patient reminders, and insurance verification. By delegating these tasks to voice bots, healthcare professionals can save time and dedicate their attention to critical patient care responsibilities. Moreover, Gridspace excels at triaging and directing patient inquiries in real-time, providing valuable insights. This application showcases the transformative potential of Generative AI in reshaping patient interactions, streamlining administrative workflows, and elevating overall healthcare efficiency and patient satisfaction.

3.2.4. Electronic Health Records (EHRs)

During the Covid-19 pandemic, Electronic Health Records (EHRs) played a pivotal role in managing patient information, facilitating communication among healthcare providers, and supporting decision-making processes. EHRs serve as digital repositories of a patient's complete medical history, encompassing diagnoses, treatments, medications, test results, and other pertinent health data. The process of employing generative AI to listen to and transcribe a conversation during a medical appointment, subsequently generating a summary for inclusion in an EHR, involves several technical and scientific components. These components collaborate to convert spoken words into written text, comprehend and extract the content, construct a meaningful summary, and seamlessly integrate it into the EHR system. Syntegra Medical Mind [22] leverages generative AI to create authentic synthetic patient records using real healthcare data, such as EHRs, while upholding patient privacy. Healthcare professionals can access and analyze this synthetic data for research, education, and decision-making without compromising confidentiality. The synthetic records accurately replicate the statistical properties of the original data, including rare cases and outliers, aiding specialists in comprehending diverse disease patterns. Syntegra also addresses data bias and enhances algorithmic fairness, promoting equitable treatment plans. This synthetic data layer breaks down barriers to data accessibility, fostering innovation and enhancing patient care. Muniz-Terrera et al. [24] demonstrated the potential of advancing dementia research through synthesized virtual cohorts.

3.2.5. Medical Imaging Enhancement and Simulations

Generative AI finds utility in elevating the field of medical imaging. The algorithm can learn from extensive datasets of medical images and generate high-resolution images of superior quality compared to the originals. This advancement aids doctors and healthcare providers in making more precise diagnoses. For example, generative AI can enhance MRI images of the brain, helping physicians detect subtle brain changes indicative of diseases. Additionally, generative AI can be employed to create medical simulations, benefiting healthcare provider training and ultimately improving patient outcomes. For instance, researchers at the University of Michigan have developed a generative AI algorithm capable of simulating various scenarios for treating sepsis, a life-threatening condition caused by infection. In summary, generative AI has the potential to revolutionize healthcare by enhancing the accuracy and speed of diagnoses, expediting drug discovery, and enabling personalized treatment plans.

4. Challenges in the Field of Generative AI

Generative AI holds significant promise for revolutionizing the field of medicine in the forthcoming years [50]. The practical illustrations provided in this article offer a glimpse of the transformative potential. As of July 31, 2023, a quick query on PubMed using the keyword 'ChatGPT' yielded 924 research publications (four from 2022 and 920 from the first seven months of 2023). Interestingly, a follow-up query on August 18, 2023, returned 1049 records [17]. While ChatGPT undeniably stands out as a dominant player in the generative AI landscape of 2023, it is essential to recognize that it represents just one facet of the broader GPT architecture and its various models. We anticipate continued momentum in generative AI in the coming months and years. In the subsequent sections, we will delve into some prevalent concerns, obstacles, and potential prospects tied to generative AI and its derivative products, including ChatGPT.

4.1. Copyright and Plagiarism Concerns

Despite the myriad potential applications, the integration of ChatGPT and other artificial intelligence (AI) tools into medical writing raises ethical and legal dilemmas. These encompass the risk of copyright infringement, medico-legal complexities, and the potential for inaccuracies or biases in generated content. Therefore, it is crucial to acknowledge and confront the limitations and challenges associated with AI in the realm of medical writing. Two research papers published in radiology journals emphasize that the accuracy of AI-generated text is greatly contingent on the quality and character of the training data used. In certain instances, output from such models can be erroneous, potentially leading to legal ramifications such as lawsuits. Issues like inaccuracies, biases, and the need for transparency are additional aspects that necessitate attention when working with AI-generated text. The unethical deployment of AI technology may extend to the fabrication of images, constituting a form of scientific misconduct. Identifying ChatGPT-generated text that includes fabricated quotes and irrelevant references can assist in identifying instances of plagiarism and other improprieties. Nevertheless, concerns persist regarding the possibility of students and scientists utilizing ChatGPT to deceive others or pass off its generated content as their original work.

Table 7. Chat with ChatGPT - Challenges using AI in Healthcare

<p>Question: What are some of your challenges using you in healthcare?</p> <p>ChatGPT: Using AI models like mine in healthcare comes with several challenges and considerations:</p> <p>Data Privacy and Security: Healthcare data is highly sensitive and subject to strict privacy regulations. Ensuring that patient data is handled securely and in compliance with laws like HIPAA (in the United States) is a significant challenge.</p> <p>Trust and Validation: Establishing trust in AI-generated information is crucial in healthcare. AI models should consistently provide accurate and reliable information to be considered a valuable tool by healthcare professionals.</p> <p>Regulatory Compliance: AI applications in healthcare must adhere to a complex web of regulations and certifications. Ensuring compliance with these regulations can be time-consuming and costly.</p> <p>Bias and Fairness: AI models can inherit biases present in the data they are trained on. In healthcare, these biases can have severe consequences, leading to disparities in patient care.</p> <p>Interoperability: Healthcare systems often rely on a patchwork of legacy software and data formats. Ensuring that AI systems can integrate seamlessly with existing systems and share data effectively can be challenging.</p> <p>Continuous Learning: Healthcare is a constantly evolving field. AI models need to adapt to new research, treatment protocols, and medical knowledge to remain relevant.</p> <p>Ethical Considerations: Decisions made by AI in healthcare can have life-or-death consequences. Ethical dilemmas, such as who is responsible when AI makes a critical decision, need to be addressed.</p> <p>User Training: Healthcare professionals must be trained to use AI tools effectively. This includes understanding their limitations and how to interpret AI-generated recommendations.</p> <p>Data Quality: AI models require high-quality, well-structured data to provide accurate results. Ensuring data quality and integrity is a significant challenge.</p> <p>Patient Acceptance: Patients may be hesitant or resistant to the use of AI in their healthcare, particularly in decision-making processes. Building patient trust and acceptance is crucial.</p> <p>Cost and Resource Allocation: Implementing AI in healthcare can require significant financial and resource investments. Healthcare organizations must consider the cost-effectiveness of AI solutions.</p> <p>Legal Liability: Determining legal liability in cases where AI is involved in healthcare decisions can be complex and is still a developing area of law.</p> <p>Algorithmic Transparency: Understanding how AI models arrive at their decisions is essential, especially when those decisions affect patient care. Ensuring transparency in AI algorithms is challenging but vital.</p> <p>Overall, while AI holds great promise in healthcare, it must be implemented thoughtfully and ethically, with careful consideration of these challenges to ensure patient safety and well-being.</p>
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4.2. Confidence

Confidence and verification play a pivotal role in the successful integration of generative AI in the field of medicine and healthcare. ChatGPT's responses exhibit significant variability in terms of quality and accuracy, which is particularly concerning due to its unpredictable nature. This unpredictability serves as the primary obstacle to its widespread adoption. The challenge lies in discerning when to rely on generative AI for accurate information and when to exercise caution, especially when users lack the expertise to evaluate response quality in terms of accuracy and completeness. As of the current state of technology, ChatGPT is known to sometimes generate fictitious content, even attributing it to non-existent academic sources [21–25]. This phenomenon, referred to as generative AI "hallucinations," can be mitigated through approaches like Retrieval Augmented Generation (RAG) [27]. Additionally, generative AI is susceptible to various forms of bias, depending on its training data [19], and may not consistently perform well in different languages [28]. The discussion on trust also encompasses the related concerns of clinical safety and reliability. As long as we lack a generative AI specifically trained and validated for medical applications (such as ChatGPT, which is not specialized in medicine), trust, safety, and reliability issues will persist and impede its meaningful use in the medical field. By "medically trained," we refer to a model that undergoes thorough training using high-quality, evidence-based medical texts that comprehensively cover a specific medical domain of specialization.

4.3. Regulatory Considerations

The challenge is further complicated by the constantly evolving landscape of medical and clinical knowledge, necessitating a form of generative AI that can be consistently and continuously trained and updated. Additionally, the rapid advancement of large language models and generative AI poses challenges in terms of their clinical assessment, regulation, and certification. For instance, there are already several iterations of OpenAI's ChatGPT, such as GPT3.5, GPT-4, and DALL-E 2 (for images) [29], as well as offerings from Meta (Llama 1 and 2, in collaboration with Microsoft [30]) and Google (Bard [31], which, as of the current writing, cannot provide specific clinical answers, likely due to an artificial limitation imposed by Google). Typically, newer versions of models tend to perform better [10], although this isn't guaranteed [20]. We anticipate that dedicated, medically trained large language models and generative AI will also undergo multiple successive versions in the near future. However, clinical evaluation and certification traditionally involve lengthy processes, creating a risk that by the time an evaluation is completed, the AI being assessed has undergone significant changes with the release of a new version, necessitating a fresh evaluation. Regulatory bodies are striving to keep up by establishing mechanisms to handle AI as a medical device [34]. Nonetheless, Large Language Models (LLMs) present unique challenges compared to already regulated AI-based technologies, requiring additional regulatory adjustments [35].

4.4. Privacy Concerns

In April 2023, Italy temporarily blocked access to ChatGPT within the country due to privacy apprehensions, including concerns related to the collection and storage of personal user data for model training purposes [15]. Access was later reinstated in Italy [24] following the introduction of new features in ChatGPT, allowing users to disable chat history and thus determine which conversations could or could not be used to enhance the underlying models [39]. However, until healthcare organizations have the means [40] to operate their own fully localized and controlled instances of these models and tools that can be trusted not to transmit any data to external entities for processing, it is highly recommended (if not mandatory, especially in the case of confidential patient information) that users avoid entering sensitive information or personal data into these tools [46].

On a different note, medical educators might find text-to-image generative AI valuable for creating high-quality teaching images representing various clinical conditions without the confidentiality and consent concerns associated with using real patient photos, especially when depicting whole-face images becomes necessary. Crucially, there remains a lack of transparency and openness regarding the training data and code used to train these models [19]. Unauthorized access (without consent) to data sources, potentially including private and confidential ones, for generative AI learning and training is currently the subject of a legal case in the USA [42]. Some researchers are already advocating for AI models to adhere to privacy laws, including the 'right to be forgotten' and the capacity to forget or unlearn information related to specific situations or individuals [43].

5. Conclusions

Generative AI has made significant strides in the healthcare sector, offering healthcare professionals the means to enhance data management, communication, and deliver more personalized and effective patient care. This article has explored various illustrative applications of generative AI in medicine and healthcare. It has also touched on associated concerns such as trustworthiness, accuracy, clinical safety, reliability, privacy, copyright, ownership, and the potential for creating user-friendly AI-driven conversational interfaces for health applications. We anticipate that as legal, policy, and regulatory frameworks surrounding generative AI continue to evolve, many of these concerns will be gradually addressed. We share the viewpoint expressed by Lee, Goldberg, and Kohane [47] that generative AI will increasingly play a pivotal role in the field of medicine and healthcare as it becomes more tailored to the unique needs and demands of the medical domain. In the near future, we expect the introduction of novel models specifically and comprehensively trained using high-quality, evidence-based medical texts that cover various clinical specialties. These models will prove invaluable to healthcare professionals and their patients.

Rather than AI replacing human clinicians, we envision "clinicians using AI" replacing "clinicians who do not use AI" in the coming years [18]. Generative AI has immense potential for positive impact, and its utility is undeniable. However, it is crucial to establish appropriate regulations to prevent potential negative consequences in healthcare. ChatGPT, for instance, can significantly reduce the time required for various tasks. However, its use in tasks like summarizing patient data, research, and AI-assisted clinical support has been limited to a select few individuals. When used judiciously, the time saved with ChatGPT can be redirected toward more productive and higher-priority tasks. Healthcare professionals can also leverage it to translate and elucidate patient medical notes or diagnoses in a more understandable manner for patients. Furthermore, as Large Language Models (LLMs) are designed to learn and improve through user interactions, there is a risk that they may inadvertently process and retain personal information provided in prompts. For instance, if a user provides contact details or other sensitive information during an interaction with ChatGPT, there is a potential for the model to learn and subsequently generate this information in future outputs.

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