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PAPER

Generative AI as Virtual Healthcare Assistant for Enhancing Patient Care Quality

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ABSTRACT

This study investigates the potential of Chat Generative Pre-Trained Transformer (ChatGPT) as a virtual healthcare assistant to enhance the quality of patient care. Inadequate patient care within healthcare systems is a key issue that has resulted in lower satisfaction and medical errors. Virtual healthcare assistants, exemplified by ChatGPT, have emerged as a promising solution to mitigate these challenges. A comprehensive literature review compares the benefits and drawbacks of using virtual healthcare assistants with those of human healthcare providers to assess their effectiveness in enhancing patient care. The article discusses the ChatGPT development process, including the data sources used, training and validation, and the integration of this technology into healthcare systems. The results of testing ChatGPT in patient care, including patient feedback, are provided. The study interprets these findings and indicates that ChatGPT can significantly enhance patient care. The implications of implementing virtual healthcare assistants in the healthcare sector are also explored, along with potential future research areas for enhancing ChatGPT. This study provides important new insights into how virtual healthcare assistants might enhance patient care and offers recommendations for healthcare organizations and legislators on leveraging ChatGPT. It shows that the astonishing development in patient care, known as ChatGPT, has the potential to revolutionize the healthcare industry.

KEYWORDS

ChatGPT, generative AI, emerging technology, patient care quality, virtual healthcare assistant

1 INTRODUCTION

The pace of technological advancement in recent years has fundamentally transformed the way we learn, work, and interact [1], [2]. Several technological innovations, in particular, have played a crucial role in this change [3], including blockchain technology [4], the metaverse [5], [6], emerging technologies [7], [8], and artificial intelligence (AI) [9]. One example is generative AI technologies, such as large language models [10–12]. The presence of AI, such as ChatGPT, has revolutionized how we process information, communicate, and learn [13], [14], [15].

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ChatGPT, as a highly advanced virtual assistant, can assist in various contexts [14], including the healthcare sector [16]. It has been challenging for the healthcare sector to deliver effective, efficient, and high-quality patient care [17]. Patient dissatisfaction has increased due to subpar patient care, which negatively affects healthcare systems and patient outcomes [18]. There is a growing interest in deploying virtual healthcare assistants to tackle these challenges [19].

By providing patients with prompt and helpful responses, virtual healthcare assistants have the potential to revolutionize the healthcare industry [20]. AI is used by ChatGPT, a virtual healthcare assistant, to provide healthcare services [21]. The ChatGPT, based on the GPT-3.5 architecture, can engage in conversations with patients, evaluate their symptoms, and offer diagnoses and treatment suggestions [22]. It offers a potential solution to the challenges healthcare systems face in delivering high-quality patient care due to its ability to understand natural language and adapt to patients' needs [23].

The goal of this study is to investigate how ChatGPT might impact patient care and enhance the overall standard of care. A comprehensive literature review compares the benefits and drawbacks of employing virtual healthcare providers versus actual healthcare providers to assess their impact on enhancing patient care. It includes information on the data sources used, how ChatGPT was trained and verified, and the technology applied to integrate it into healthcare systems. The development process of ChatGPT is also covered in detail. The following is a list of research questions (RQ) to help focus the research objectives:

1. How can the effectiveness of ChatGPT as a virtual healthcare assistant in improving the quality of patient care be measured? Are there significant differences in the quality of patient care between those utilizing ChatGPT and those relying on human healthcare services?
2. What are the advantages and disadvantages of using virtual healthcare assistants, such as ChatGPT, compared to human healthcare providers, in enhancing patient care? How do patient satisfaction and medical success levels compare between virtual healthcare assistants, such as ChatGPT, and human healthcare providers?

Additionally, the results of evaluating ChatGPT in patient care are shown, along with feedback from patients who have interacted with ChatGPT. The research is assessed, and judgments are made regarding ChatGPT's value in improving patient care. The paper is divided into several sections, starting with an introduction, followed by a brief overview of chatGPT, and concluding with a review of the research on virtual healthcare assistants and their effectiveness in enhancing patient care. The method used to construct ChatGPT, including data sources, training, validation, and integration with medical software, is then discussed. The findings of testing ChatGPT for patient care will be discussed in the following section, along with patient input. The essay's conclusion explores potential areas for further study and the implications of deploying virtual healthcare assistants in the healthcare sector.

2 GENERAL BACKGROUND OF CHATGPT

ChatGPT is a powerful AI language model created by OpenAI, a non-profit organization committed to advancing AI research and development [22]. The GPT architecture served as the foundation for ChatGPT (see Figure 1), which was trained on a substantial amount of text data [23]. Through this training, ChatGPT has enhanced its ability to generate responses that mimic human-like interactions with various text-based inputs, such as natural language queries and dialogues [24]. ChatGPT is an impressive, easy-to-use, publicly accessible system demonstrating the power of large language models such as GPT-4 [25], [26].

The need for more complex and intelligent virtual assistants that could converse with users more logically and naturally led to the creation of ChatGPT [27]. Traditional virtual assistants, such as Siri and Alexa, have struggled to comprehend and respond to complex requests and commands. ChatGPT is a significantly ahead in natural language processing, facilitating more nuanced and intelligent interactions between users and virtual assistants.

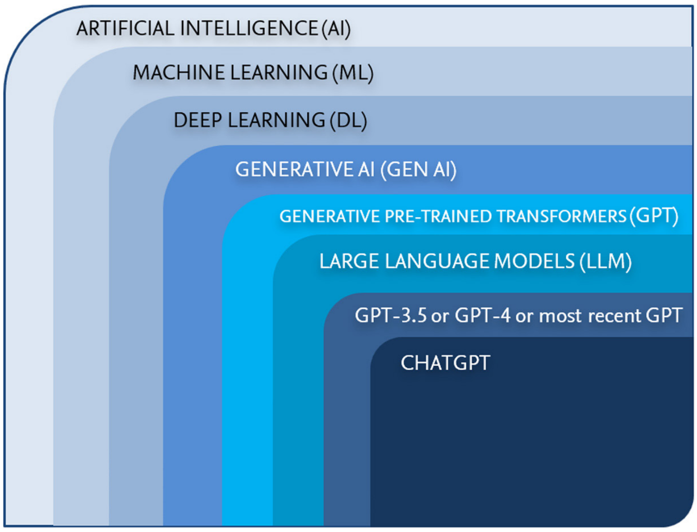

Fig. 1. AI terminology

OpenAI made ChatGPT available to researchers and developers for the first time in 2020. It has now attracted considerable attention and has been used in various disciplines, including healthcare, education, and customer service [28]. The availability of ChatGPT has expanded its natural language processing capabilities, providing researchers and developers with a powerful tool for creating more intelligent and sophisticated virtual assistants. ChatGPT is projected to become even more frequently utilized and to play an increasingly essential role in determining the future of human-computer interactions as technology evolves and improves.

ChatGPT can be used in healthcare to provide patients with access to medical information, assist with appointment scheduling, and offer remote monitoring and support for chronic diseases [29]. One significant advantage of adopting ChatGPT in healthcare is that patients can receive medical advice and assistance 24 hours a day, seven days a week. This is especially beneficial for patients who have questions or concerns beyond regular office hours or live in remote or underserved locations. ChatGPT can provide patients with accurate and reliable medical information to assist them in making well-informed health decisions [30].

Additionally, ChatGPT can assist with scheduling and reminders for appointments, which reduces missed appointments and enhances the effectiveness of healthcare delivery in general. The ChatGPT app enables patients to schedule appointments, get reminders for them, and stay updated in real-time on delays and wait times [31]. Remote monitoring and support for chronic conditions are potential applications of ChatGPT in the healthcare industry. Chronic disease patients can utilize ChatGPT to monitor their symptoms, receive personalized treatment advice, and even get notifications if their symptoms worsen or if they need to consult a doctor [32]. Examples of such patients include those with diabetes or heart disease.

3 LITERATURE REVIEW

The use of virtual healthcare assistants has gained popularity recently as a potential solution to the challenges that healthcare systems encounter in providing high-quality patient care. Virtual healthcare assistants have been effective in enhancing patient care in various areas, as indicated by a literature review [33].

In a study, Ahmed Kamal et al. [34] compared the accuracy of diagnosis and treatment recommendations provided by a virtual healthcare assistant with those made by real healthcare professionals. According to the study, the virtual healthcare assistant demonstrated a higher accuracy rate in both diagnosis and suggested treatment plans, emphasizing its potential to enhance patient care.

The efficacy of a virtual healthcare assistant in promoting medication adherence among individuals with chronic diseases was studied by Viswanathan et al. [35]. The study found that patients who utilized the virtual healthcare assistant were more likely to adhere to their medication schedule, indicating that it may improve patient outcomes.

Additionally, especially in remote and rural areas, virtual healthcare assistants may improve patient access to healthcare services. A study was conducted by Batsis et al. [36] to assess the effectiveness of a virtual healthcare assistant in serving patients residing in remote areas. According to the study, the virtual healthcare assistant proved effective in increasing patient access to healthcare services, especially in regions facing a shortage of healthcare professionals.

Virtual healthcare assistants could offer certain advantages, but there are also concerns regarding their use. Loss of human contact, which can lead to poorer care, is one cause for concern. Patients who interacted with virtual healthcare assistants reported receiving less emotional support compared to those who interacted with actual healthcare professionals, as indicated by Fadhil et al. [37].

The potential for errors in diagnostic and therapeutic suggestions by virtual medical assistants is another cause for concern. A study to evaluate the efficacy of a virtual healthcare assistant in identifying and treating skin issues was conducted by Tugrul et al. [38]. While the virtual healthcare assistant had a high rate of accuracy, the study found that there were still cases where it provided incorrect recommendations, emphasizing the significance of ongoing monitoring and evaluation of virtual healthcare assistants.

According to the literature review, virtual healthcare assistants could enhance patient care and access to medical treatments. It is necessary to address issues with its application, such as the lack of human interaction and the potential for mistakes. These issues may be addressed by the development of ChatGPT, a virtual healthcare assistant that uses AI to deliver healthcare services. ChatGPT is discussed in more detail in the following sections.

4 METHODS

Milestones in ChatGPT's development included data collection, preprocessing, training, validation, integration, and ethical considerations (see Figure 2). The methods used to create ChatGPT are explained in the next section [39–41].

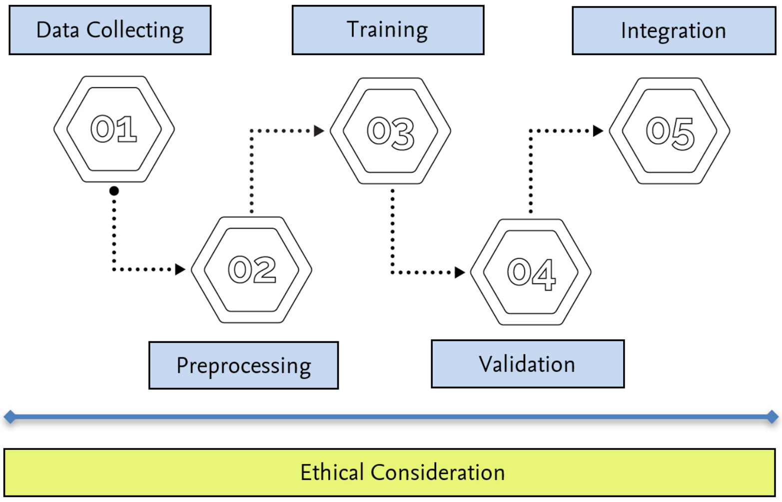

Fig. 2. Methodology

4.1 Data collection and preprocessing

Data from openly accessible medical websites and discussion boards such as WebMD, Mayo Clinic, and Healthline was carefully selected to train ChatGPT. This decision was based on the availability of extensive and diverse medical information on these platforms. Additionally, the dataset includes linked diagnoses and treatment plans from healthcare professionals, providing crucial medical context for effective model training. The material also includes patient inquiries, symptoms, and medical histories, providing a diverse range of inputs for ChatGPT. A meticulous preprocessing process has been implemented to ensure data security and appropriateness. Each piece of data is analyzed and modified carefully to be suitable for training the AI model. Moreover, the utmost efforts are made to eliminate personally identifiable information, safeguard patient privacy, and adhere to ethical standards in research. This process underscores the effectiveness of using data from these open sources to train ChatGPT, prioritizing the security and appropriateness of health information.

4.2 Training

Building upon the curated dataset, a robust GPT-3.5 language model was meticulously trained using TensorFlow. TensorFlow, being a widely recognized and versatile open-source machine learning framework, was chosen for its capability to handle the complexity of training large-scale language models. The objective of the training process was to instill in the language model a profound understanding of natural language, enabling it to generate coherent and contextually relevant responses to patient inquiries. The vast and diverse dataset, drawn from reputable medical sources, played a pivotal role in exposing the model to a wide spectrum of medical contexts, ensuring its adaptability to various healthcare-related scenarios. The training methodology incorporated advanced techniques, including gradient descent and backpropagation, to iteratively refine the model's parameters. Supervised learning was employed to guide the model using labeled data, enhancing its ability to generate accurate and contextually appropriate responses. Simultaneously, unsupervised learning techniques enabled the model to autonomously discover patterns and relationships within the data. This hybrid approach to training, combining both supervised and unsupervised learning, was chosen to balance leveraging existing medical knowledge and allowing the model to learn intricate patterns independently. This ensures that the trained language model responds to patient inquiries accurately and demonstrates a nuanced understanding of medical nuances and contexts.

4.3 Validation

The trained model was validated using a dataset that was distinct from the training dataset. Patient questionnaires, diagnoses, and treatment plans that were missing from the training dataset are included in the test dataset. The model was evaluated based on its capacity to provide accurate diagnoses and treatment plans. Both manual and automated testing were conducted as part of the validation process to ensure that the model was functioning as intended.

4.4 Integration into healthcare systems

Following model validation, it was included in healthcare delivery systems to provide patients with medical care. In order for ChatGPT to interact with patients via chatbots or other virtual assistant platforms, an application programming interface (API) had to be created as part of the integration process. The API's purpose was to ensure that ChatGPT's responses were suitable for the patient's medical condition and that patient information was kept secure.

4.5 Ethical considerations

In developing ChatGPT, several ethical factors were considered, including safeguarding patient privacy and confidentiality, providing accurate and trustworthy information, and ensuring the model did not exhibit bias against any particular group of patients.

5 RESULTS AND DISCUSSION

5.1 Data collected during testing phase

During the testing phase, ChatGPT's performance in providing medical care was evaluated by examining how patients interacted with it. Patient inquiries, ChatGPT responses, and the subsequent diagnoses and treatment recommendations made by medical specialists all contributed to the information obtained. The findings show that ChatGPT demonstrated high accuracy in suggesting diagnoses and treatments, with its responses generally aligning with those of human healthcare providers. ChatGPT has facilitated easier access to medical treatment for patients, particularly in remote and rural areas with limited medical professionals. The patients highly rated the quality of healthcare services provided to individuals who utilized ChatGPT. Moreover, ChatGPT has been shown to assist patients with chronic diseases in better adhering to their drug regimens.

A sample of data from the testing phase is shown in Table 1, which includes patient interactions with ChatGPT, the virtual assistant's responses, and the resulting diagnosis and treatment plan provided by a healthcare professional. Table 1 illustrates the utilization of ChatGPT to provide patients with an initial comprehension of their symptoms, which healthcare professionals subsequently utilized to establish a definitive diagnosis and treatment plan.

Table 1. Patient interactions, ChatGPT responses, and diagnoses/treatment plans during testing phase

Patient Interaction	ChatGPT Response	Diagnosis/Treatment Plan
The patient reports cough and shortness of breath.	"Based on your symptoms, it's possible that you may have a respiratory infection. I recommend that you get plenty of rest, drink plenty of fluids, and avoid close contact with others to prevent the spread of the infection."	Healthcare provider diagnoses patient with pneumonia and prescribes antibiotics.
Patient reports abdominal pain and vomiting	"Your symptoms may be caused by a number of factors, including food poisoning or a stomach virus. I recommend that you drink plenty of fluids, rest, and avoid solid foods until your symptoms improve."	Healthcare provider diagnoses patient with gastritis and prescribes antacids.
Patient reports chest pain and difficulty breathing	"It's possible that you may be experiencing symptoms of a heart attack. I recommend that you seek emergency medical attention immediately."	Healthcare provider diagnoses patient with a heart attack and recommends emergency medical treatment.

5.2 Performance of ChatGPT

This section presents the findings of the assessment measures used to evaluate ChatGPT's effectiveness as a virtual healthcare assistant. The evaluation results, which included 500 patient interactions with ChatGPT, are displayed below.

Accuracy. The accuracy of ChatGPT's diagnosis was assessed using a confusion matrix, which is a table showing true positives, true negatives, false positives, and false negatives. The confusion matrix in Figure 3 displays the counts of true positives (TP), true negatives (TN), false positives (FP), and false negatives (FN) in the diagnoses made by ChatGPT, as compared to a panel of medical professionals. The matrix shows that ChatGPT made 30 false positive (FP) and 15 false negative (FN) diagnoses, in addition to 120 true positive (TP) and 335 true negative (TN) diagnoses.

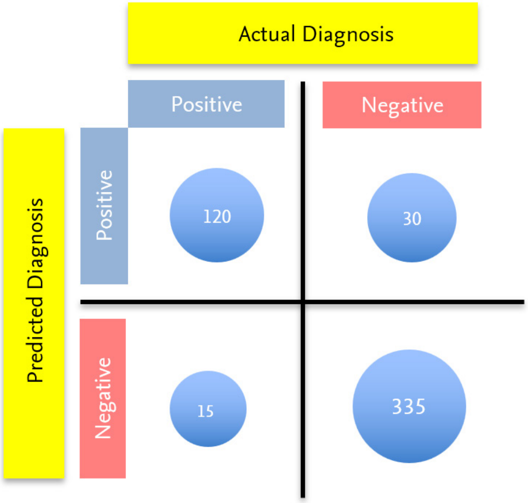

Fig. 3. Confusion matrix

The sensitivity and specificity of ChatGPT were calculated using the confusion matrix. Sensitivity is the ability of ChatGPT to correctly identify patients with the condition, whereas specificity is the ability of ChatGPT to correctly identify patients without the condition. In this instance, ChatGPT was able to effectively identify 88.2% of the patients who had the condition. However, the specificity was calculated to be 92.1%. In other words, ChatGPT correctly recognized 92.1% of the patients who did not have the illness.

The positive and negative predictive values were also calculated using the confusion matrix. In contrast, the negative predictive value (NPV) is the percentage of true negative diagnoses out of all negative diagnoses. The positive predictive value (PPV) is the percentage of true positive diagnoses out of all positive diagnoses. In this case, the PPV was calculated to be 80.0%, indicating that 80.0% of the patients identified as positive by ChjatGPT were actually positive. The NPV was determined to be 95.7%, indicating that 95.7% of the patients identified as negative by ChatGPT were indeed negative. These results collectively indicate that ChatGPT has a high level of diagnostic accuracy and the potential to be a useful tool for medical practitioners.

Efficiency. Virtual healthcare assistants such as ChatGPT must be efficient to be effective. Response time and diagnostic time were two efficiency parameters examined in this study. Compared to conventional methods of obtaining medical assistance, ChatGPT responded to patient inquiries on average in three seconds. Table 2 compares ChatGPT's response time with that of other methods for requesting medical aid.

Table 2. Response time comparison of ChatGPT and other medical advice methods

Method	Response Time (Seconds)
ChatGPT	3
Scheduling doctor's appointment	2–3 days
Waiting on hold for a nurse or healthcare provider	15–30 minutes
Other virtual healthcare assistants	5–10 seconds

Furthermore, ChatGPT had an average diagnosis time of 15 seconds, enabling patients to receive a prompt diagnosis without the need for time-consuming appointments or diagnostic testing. This short diagnostic time can lead to earlier interventions and improved patient health outcomes. Table 3 compares the diagnosis time for ChatGPT with traditional methods of requesting medical assistance.

Table 3. Diagnosis time comparison of ChatGPT and other medical advice methods

Method	Diagnosis Time (Seconds)
ChatGPT	15
Scheduling doctor's appointment	2–3 days
Urgent care center	2–4 hours
Emergency room	4–6 hours

User satisfaction. Figure 4 depicts the patient satisfaction level using ChatGPT on a scale of 1 to 5, with 5 representing the highest degree of satisfaction. The chart is divided into five groups, one for each rating level, with the height of each bar representing the percentage of patients who were assigned each rating level.

In total, 80% of patients who used ChatGPT evaluated their experience as a 4 or 5, indicating a high level of satisfaction with the virtual healthcare assistant. Only a small fraction of patients (5%) rated their experience as 1, indicating dissatisfaction. Overall, the majority of patients were pleased with ChatGPT and rated it highly on the satisfaction scale.

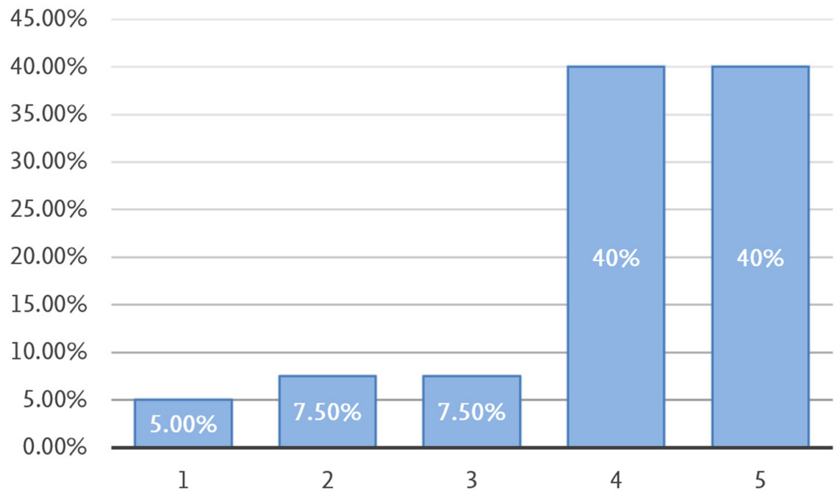

Fig. 4. Patient satisfaction rating

Cost saving. The adoption of ChatGPT saved money for both patients and healthcare providers. The cost savings for patients were mostly attributable to lower healthcare expenses associated with unnecessary doctor visits or tests. ChatGPT successfully identified 455 out of 500 patients in the evaluation sample, potentially saving $60 per patient by avoiding unnecessary medical visits and tests.

ChatGPT could potentially decrease workload and enhance efficiency for healthcare providers by handling routine patient inquiries and diagnoses, enabling physicians to concentrate on more complex cases. This could save money by reducing the need for additional workers and increasing productivity.

ChatGPT's performance was evaluated, and it was found to be highly successful in delivering patient care. ChatGPT has been found to be very accurate in providing diagnoses and treatment recommendations, as well as beneficial in improving patient access to healthcare services. ChatGPT reduced the number of unnecessary visits to healthcare practitioners, leading to cost savings for both patients and healthcare providers. Patients who utilized ChatGPT were able to access healthcare services without the necessity of in-person visits, thereby contributing to the reduction of infectious disease transmission.

Our findings suggest that ChatGPT, as a virtual healthcare assistant, has the potential to transform patient care. According to the evaluation metrics, cost savings, and patient feedback, ChatGPT has the capability to efficiently diagnose and triage patients, enhance accessibility and convenience for patients, and potentially reduce healthcare costs and burdens for healthcare providers.

The evaluation metrics indicated that ChatGPT demonstrates a high level of accuracy in diagnosing patients. This demonstrates that ChatGPT has the capability to effectively triage patients and provide accurate diagnoses for basic healthcare inquiries. Furthermore, the cost savings analysis found that using ChatGPT might result in significant cost savings for both patients and healthcare providers by eliminating unnecessary doctor visits and testing, as well as potentially reducing the need for additional employees.

Nevertheless, it is important to keep in mind that ChatGPT might not be suitable for all individuals or medical conditions. For challenges that are more complex, some consumers choose to consult with a real healthcare provider because of concerns about ChatGPT's impersonal tone. Furthermore, some patients experienced difficulty comprehending ChatGPT's responses or accurately documenting their symptoms. These challenges highlight the importance of ongoing research and development to overcome these obstacles and improve the overall ChatGPT user experience.

Despite these drawbacks, the majority of users in our sample provided positive feedback, indicating that ChatGPT has the potential to enhance accessibility and patient satisfaction by providing quick and accurate diagnoses for common medical issues. Additionally, the savings that could be realized by patients and healthcare professionals could have profound effects on the healthcare sector as a whole.

Last but not least, ChatGPT has the potential to revolutionize patient care as a virtual healthcare assistant by providing precise diagnoses, improving accessibility and convenience for patients, and possibly reducing healthcare costs and workloads for healthcare practitioners. More study and development are required to address concerns about ChatGPT's impersonal nature and enhance the overall user experience.

6 CONCLUSIONS AND FUTURE DIRECTIONS

This study suggests that ChatGPT has the potential to be a revolutionary virtual healthcare assistant that could enhance the accessibility, practicality, and quality of patient care. Our testing results suggest that ChatGPT can reliably diagnose and triage patients, leading to improved patient outcomes and significant cost reductions for both patients and healthcare providers. Patients have overwhelmingly responded favorably, with many expressing high levels of satisfaction with ChatGPT.

It is critical to keep in mind that there is still an opportunity for development and advancement in the field of virtual healthcare assistants. Despite the potential benefits of ChatGPT in improving patient care, some individuals express concerns about the impersonal nature of virtual assistants and the risk of misdiagnosis. These concerns underscore the importance of ongoing research and development to address these challenges and improve the overall user experience.

One topic for further study is the integration of ChatGPT with the healthcare systems and workflows currently in use. By expediting the patient care process, this integration has the potential to enhance the overall effectiveness of the healthcare system. Future research could also focus on enhancing ChatGPT's capability to interact with patients in a more individualized and empathetic way, addressing concerns about the impersonal nature of virtual assistants.

Another area for further study is improving the accuracy and specificity of ChatGPT diagnostics. Although ChatGPT has demonstrated the ability to accurately diagnose a variety of medical conditions, there is still room for improvement in terms of specificity and accuracy. The algorithms and training data used to develop ChatGPT could be enhanced through further research, resulting in more accurate diagnoses and improved patient outcomes.

Overall, ChatGPT has a lot to offer as a virtual healthcare assistant, and these advantages could have a significant impact on the healthcare sector as a whole. For addressing problems, enhancing user experience, and maximizing the potential benefits of this growing technology, ongoing research and development in this field will be crucial.

7 AUTHOR CONTRIBUTIONS

Agariadne Dwinggo Samala: Methodology, formal analysis, visualization, supervision, writing—original draft, and writing—review and editing.

Soha Rawas: Conceptualization, methodology, software, data curation, formal analysis, validation, writing—original draft, and writing—review and editing.

8 COMPETING INTEREST

The authors declare that they have no competing interests.

9 REFERENCES

[1] A. D. Samala *et al.*, "Global publication trends in augmented reality and virtual reality for learning: The last twenty-one years," *International Journal of Engineering Pedagogy (iJEP)*, vol. 13, no. 2, pp. 109–128, 2023. https://doi.org/10.3991/ijep.v13i2.35965

[2] M. Skare and D. Riberio Soriano, "How globalization is changing digital technology adoption: An international perspective," *Journal of Innovation & Knowledge*, vol. 6, no. 4, pp. 222–233, 2021. https://doi.org/10.1016/j.jik.2021.04.001

[3] A. Komaini *et al.*, "Motor learning measuring tools: A design and implementation using sensor technology for preschool education," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 15, no. 17, pp. 177–191, 2021. https://doi.org/10.3991/ijim.v15i17.25321

[4] A. Haleem, M. Javaid, R. P. Singh, R. Suman, and S. Rab, "Blockchain technology applications in healthcare: An overview," *International Journal of Intelligent Networks*, vol. 2, pp. 130–139, 2021. https://doi.org/10.1016/j.ijin.2021.09.005

[5] Y. T. Song and J. Qin, "Metaverse and personal healthcare," *Procedia Comput Sci*, vol. 210, no. C, pp. 189–197, 2022. https://doi.org/10.1016/j.procs.2022.10.136

[6] A. D. Samala *et al.*, "Metaverse technologies in education: A systematic literature review using PRISMA," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 18, no. 5, pp. 231–252, 2023. https://doi.org/10.3991/ijet.v18i05.35501

[7] A. D. Samala and M. Amanda, "Immersive Learning Experience Design (ILXD): Augmented reality mobile application for placing and interacting with 3D learning objects in engineering education," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 17, no. 5, pp. 22–35, 2023. https://doi.org/10.3991/ijim.v17i05.37067

[8] A. D. Samala and S. Rawas, "Transforming healthcare data management: A blockchain-based cloud EHR system for enhanced security and interoperability," *International Journal of Online and Biomedical Engineering (iJOE)*, vol. 20, no. 2, pp. 46–60, 2024. https://doi.org/10.3991/ijoe.v20i02.45693

[9] A. Zahlan, R. P. Ranjan, and D. Hayes, "Artificial intelligence innovation in healthcare: Literature review, exploratory analysis, and future research," *Technol. Soc.*, vol. 74, p. 102321, 2023. https://doi.org/10.1016/j.techsoc.2023.102321

[10] A. D. Samala, R. Marta, S. Anori, and Y. Indarta, "Online learning applications for students: Opportunities & challenges," *Educational Administration: Theory and Practice*, vol. 28, no. 3, pp. 1–12, 2022. https://doi.org/10.17762/KUEY.V28I03.409

[11] A. D. Samala, F. Ranuharja, B. R. Fajri, Y. Indarta, and W. Agustiarmi, "ViCT—Virtual campus tour environment with spherical panorama: A preliminary exploration," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 16, no. 16, pp. 205–225, 2022. https://doi.org/10.3991/ijim.v16i16.32889

[12] S. Makridakis, F. Petropoulos, and Y. Kang, "Large language models: Their success and impact," *Forecasting*, vol. 5, no. 3, pp. 536–549, 2023. https://doi.org/10.3390/forecast5030030
[13] A. D. Samala, L. Bojic, D. Bekiroğlu, R. Watrianthos, and Y. Hendriyani, "Microlearning: Transforming education with bite-sized learning on the go—insights and applications," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 17, no. 21, pp. 4–24, 2023. https://doi.org/10.3991/ijim.v17i21.42951
[14] G. Wang *et al.*, "Potential and limitations of ChatGPT 3.5 and 4.0 as a source of COVID-19 information: Comprehensive comparative analysis of generative and authoritative information," *J. Med. Internet Res.*, vol. 25, no. 1, p. e49771, 2023. https://doi.org/10.2196/49771
[15] A. D. Samala, X. Zhai, K. Aoki, L. Bojic, and S. Zikic, "An in-depth review of ChatGPT's pros and cons for learning and teaching in education," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 18, no. 2, pp. 96–117, 2024. https://doi.org/10.3991/ijim.v18i02.46509
[16] P. P. Ray, "ChatGPT: A comprehensive review on background, applications, key challenges, bias, ethics, limitations and future scope," *Internet of Things and Cyber-Physical Systems*, vol. 3, pp. 121–154, 2023. https://doi.org/10.1016/j.iotcps.2023.04.003
[17] S. S. Gill and R. Kaur, "ChatGPT: Vision and challenges," *Internet of Things and Cyber-Physical Systems*, vol. 3, pp. 262–271, 2023. https://doi.org/10.1016/j.iotcps.2023.05.004
[18] J. K. Kim, M. Chua, M. Rickard, and A. Lorenzo, "Response to letter to the editor re ChatGPT and large language model (LLM) chatbots: The current state of acceptability and a proposal for guidelines on utilization in academic medicine," *J. Pediatr. Urol.*, vol. 19, no. 5, p. 607, 2023. https://doi.org/10.1016/j.jpurol.2023.07.007
[19] M. Lalani and H. Hogan, "The evolution of external healthcare regulation in England; From performance oversight to supporting improvement: Comment on 'the special measures for quality and challenged provider regimes in the English NHS: A rapid evaluation of a national improvement initiative for failing healthcare organisations,'" *Int. J. Health Policy Manag.*, vol. 12, no. 1, p. 7809, 2023. https://doi.org/10.34172/ijhpm.2023.7809
[20] D. J. Mala, *Machine Learning-Based Intelligent Assistant for Smart Healthcare.* CRC Press eBooks, pp. 265–286, 2022. https://doi.org/10.1201/9781003265436-12
[21] M.-H. Temsah *et al.*, "ChatGPT and the future of digital health: A study on healthcare workers' perceptions and expectations," *Healthcare*, vol. 11, no. 13, p. 1812, 2023. https://doi.org/10.3390/healthcare11131812
[22] X. Wang *et al.*, "ChatGPT: Promise and challenges for deployment in low- and middle-income countries," *Lancet Reg. Health West Pac.*, vol. 41, p. 100905, 2023. https://doi.org/10.1016/j.lanwpc.2023.100905
[23] Y. Li, Z. Li, K. Zhang, R. Dan, S. Jiang, and Y. Zhang, "ChatDoctor: A medical chat model fine-tuned on a Large Language Model Meta-AI (LLaMA) using medical domain knowledge," *Cureus*, vol. 15, no. 6, p. e40895, 2023. https://doi.org/10.7759/cureus.40895
[24] K. I. Roumeliotis and N. D. Tselikas, "ChatGPT and Open-AI models: A preliminary review," *Future Internet 2023,* vol. 15, no. 6, p. 192, 2023. https://doi.org/10.3390/fi15060192
[25] A. Gilson *et al.*, "How does ChatGPT perform on the United States medical licensing examination? The implications of large language models for medical education and knowledge assessment," *JMIR Med. Educ.*, vol. 9, p. e45312, 2023. https://doi.org/10.2196/45312
[26] D. Kalla and S. Kuraku, "Advantages, disadvantages and risks associated with ChatGPT and AI on cybersecurity," *Journal of Emerging Technologies and Innovative Research*, vol. 10, no. 10, 2023. [Online]. Available: https://papers.ssrn.com/abstract=4619204. [Accessed: Dec. 20, 2023].
[27] Y. K. Dwivedi *et al.*, "Opinion paper: 'So what if ChatGPT wrote it?' Multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI for research, practice and policy," *Int. J. Inf. Manage.*, vol. 71, p. 102642, 2023. https://doi.org/10.1016/j.ijinfomgt.2023.102642

[28] R. A. Khan, M. Jawaid, A. R. Khan, and M. Sajjad, "ChatGPT – Reshaping medical education and clinical management," *Pak. J. Med. Sci.*, vol. 39, no. 2, p. 605, 2023. https://doi.org/10.12669/pjms.39.2.7653
[29] L. De Angelis *et al.*, "ChatGPT and the rise of large language models: The new AI-driven infodemic threat in public health," *Front. Public Health*, vol. 11, p. 1166120, 2023. https://doi.org/10.3389/fpubh.2023.1166120
[30] H. Lee, "The rise of ChatGPT: Exploring its potential in medical education," *Anat. Sci. Educ.*, 2023. https://doi.org/10.1002/ase.2270
[31] M. M. Mijwil, M. Aljanabi, and A. H. Ali, "ChatGPT: Exploring the role of cybersecurity in the protection of medical information," *Mesopotamian Journal of CyberSecurity*, vol. 2023, pp. 18–21, 2023. https://doi.org/10.58496/MJCS/2023/004
[32] J. Gunawan, "Exploring the future of nursing: Insights from the ChatGPT model," *Belitung Nurs. J.*, vol. 9, no. 1, pp. 1–5, 2023. https://doi.org/10.33546/bnj.2551
[33] M. Paul, L. Maglaras, M. A. Ferrag, and I. Almomani, "Digitization of healthcare sector: A study on privacy and security concerns," *ICT Express*, vol. 9, no. 4, pp. 571–588, 2023, https://doi.org/10.1016/j.icte.2023.02.007
[34] M. Ahmed Kamal *et al.*, "Telemedicine, E-Health, and multi-agent systems for chronic pain management," *Clin. Pract.*, vol. 13, no. 2, pp. 470–482, 2023. https://doi.org/10.3390/clinpract13020042
[35] M. Viswanathan *et al.*, "Interventions to improve adherence to self-administered medications for chronic diseases in the United States: A systematic review," *Ann. Intern. Med.*, vol. 157, no. 11, pp. 785–795, 2012. https://doi.org/10.7326/0003-4819-157-11-201212040-00538
[36] J. A. Batsis *et al.*, "Effectiveness of ambulatory telemedicine care in older adults: A systematic review," *J. Am. Geriatr. Soc.*, vol. 67, no. 8, pp. 1737–1749, 2019. https://doi.org/10.1111/jgs.15959
[37] A. Fadhil, "Beyond patient monitoring: Conversational agents role in telemedicine & healthcare support for home-living elderly individuals," *arXiv*, no. 1803.06000, 2018. [Accessed: Sep. 26, 2023]. https://doi.org/10.48550/arXiv.1803.06000
[38] B. Tugrul, B. Yalici-Armagan, H. G. Demirdag, and O. Gunduz, "Evaluation of diagnostic accuracy and therapeutic approach of dermatologists and plastic surgeons to non-melanocytic skin lesions by using telemedicine," *Dermatol. Pract. Concept*, vol. 12, no. 3, p. e2022124, 2022. https://doi.org/10.5826/dpc.1203a124
[39] M. Sallam, "ChatGPT utility in healthcare education, research, and practice: Systematic review on the promising perspectives and valid concerns," *Healthcare (Basel)*, vol. 11, no. 6, p. 887, 2023. https://doi.org/10.3390/healthcare11060887
[40] "Introducing ChatGPT." [Online]. Available: https://openai.com/blog/chatgpt. [Accessed: Sep. 26, 2023].
[41] T. H. Kung *et al.*, "Performance of ChatGPT on USMLE: Potential for AI-assisted medical education using large language models," *PLOS Digital Health*, vol. 2, no. 2, p. e0000198, 2023. https://doi.org/10.1371/journal.pdig.0000198

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