

Review Article

Chatbots in Healthcare – A Study

Sumaira Idrees¹, Hemalatha Thanganadar^{1*}, Wajiha Rehman¹, Asim Mehmood¹, Fahad Khan Azeez¹, Rahama Salman Mohammad²

¹Department of Health Informatics, College of Public Health and Tropical Medicine, Jazan University, Jazan, Kingdom of Saudi Arabia

²Department of Information Technology and Security, College of Computer Science & Information Technology, Jazan University Jazan, Kingdom of Saudi Arabia.

*Corresponding Author : hthanganadar@jazanu.edu.sa

Received: 06 February 2024

Revised: 14 May 2024

Accepted: 15 June 2024

Published: 26 July 2024

Abstract - Fast-paced and busy lives require immediate solutions, and people want easy and quick responses to queries. A Chatbot is a conversational agent designed using Artificial Intelligence (AI) to chat with people. This software not only understands human conversation but also responds to their questions. Chatbots are designed to generate meaningful responses using AI techniques to understand human natural language and emotions. In recent years, Chatbots have experienced explosive growth in both development and implementation for various healthcare applications. The Chatbot offers advice in return for people's medical troubles. By taking symptoms as input stated by the patients, a Medical Chatbot can assist in making predictions about various illnesses using the Machine Learning concept. Chatbots have the potential to incorporate with clinical practice and can help in reducing costs, efficient workflow, and enhancing patient outcomes by collaborating with medical professionals. This article covers the definition of a medical Chatbot, types of Chatbots, how a Chatbot works, the use of Chatbots in the healthcare industry, challenges and security risks (vulnerabilities and threats), and security measures associated with Chatbots in healthcare.

Keywords - Chatbot, Machine learning, Artificial Intelligence, Healthcare, Predictions.

1. Background

As smart devices become more prevalent, Internet usage is increasing. Humans can now access information with just a click, thanks to the internet. Busy and fast life wants easy and quick access to all human needs, including solutions to medical and health problems. The Artificial Intelligence (AI) space has yielded several benefits across a wide range of industries, as it can emulate human cognitive functions and enhance decision-making. Satisfaction of customers with the product and services has a major role in productivity. Customer service offers product suggestions, solves queries and complaints, or responds to general questions asked by customers. Artificial Intelligence has played a major role in reducing the pressure on the customer service staff. Conversational agents have been designed to respond automatically to the customer's questions and queries.

2. Introduction

A Chatbot is a conversational agent that understands customer questions and automates client responses by simulating human conversation. Chatbot technology emerged in 1966 with the development of the first Chatbot named ELIZA. Chatbots are potentially referred to as the most promising and advanced form of human-machine interactions

[1] because, in addition to conversational commerce (electronic chat), Chatbots can also be used for analytics, communication, customer support, design, developer tools, education [2], entertainment, finance, food, games, health, HR, marketing, news, personal, productivity, shopping, social, sports, travel, and utilities [3]. AI is the driving force behind Chatbots; it combines Machine Learning and underlying technologies such as Natural Language Processing for conversation. Chatbots characterize the practical implementation of computational linguistics over the internet as portable device assistants. The basic principle employed in Chatbots consists of an environment that receives questions in natural human language, associates these questions with a knowledge base, and then provides a response [4].

General-purpose Chatbots such as Google Assistant, Siri, and Alexa are not restricted to specific domains. ELIZA is a very basic psychotherapist Chatbot with limited program scripts. Medical Chatbots have been designed to respond automatically to patients' questions and queries. The healthcare industry is currently witnessing the emergence of revolutionary Chatbot technology. It has caught the attention of many due to its promising potential to transform how medical services are provided [5].



In recent years, Chatbots have experienced explosive growth in development and implementation for various healthcare applications. A Chatbot can educate about disease prevention, promote healthy behaviors, and encourage self-care [6]. Sometimes, it is difficult to get an appointment with a doctor for health issues; using Chatbots, people can easily get basic knowledge about diseases, and users can diagnose the symptoms before the consultation. Patient satisfaction is integral to running the healthcare industry smoothly. Chatbots are more prevalent because the health sector is closely associated with human contact [7]. The idea is simple, automated responses initiated on user interaction. Patients can access the responses 24/7 from their smartphones, no matter where they are, at any time, without geographical limitations since the responses have already been stored in health databases [8].

3. Definitions of Chatbot and Medical Chatbot

A Chatbot is a computer program that mimics written and spoken human speech for interaction with humans in the real world without human assistance by enabling communication among machines and people using machine learning algorithms and Natural Language Processing. A medical Chatbot or a healthcare Chatbot is nothing but a conversational AI-powered solution specifically designed to make healthcare much more interactive and proactive [10].

3.1. Types of Chatbot

A Chatbot has three types: simple, smart, and hybrid. Simple Chatbots are rule-based, and Smart Chatbots are AI-driven. Those Chatbots that are designed using both of these

types are known as hybrid Chatbots. Simple Chatbots are also called decision-tree Chatbots, as they respond to queries using rules. These types of bots are designed for straightforward dialogues, and they respond using predetermined options. Smart Chatbots respond using natural language processing phenomenon. These types of bots are designed using complex programming to understand human interaction, language, and emotions.

Hybrid Chatbots are designed to understand rule-based tasks along with intentions and context. They chat with humans to provide an automated and personalized reply. AI facilitates a hybrid Chatbot to deal with complex problems, and a rule-based system ensures accuracy and uniformity.

3.2. How Chatbot Works

A Chatbot uses Artificial Intelligence (AI) and Natural Language Processing (NLP) to understand human queries and respond accordingly. A Chatbot works on a 4-stage principle. 1)Input, 2) Analysis, 3) Output, and 4) reinforcement learning (Figure 1) by adopting three classification models of machine learning: 1) Pattern matching, 2) Algorithms, and 3) Neural Networks.

3.2.1. Pattern Matching

Pattern matching is a technique for checking an expression against a pattern. Pattern matching in the Chatbot is a mechanism where user input(text) will be compared against the text stored in the database to provide an appropriate response to the user [9]. An example of a simple pattern matching in a healthcare Chatbot is shown in Figure 2.

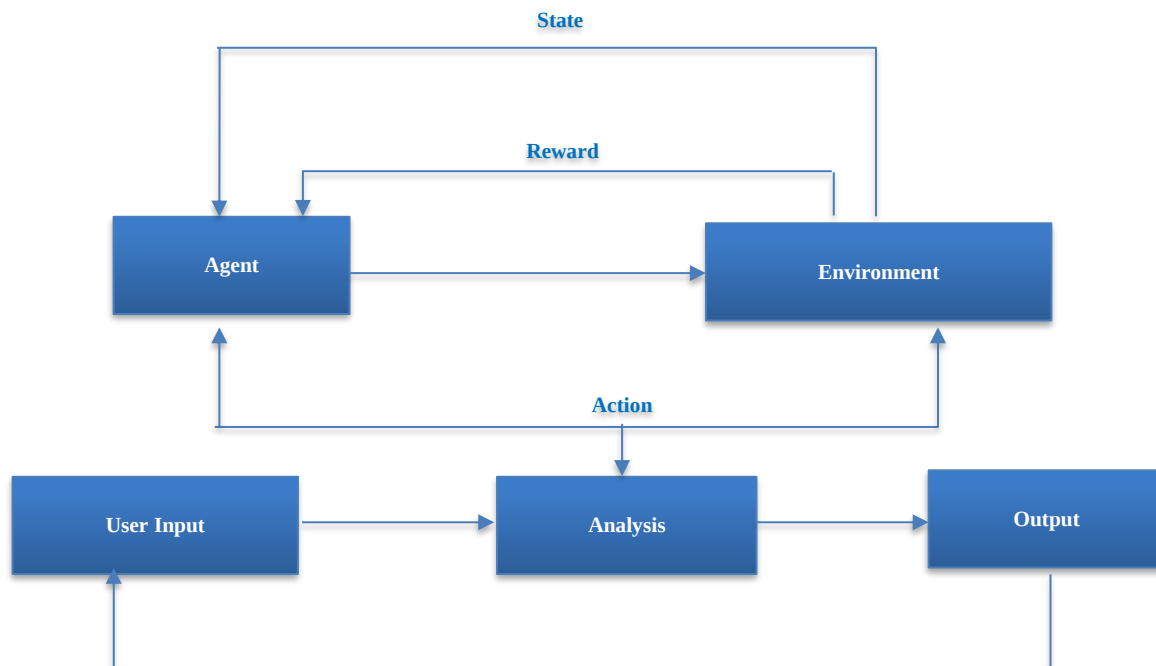


Fig. 1 A Four-Stage principle

```
#user input can I book appointment with Dr.Smith tonight?

<category>
<pattern> can I book appointment with Dr.Smith tonight?</pattern>

<template>
<condition name= "Dr.Smith" date= "27th May 2023" day= "saturday"> </condition>
</template>
</category>

#respond data stored in database

<category>
<pattern> Saturday is off day for Dr.smith.</pattern>
<template>Dr.smith has day off.</template>
</category>
```

Fig. 2 Pattern matching in a healthcare chatbot

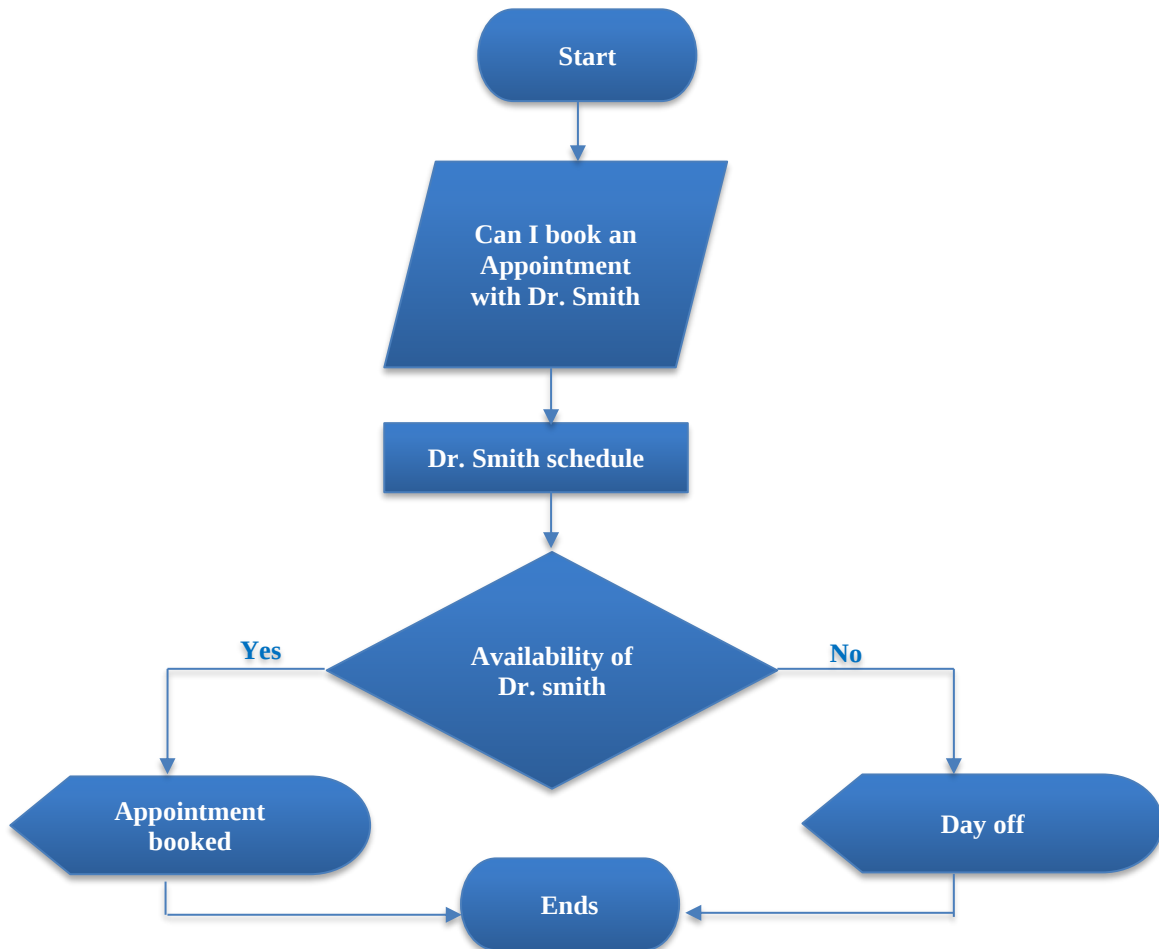


Fig. 3 A graphical representation of an algorithm

3.2.2. Algorithms

Large datasets are analyzed by Chatbots using algorithms. An algorithm is a sequence of activities to be processed to get the desired output from a given input. It consists of a finite number of steps to solve a particular problem; each step of the algorithm must be precisely and unambiguously stated. An Algorithm takes zero or more input and produces at least one output.

A Chatbot algorithm translates and mimics human conversation through predictive analytics, sentiment analysis, and text classification. It searches for a similar text from previous customer conversations based on predefined responses, and by applying *Natural Language Processing*, it offers the most appropriate response. A graphical representation (Flow Chart) of a simple algorithm is shown in Figure 3.

3.2.3. Neural Networks

Neural Networks (NNs) are a subset of machine learning and the heart of deep learning, also known as Artificial Neural Networks (ANNs) or Simulated Neural Networks (SNNs). They rely on training data to learn and improve their accuracy over time to solve complex problems and pattern recognition. Artificial Neural Networks (ANNs) are comprised of node layers called neurons, containing an input layer, one or more hidden layers, and an output layer [11]. Patterns are introduced into the neural network through the input layer,

which contains one neuron for each component in the input data. Information is transmitted downstream from the neuron to other neurons connected to it. It is then communicated to the hidden layer for analysis; at the end of the process, the hidden layer leads to the output layer, which has one neuron for each possible desired output Figure 4.

4. Input and Output of Chatbots

A Chatbot system generates contextual input/output messages. The three components of a Chatbot are 1) An interactive dialogue interface, 2) a knowledge database, and 3) a processor. Conversations between a Chatbot and a user are called chat sessions. The response which the user receives from the Chatbot is often preprogrammed. Figures 5 and 6 show examples of a chat session from the online Chatbot “ELIZA” and “deepai (AI chat)”.

ELIZA works using “pattern matching” and substitution methodology, the program gives canned responses that make early users feel they were talking to someone who understood their input. The “deepai (AI chat)” is a large language model with a complex software system that’s trained on a massive amount of text data. It can respond in a variety of formats, including text, images, and even audio. Another type of online AI-powered Chatbot called “chataigpt” receives input in multiple languages Figure 7. To interpret and respond to human language naturally, it utilizes an advanced technology known as conversational ChatGPT Free.

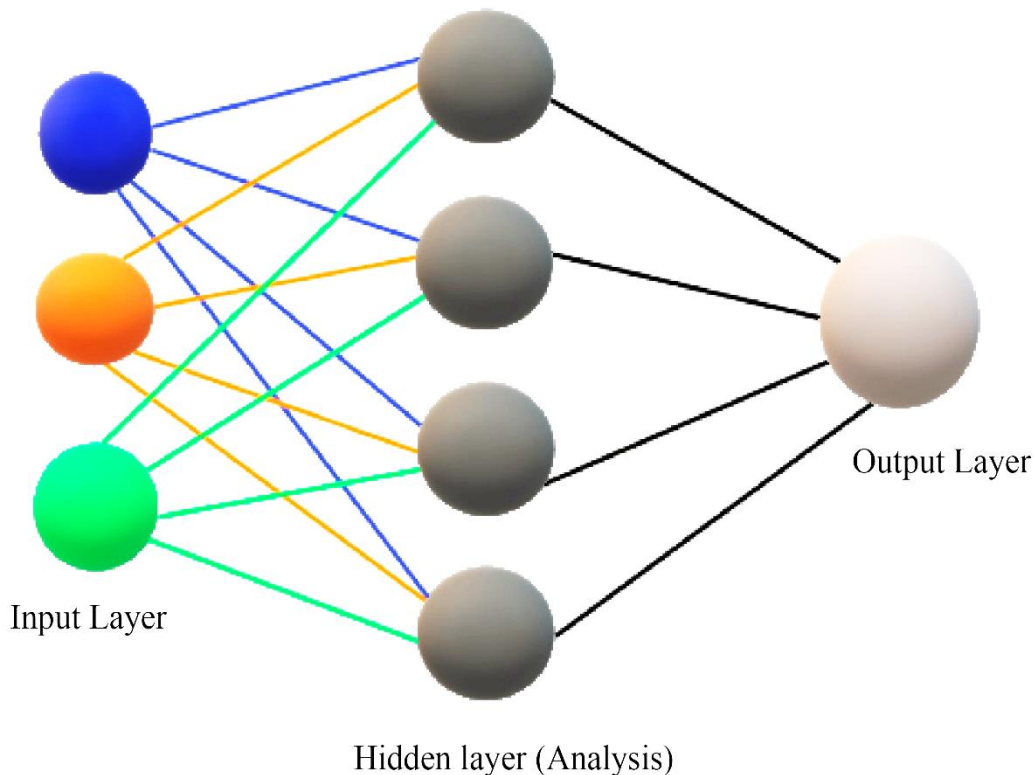


Fig. 4 Layers of neural networks

ELIZA: a very basic Rogerian psychotherapist chatbot

Talk to Eliza by typing your questions and answers in the input box.

```
* can I share my current symptoms with you ?
> I'm not convinced that you truly want to share your current symptoms with me?
* i haven't been go through therapy before
> Would you say that you have psychological problems?
* yes
> Are you sure about that?
* everybody said my symptoms are associated with some psychological problem
> Can you elaborate on that?
* Feeling worried, depressed, guilty, worthless
> I'm not sure I understand you fully.
```

TYPE HERE

Fig. 5 A conversation with “ELIZA”

hello Delete

Hello! It's nice to meet you. Is there something I can help you with, or would you like to chat? Copy Search Web Summarize Delete

can I ask you about health probelm? Delete

I'm happy to help you with any health-related concerns or questions you may have. Please keep in mind that I'm not a medical professional, so I'll do my best to provide general information and resources to help you understand your symptoms. However, it's always best to consult with a qualified healthcare professional for personalized advice and treatment.

What's been going on with your health? Are you experiencing any specific symptoms or issues that you'd like to talk about? Copy Search Web Summarize Delete

I have body pain, headache, and running nose. Delete

Sorry to hear that you're experiencing those symptoms. It's possible that you may be dealing with a viral or bacterial infection, such as a cold or sinusitis. Here are some general suggestions and information that might be helpful:

Body pain:

- Body pain can be caused by a variety of factors, including muscle strain, fatigue, or an underlying medical condition.
- If your body pain is severe or persistent, it's a good idea to consult with a healthcare professional to rule out any underlying conditions.

Headache:

- Headaches can be caused by a variety of factors, including dehydration, stress, fatigue, or sinus pressure.
- If you're experiencing frequent or severe headaches, it's a good idea to consult with a healthcare professional to rule out any underlying conditions.

Fig. 6 Chat session with “deepai(AI chat)”



Fig. 7 Chat AI GPT conversation

5. Use of Chatbots in Healthcare

Chatbots are increasingly being applied in healthcare to facilitate access to information from the patient side and reduce the strain on the clinician side. Patients can use medical Chatbots not only to manage their health but also to communicate with healthcare providers. Chatbots provide instant access to care by giving quick responses and initiating notifications and reminders, and they are quite helpful in increasing patient satisfaction.

Chatbot can schedule appointments based on the doctor's availability, it can gather data, create medical records, and facilitate insurance. Medical Chatbots can provide 24/7 access to healthcare services and information [12], and people can get medical advice and refill prescriptions. Chatbots can improve the quality or experience of care by providing efficient, equitable, and personalized medical services [13].

These AI-based conversational agents utilize natural language processing and machine learning to offer patients personalized advice that promotes health, education, and behavior change [14]. Chatbots analyze medical histories and symptoms to provide tailored recommendations that are unique to each patient's situation. They also deliver actionable suggestions that can help one maintain their overall well-being. This technology is particularly beneficial for people who live in regions where access to healthcare professionals is limited or those with time constraints or exposure fears surrounding traditional hospital visits. The use of synchronous text-based communication systems for remote health care is becoming increasingly popular [15].

Moreover, Chatbots are highly cost-effective compared to conventional healthcare delivery methods. Chatbots have immense potential for extending healthcare access beyond traditional medical facilities by improving marginalized communities' health outcomes who face transportation challenges and long wait times for consultations.

Chatbots can offer personalized healthcare recommendations that lead to better patient outcomes and reduced costs [17]. Chatbots offer a diagnosis of symptoms, mental healthcare consultation, nutrition facts and tracking, and more during a pandemic. WHO teamed up with WhatsApp and made use of Chatbots to provide guidance and combat misinformation about COVID-19 [18].

Chatbots communicate in several different languages through WhatsApp, Viber, and Facebook Messenger, which has reportedly reached over 12 million people [19, 20]. Chatbots are programmed to recognize when a patient needs assistance the most, such as in the case of an emergency or during a medical crisis when someone needs to see a doctor right away; they provide predicted diagnoses based on information stated by the patients. Some medical Chatbots act as medical reference books or preliminary diagnostic tools that help the patient know about his disease and help in the improvement of health [21]. Chatbots help in monitoring patients suffering from chronic diseases and remind them to take their medications [22]. Chatbots enable effective evidence-based therapies. The study showed that Chatbots have great potential to offer social and psychological support in situations where real-world human interaction, such as connecting to friends or family members or seeking professional support, is not preferred or possible to achieve [24]. Therapist Chatbots may help in improving patient mental health using cognitive behavioral therapy and techniques [26,29]. The results of a randomized controlled trial among students using Woebot (therapist Chatbot) found that Woebot significantly reduced symptoms of depression within 2 weeks [26]. Chatbot "iHelpr" has been developed for self-assessment along with tips about mental issues such as stress, anxiety, depression [23], sleep, and self-esteem [27]. The study about iHelpr was conducted using a questionnaire, and it found that the Chatbot is enjoyable and easy to use [27]. Chatbots are capable of assisting health professionals. The study revealed that it is possible to employ medical Chatbots as a helper for

health practitioners and patients [31]. They can help in predicting diagnosis [32] and diagnostic decision support [33]. Chatbots in the healthcare industry are time-saving and burden-relieving for health professionals. They can gather and store the patient's data that physicians can later use. Chatbots can automate administrative tasks, admission and discharge. The automated billing feature of the Chatbot helps health professionals get paid quickly for their service using automatically generated invoices. Chatbots are not only used for appointment scheduling but also send reminders and other medical notifications to health professionals. Feedback plays an important role in the productivity of the industry; medical professionals can refine their procedures using patients' comments.

Besides all the benefits medical Chatbots have limitations. A machine, even a humanoid robot, cannot do as many things as a human can do. Chatbot technology is not enough to replace visits with medical professionals. Doctors often make decisions based on wisdom and have the ability to justify them. Doctors can rectify errors. Medical Chatbots, Consequently, are incapable of reversing their mistakes and decisions due to their lack of wisdom and flexibility. One of the irreplaceable roles of health professionals is the patient-doctor relationship, which is built on trust and empathy.

6. Challenges

Despite the use of Chatbots in healthcare, they have some challenges. Chatbots have limited medical knowledge. A liability issue may arise because there is a chance of inaccurate diagnosis as they may not be aware of all the relevant factors of the patient's medical problem; hence, Chatbots fail to satisfy patients' needs. Data security, privacy, and confidentiality concerns arise as AI Chatbots deal with sharing patients' sensitive information and huge, complex volumes of data widely on the internet [35]. Promoting inclusivity and resolving ethical dilemmas are limitations of Chatbots. Another big challenge for Chatbots is integrating with existing systems because of differences in data structures, coding systems, and data protocols.

7. Security Risks Associated with Chatbots

There is no definite answer to the question "whether the Chatbots are secure or not"? even the most secure systems could have potential vulnerabilities and could be at risk for security threats. Exploitation is always connected with emerging trends, and there is a risk of hacks in Chatbots along with other threats. Vulnerabilities and threats are the risks when the organization and systems can be compromised. Computer security threats include Spoofing, Tampering, Repudiation, Information Disclosure, Denial of Service, Elevation of Privileges [36], and data theft. While using the medical Chatbot, there is a risk that data in transit can be tampered with and spoofed. Vulnerabilities refer to the weakness of the system software, hardware, and processes.

Lack of maintenance, poor/weak coding, a lack of protection such as a weak firewall, or human error can make a system vulnerable to attacks. A prompt injection attack is a type of cyberattack used against Chatbots and machine-learning models. During the training phase of Chatbots, attackers often modify or introduce new prompts. Normally, when a user enters data into the Chatbot to ask a query, the neural network generates an output based on the user's request, but if injected prompts work, it can lead to incorrect and harmful output. SQL injection is another type of cyberattack in which the attacker targets online Chatbots. In this type of attack, cyber attackers create queries to create disruptions and gain unauthorized access to confidential databases of an organization. API Vulnerabilities are also security risks for Chatbots. Mainly when they integrate with the other systems and applications to share data, these types of Vulnerabilities give cyberattackers unauthorized access to sensitive information such as patient data and passwords.

7.1. Security Measures for Chatbots

Security in medical Chatbots is vital to protect patient data and sensitive information. To defend against threats and vulnerabilities security measures should be adopted to have a safe Chatbot platform. These measures are Authenticity, Integrity, Non-repudiation, Confidentiality, Availability, Authorization [37], End-to-End Encryption, self-destructive messages, User communication data, backend side [36], and Secure protocols. Multifactor authentication adds an extra layer of protection. To avoid unauthorized access, strong and complex passwords, along with regular updates, are crucial. To transform identifiable data to an anonymous form Anonymization or pseudonymization techniques can be implemented. This process provides an additional layer of protection to the patient data. Encryption is crucial among all communication channels between users and Chatbots to prevent potential eavesdropping and data breaches.

8. Discussion

Chatbots have emerged as a promising solution for the healthcare industry. The deployment of these digital conversational agents can provide instant medical support to patients in need. This is especially crucial when traditional healthcare services may not be readily accessible. According to recent research, Chatbots can improve healthcare access in remote areas by providing instant medical support to patients [13]. Chatbots are increasingly being used across various industries, such as retail and utilities; however, their potential impact on the healthcare industry has been remarkable. With the COVID-19 outbreak creating unprecedented circumstances, organizations have responded swiftly with innovative solutions such as Chatbots that enable them to deliver timely information and assistance remotely. By bridging the gap between medical professionals and patients who may be located far away from hospitals or clinics, Chatbots help facilitate improved patient outcomes [16].

Patients receive immediate attention through intelligent symptom analysis and diagnosis without having to travel long distances or wait for extended periods before getting an appointment with a doctor. Utilizing this technology allows individuals living in remote locations to benefit from quality healthcare services at any time they require it without leaving home or spending significant amounts of money on transportation costs [13]. Overall, it is crystal clear that the immense potential of Chatbot technology could revolutionize how we approach delivering modern-day healthcare services today.

Moreover, it has also been appraised in the study that in the healthcare industry, there is a constant push toward enhancing patient care and optimizing workflows [6]. A recent solution that has emerged is the use of Chatbots, which can automate administrative tasks and enable healthcare providers to dedicate more time to personalized patient care. The literature explores that AI-powered Chatbots have several benefits, such as providing tailored, interactive, and readily available health-promoting interventions [30]. By utilizing these Chatbots for administrative purposes like scheduling appointments and refilling prescriptions, healthcare providers can operate with greater efficiency while still offering high-quality services to their patients.

Additionally, these bots are equipped to offer immediate assistance outside regular work hours or during peak periods when human staff may be thinly stretched. This not only improves access but also provides greater convenience for patients who might not be able to take leave from work or school for appointments. However, it should be noted that Chatbots cannot replace human interaction completely - some situations call for trained medical professionals exclusively; nonetheless, in part due to advancements in AI technology powering these Chatbots [34]. Healthcare professionals find themselves at the forefront of innovation, seeking ways they can enhance quality-of-life outcomes whilst streamlining clinical environments' administrative burdens.

One of the critical benefits of Chatbots in healthcare is their ability to provide quick and accessible information to patients [25]. They can offer basic medical advice, answer frequently asked questions, and guide self-care for minor ailments. This can help alleviate the burden on healthcare providers, reduce unnecessary visits to healthcare facilities, and empower patients to make informed decisions about their health. The literature also claimed that Chatbots can assist in triaging patients by collecting relevant information about their symptoms and directing them to appropriate healthcare services. By using natural language processing techniques, Chatbots can assess the severity of symptoms and recommend whether self-care, a teleconsultation, or an in-person visit is necessary. This can help prioritize urgent cases and optimize the use of healthcare resources [25]. Chatbots also have the potential to improve medication adherence and patient

monitoring. They can send medication reminders, provide information on drug interactions and side effects, and track patient compliance [28]. Additionally, Chatbots can collect patient-generated health data, such as vital signs or symptoms, and relay that information to healthcare providers, enabling remote monitoring and early intervention. Despite these advantages, the literature shows that there are challenges and considerations in implementing Chatbots in healthcare. One primary concern is ensuring the privacy and security of patient data. Healthcare Chatbots must comply with strict data protection regulations, maintain confidentiality, and implement robust security measures to safeguard sensitive information [14].

According to a study in 2019, another challenge of Chatbots in healthcare is the need for accurate and reliable information [28]. Chatbots need to be trained on high-quality data and regularly updated to ensure they provide accurate medical advice. The potential for misdiagnosis or misinterpretation of symptoms underscores the importance of integrating Chatbots into a broader healthcare system that includes human oversight and intervention when necessary. Furthermore, research proclaimed that it is crucial to address potential biases in Chatbot algorithms [14]. Chatbots may inadvertently perpetuate health disparities or provide suboptimal care to specific patient populations if the training data is not diverse or representative. Ongoing monitoring and evaluation are necessary to identify and mitigate any biases that may arise. Hence, it can be stated that Chatbots have the potential to significantly enhance healthcare delivery by improving access to information, supporting triage processes, and promoting patient engagement. However, careful attention must be given to data privacy, accuracy, bias, and the overall integration of Chatbots into the healthcare system. With proper implementation, encryption, and oversight, Chatbots can be valuable tools in healthcare, complementing the expertise of healthcare providers and improving patient outcomes.

9. Conclusion

Healthcare transformed thanks to the Chatbot. The use of Chatbots in personalized healthcare has redefined users' understanding of accessibility to care services. With this innovation comes an increased level of perplexity as people navigate these complex technological solutions while benefiting from their burstiness, delivering engaging yet informative communication about patient health statuses. No doubt, Chatbot-enabled personalized healthcare will continue transforming the industry for years ahead by providing users with unparalleled options for improved wellness management at affordable prices without compromising on quality service delivery. Chatbots hold immense potential to revolutionize the healthcare industry by reducing the load on medical personnel and providing personalized recommendations. These bots have been enabled with Natural Language Processing (NLP) and Machine Learning (ML) to better comprehend

patient needs, thereby offering tailored solutions that enhance health outcomes. As people direct toward a more technology-driven society, it is paramount to actively embrace these innovative Chatbot solutions in healthcare. Throughout this essay, it has been investigated how Chatbots are transforming numerous aspects of healthcare delivery, from diagnosing illnesses to monitoring chronic conditions. Most importantly, Chatbots can improve patient engagement by offering 24/7 care without compromising quality or accuracy. This feature allows patients who may not seek medical attention due to accessibility issues or stigma to get help when they need it

most. Nevertheless, as with any new technological implementations in healthcare, data privacy and security concerns arise. Hence, there is a need to prioritize ethical considerations when designing Chatbot systems that handle sensitive personal information.

Acknowledgements

The authors extend their appreciation to the Deputyship for Research and Innovation, Ministry of Education in Saudi Arabia, for funding her research work through project number ISP-2024.

References

- [1] Xueming Luo et al., "Frontiers: Machines vs. Humans: The Impact of Artificial Intelligence Chatbot Disclosure on Customer Purchases," *Marketing Science*, vol. 38, no. 6, pp. 937-947, 2019. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [2] Rainer Winkler, and Matthias Soellner, "Unleashing the Potential of Chatbots in Education: A State-of-the-Art Analysis," *Proceedings of the 78th Academy of Management Annual Meeting*, Chicago, IL, USA, pp. 1-40, 2018. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [3] Anuj Patil, "Healthcare Chatbot Using Artificial Intelligence," *Journal for Research in Applied Science and Engineering Technology*, vol. 10, no. 8, pp. 1-7, 2022. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [4] Nudtaporn Rosruen, and Taweesak Samanchuen, "Chatbot Utilization for Medical Consultant System," *2018 3rd Technology Innovation Management and Engineering Science International Conference (TIMES-iCON)*, Bangkok, Thailand, pp. 1-5, 2018. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [5] Lekha Athota et al., "Chatbot for Healthcare System using Artificial Intelligence," *2020 8th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO)*, Noida, India, pp. 619-622, 2020. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [6] Tom Nadarzynski et al., "Acceptability of Artificial Intelligence (AI)-Led Chatbot Services in Healthcare: A Mixed-Methods Study," *Digital Health*, vol. 5, pp. 1-12, 2019. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [7] Kyungyong Chung, and Roy C. Park, "Chatbot-based Healthcare Service with a Knowledge Base for Cloud Computing," *Cluster Computing*, vol. 22, pp. 1925-1937, 2019. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [8] Inseok Hwang et al., "Towards Interpersonal Assistants: Next-Generation Conversational Agents," *IEEE Pervasive Computing*, vol. 18, no. 2, pp. 21-31, 2019. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [9] Ayah Atiyah, Shaidah Jusoh, and Sufyan Almajali, "An Efficient Search for Context-Based Chatbots," *2018 8th International Conference on Computer Science and Information Technology (CSIT)*, Amman, Jordan, pp. 125-130, 2018. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [10] Naveen, Medical Chatbot: An Ultimate Guide on Medical Chatbot, Kommunicate, 2023. [Online]. Available: <https://www.kommunicate.io/blog/all-about-medical-chatbot/>
- [11] What is a Neural Network?, IBM. [Online]. Available: <https://www.ibm.com/topics/neural-networks>
- [12] M. Sanjay Kumar et al., "Medbot-Medical Diagnosis System Using Artificial Intelligence," *EAI Endorsed Transactions on Smart Cities*, vol. 6, no. 17, pp. 1-5, 2021. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [13] Lu Xu et al., "Chatbot for Health Care and Oncology Applications Using Artificial Intelligence and Machine Learning: Systematic Review," *JMIR Cancer*, vol. 7, no. 4, pp. 1-18, 2021. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [14] Jasmine M. Noble et al., "Developing, Implementing, and Evaluating an Artificial Intelligence-Guided Mental Health Resource Navigation Chatbot for Health Care Workers and Their Families During and Following the COVID-19 Pandemic: Protocol for a Cross-sectional Study," *JMIR Research Protocols*, vol. 11, no. 7, pp. 1-17, 2022. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [15] Martien J.P. Van Bussel et al., "Analyzing the Determinants to Accept a Virtual Assistant and use Cases among Cancer Patients: A Mixed Methods Study," *BMC Health Services Research*, vol. 22, pp. 1-23, 2022. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [16] B.R. Kavitha, and Chethana R. Murthy, "Chatbot for Healthcare System using Artificial Intelligence," *International Journal of Advance Research, Ideas and Innovations in Technology*, vol. 5, no. 3, pp. 1304-1307, 2019. [[Google Scholar](#)] [[Publisher Link](#)]
- [17] Prathamesh Kandpal et al., "Contextual Chatbot for Healthcare Purposes (Using Deep Learning)," *2020 Fourth World Conference on Smart Trends in Systems, Security and Sustainability (WorldS4)*, London, UK, pp. 625-634, 2020. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [18] Josephine Walwema, "The WHO Health Alert: Communicating a Global Pandemic with WhatsApp," *Journal of Business and Technical Communication*, vol. 35, no. 1, pp. 35-40, 2021. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]

- [19] Lee Wilson, and Mariana Marasoiu, "The Development and Use of Chatbots in Public Health: Scoping Review," *JMIR Human Factors*, vol. 9, no. 4, pp. 1-11, 2022. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [20] WHO Launches a Chatbot on Facebook Messenger to Combat COVID-19 Misinformation, World Health Organization, 2020. [Online]. Available: <https://www.who.int/news-room/feature-stories/detail/who-launches-a-chatbot-powered-facebook-messenger-to-combat-covid-19-misinformation>
- [21] S. Divya et al., "A Self-Diagnosis Medical Chatbot Using Artificial Intelligence," *Journal of Web Development and Web Designing*, vol. 3, no. 1, pp. 1-7, 2018. [[Google Scholar](#)] [[Publisher Link](#)]
- [22] Myroslava Bublyk et al., "Decision Support System Design For Low-Voice Emergency Medical Calls At Smart City Based On Chatbot Management In Social Networks," *Webology*, vol. 19, no. 2, pp. 2135-2178, 2022. [[Google Scholar](#)] [[Publisher Link](#)]
- [23] Russell Fulmer et al., "Using Psychological Artificial Intelligence (Tess) to Relieve Symptoms of Depression and Anxiety: Randomized Controlled Trial," *JMIR Mental Health*, vol. 5, no. 4, pp. 1-15, 2018. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [24] Romael Haque, and Sabirat Rubya, "An Overview of Chatbot-Based Mobile Mental Health Apps: Insights from App Description and User Reviews," *JMIR mHealth uHealth*, vol. 11, pp. 1-18, 2023. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [25] Samuel Holmes et al., "Usability Testing of a Healthcare Chatbot: Can we Use Conventional Methods to Assess Conversational User Interfaces?," *Proceedings of the 31st European Conference on Cognitive Ergonomics*, Belfast, United Kingdom, pp. 207-214, 2019. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [26] Kathleen Kara Fitzpatrick, Alison Darcy, and Molly Vierhile, "Delivering Cognitive Behavior Therapy to Young Adults with Symptoms of Depression and Anxiety Using a Fully Automated Conversational Agent (Woebot): A Randomized Controlled Trial," *JMIR Mental Health*, vol. 4, no. 2, pp. 1-11, 2017. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [27] Gillian Cameron et al., "Assessing the Usability of a Chatbot for Mental Health Care," *Internet Science, Lecture Notes in Computer Science*, vol. 11551, pp. 121-132, 2019. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [28] Moshir Rahman et al., "Disha: An Implementation of a Machine Learning-based Bangla Healthcare Chatbot," *2019 22nd International Conference on Computer and Information Technology (ICCIT)*, Dhaka, Bangladesh, pp. 1-6, 2019. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [29] Shinichiro Suganuma, Daisuke Sakamoto, and Haruhiko Shimoyama, "An Embodied Conversational Agent for Unguided Internet-Based Cognitive Behavior Therapy in Preventative Mental Health: Feasibility and Acceptability Pilot Trial," *JMIR Mental Health*, vol. 5, no. 3, pp. 1-12, 2018. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [30] Sven Laumer, Christian Maier, and Fabian Tobias Gubler, "Chatbot Acceptance in Healthcare: Explaining User Adoption of Conversational Agents for Disease Diagnosis," *Association for Information Systems, AIS Electronic Library*, pp. 1-19, 2019. [[Google Scholar](#)] [[Publisher Link](#)]
- [31] Chin-Yuan Huang et al., "Modeling Consumer Adoption Intention of an AI-Powered Health Chatbot in Taiwan: An Empirical Perspective," *International Journal of Performability Engineering*, vol. 18, no. 5, pp. 338-349, 2022. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [32] Yalan Chen et al., "Prostate Cancer Management with Lifestyle Intervention: From Knowledge Graph to Chatbot," *Clinical and Translational Discovery*, vol. 2, no. 1, pp. 1-14, 2022. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [33] Salman Razzaki et al., "A Comparative Study of Artificial Intelligence and Human Doctors for the Purpose of Triage and Diagnosis," *arXiv*, pp. 1-15, 2018. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [34] Chin-Yuan Huang et al., "A Chatbot-Supported Smart Wireless Interactive Healthcare System for Weight Control and Health Promotion," *2018 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, Bangkok, Thailand, pp. 1791-1795, 2018. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [35] Jingquan Li, "Security Implications of AI Chatbots in Health Care," *Journal of Medical Internet Research*, vol. 25, pp. 1-7, 2023. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [36] Martin Hasal et al., "Chatbots: Security, Privacy, Data Protection, and Social Aspects," *Concurrency and Computation: Practice and Experience*, vol. 33, no. 19, pp. 1-13, 2021. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]
- [37] Mina Deng et al., "A Privacy Threat Analysis Framework: Supporting the Elicitation and Fulfillment of Privacy Requirements," *Requirements Engineering*, vol. 16, pp. 3-32, 2011. [[CrossRef](#)] [[Google Scholar](#)] [[Publisher Link](#)]