ORIGINAL PAPER

Health Chatbots for Fighting COVID-19: a Scoping Review

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ABSTRACT

Background: Health chatbots are rising in popularity and capability for fighting the novel SARS-CoV-2 coronavirus (COVID-19). **Objectives:** This study aims to review the current literature on COVID-19 related chatbots in healthcare, identify and characterize these emerging technologies and their applications for combating COVID-19, and describe related challenges. **Methods:** The authors conducted a scoping review of peer-reviewed literature on COVID-19, guided by the Arksey and O'Malley framework. PubMed/MEDLINE and Google Scholar were searched over a period between January and September 2020 by using the keywords "COVID* chatbot", "virtual assistant", "AI enabled platform COVID" and associated synonyms. Relevant studies' references were checked for further articles. The content of these studies was screened and thematically analyzed by the two authors. **Results:** Out of 543 articles initially identified, 9 were eligible for inclusion. Studies describing chatbots' development and architecture (n=6) were the most common, and only 3 empirical studies on the user experience were identified. Our scoping review identified five key applications of the current health chatbots, which were: disseminating health information and knowledge; self-triage and personal risk assessment; monitoring exposure and notifications; tracking COVID-19 symptoms and health aspects; and combating misinformation and fake news. Furthermore, these technologies can accomplish the following tasks: ask and answer questions; create health records and history of use; complete forms and generate reports; and take simple actions. Nonetheless, the use of health chatbots poses many challenges both at the level of the social system (i.e., consumers' acceptability) as well as the technical system (i.e., design and usability). **Conclusion:** Using health chatbots to combat COVID-19 is a practice still in its infancy. We believe that our work will help researchers in this domain gain better understanding of this novel technology's design and applications, which are needed for continuous improvement in the health chatbots' functionalities and their usefulness to fight COVID-19.

Keywords: health chatbots, apps, COVID-19, coronavirus, conversational agents, health care.

1. INTRODUCTION

Artificially intelligent (AI) based conversational agents, otherwise known as chatbots, are the latest inventions utilized to combat the novel SARS-CoV-2 coronavirus (COVID-19) (1). Chatbots enable users to communicate and interact with software applications that use AI-based tools. These applications can be accessed via a website or social media messaging platforms such as WhatsApp and Facebook (1-3). For example, the World Health Organization (WHO) Technology program developed a chatbot to fight COVID-19; an initiative which can be accessed via WhatsApp and Facebook messenger (3). Its users utilize the chatbot to find answers to their questions on protecting themselves from the Coronavirus, to understand the facts and news related to the disease, and to contribute to preventing its spread.

In an effort for mitigating COVID-19, health chatbots are rising in popularity. The WHO chatbot reached more than 12 million people via WhatsApp in

its first month of operation, and it has been estimated to reach 4.2 billion people by the end of 2020 (4). In addition, consumers, healthcare providers, and public health policymakers alike have increased their use of health chatbots in healthcare (5); in 2018, the chatbots earned 36.5USD million in revenue – a figure anticipated to grow over 498.1USD million by the end of 2029 (6). These novel technologies are excellent benefactors for facilitating progress in healthcare as they enable better accessibility and personalization for consumers and efficiency for healthcare providers and public health officials (5).

Furthermore, future possible health chatbots will not be limited to answering the end-user's questions. These innovative technologies will be able to newly assist consumers in scheduling their appointments and issuing reminders, in improving medication adherence, and in acting as health consultants. Developers anticipate AI-based technologies will have human-level intelligence by 2029 and are expected to be "smarter" than humans by 2049 (7).

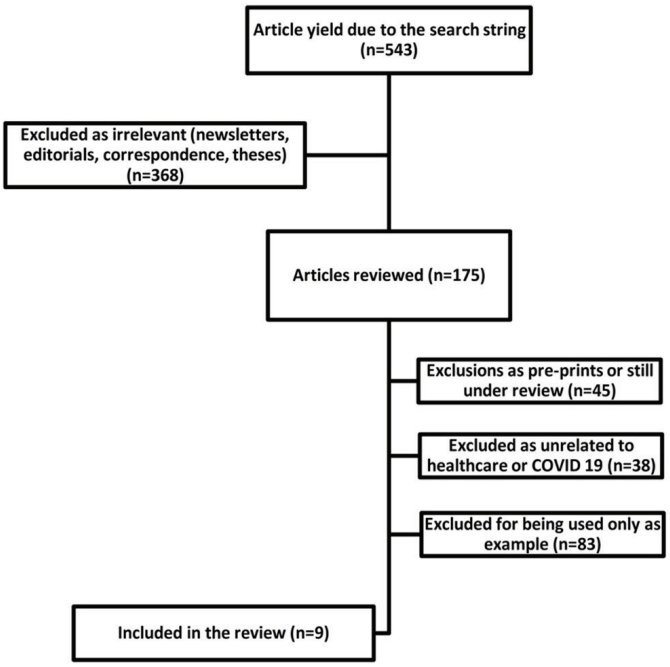

Figure 1. The flowchart of our search strategy and article selection process.

2. OBJECTIVE

This study aimed to review recent literature on COVID-19 related chatbots in healthcare, identify and characterize these emergent technologies and their applications for combating the Corona disease, and describe challenges related to doing so. As such, this review will provide insights into current health chatbots research, characteristics, applications, and recommendations for future research in this field to overcome identified challenges.

3. METHODS

To achieve our aim, we performed a scoping review of peer-reviewed literature on COVID-19 by using the Arksey and O'Malley framework for conducting scoping reviews (8). This framework is composed of five stages: a) identifying the research question; b) identifying relevant studies; c) selecting studies; d) charting the data; and e) collating, summarizing, and reporting the results. The following paragraphs present these stages.

Stage 1. Identifying the research questions

The following questions guided our scoping review: a) How were health chatbots described in recent peer-reviewed literature written on COVID-19? b) How were these emerging technologies used to combat COVID-19? and c) What challenges did use of health chatbots pose?

Stage 2. Identifying relevant studies

We searched PubMed/MEDLINE and Google Scholar with the following keywords: 'COVID* chatbot', 'health chatbot', 'Corona* chatbot', 'virtual assistant', and 'AI-enabled platform COVID'. Our search included articles and conference proceedings that were written in English and published between January 2020 and September 2020. In addition, the articles' reference sections were reviewed to identify further articles that might have been missed by our keywords list. During this process, the authors initially identified 543 articles. Figure 1 presents a flowchart of our search strategy and article selection process.

Stage 3. Selecting studies

The authors screened titles, abstracts, and keywords were screened according to our developed inclusion and exclusion criteria. A publication was excluded if it was not a peer-reviewed article or conference proceeding (e.g., newsletters, editorials, viewpoints, tutorials, correspondences, commentaries, reports, sounding board, field notes, books, and thesis). Using this criterion resulted in the elimination of 368 publications. Articles that were available as preprints or still under review were also excluded, totaling 45 articles. Lastly, the authors excluded articles that were not related to health and COVID-19, which ruled out an additional 38 articles. No restrictions were made regarding the study design and methodology as our reviews emphasis focused on broad coverage rather than on a particular standard of evidence.

During the review process, the authors discussed uncertainties related to study inclusion. Any discrepancies were resolved by consensus and the subsequent list of selected articles was revised. For example, a decision was made to exclude any article if it solely mentioned chatbots as an example of emerging technologies for combating COVID-19 without any further information or descriptions of health chatbots. This ultimately led to the elimination of 83 articles and left a total of 9 included articles (1-3, 9-14).

Stage 4. Charting the data

The included articles were categorized by their first author's name, the country of the publication's origin, the domain of the publication, study objectives, study

design, description of the chatbot, and key outcomes. The authors then performed open coding by screening all articles to extract and synthesizing information/excerpts that provided answers to the Stage 1's research questions. For example, to answer the first research question, the authors narratively synthesized information pertaining to the health chatbots' characteristics and functionalities. A qualitative data analysis application (i.e., Dedoose Version 8.3.35) was used for coding the included articles. Any disagreements about the selection of excerpts were resolved by consensus.

Stage 5. Collating, summarizing, and reporting the results

Generated article excerpts were summarized and descriptive statistics (frequencies) were used to describe the articles' characteristics. Appendix 1 presents the characteristics of the included studies.

4. RESULTS

4.1. Characteristics of the included studies

Out of the 543 articles initially identified, 9 were considered eligible for inclusion and a full-text review (Appendix 1). The majority of those studies (n=3) came from North America (i.e., the United States of America) whereas the rest were from Europe (i.e., the United Kingdom and Italy), Asia (i.e., India, Thailand, and Japan), and South America (i.e., Brazil).

The most common type of studies described the development and architecture of chatbots (n=6). We identified only 3 empirical studies on the user experience. Additionally, our review showed that health chatbots were used in multiple domains. The most prevalent domains were preventive care and risk communication (n=3) (3, 9,12), public health surveillance by health officials (n=2) (2, 10), Telehealth (n=2) (1, 11), workplace health and safety (n=1) (13), and care of the elderly (n=1) (14).

4.2. Characteristics of the COVID-19 related chatbots

To properly characterize chatbots, the authors needed to properly assess their definition and importance in healthcare. The recent literature describes chatbots as virtual agents that enable users to interact with an AI-based computer program (1, 2). These virtual agents work through receiving requests and returning responses (1). Technical features such as speech synthesis from text, data visualization, conversational ability, customization were all vital additions to chatbot applications (1-3, 10-13). Chatbots can be launched from a smartphone-based application (apps) such as LINE, WhatsApp and Telegram (10, 14); social media platforms such as Facebook and Twitter (3); or the developer or service providers' websites (2, 13). Likewise, chatbots can be standalone apps such as the one proposed by Battineni et al. (1).

In addition, these novel technologies can currently accomplish the following tasks:

4.2.1. Health chatbots answer questions

Initially, health chatbots were configured to instantly answer various questions related to COVID-19 (10-12). Once the user asks a question to a chatbot, a logical response is provided, exploiting its back-end information or knowledge base. To build this information, developers utilize Artificial Intelligence Markup Language (AIML). AIML works by recognizing keywords, patterns, and "Question-Answer pairs". These Question-Answer pairs were mainly generated from frequently asked questions (FAQ) that are available on health official sources such as the WHO, CDC, and other information sources (2, 3, 11, 12).

4.2.2. Health chatbots ask questions

In order to best assist users, some chatbots will ask the interested individual to answer questions about themselves. In some cases, chatbots ask users about their demographic data, medical history, residence information, and COVID-19 related symptoms (2, 10, 13). For those with symptoms, additional data can be requested such as the last clinic visits and diagnoses results. Those questions were necessary to screen users and determine their COVID-19 symptom and infection severity status (1).

4.2.3. Health chatbots create health records and history of use

Chatbots can store daily logs of their users' health conditions and build records of their health history and usage (1, 14). Storing and maintaining these daily logs can assist in effectively tracking user health status, symptoms, and physical activity patterns. For example, a proposed mobile application with chatbots had the potential of recording user data related to physical activity and nutrition for the purpose of interoperability that was essential to integrate data from chatbots' users with hospital healthcare systems (14).

4.2.4. Health chatbots fill forms and generate reports

In an effort to assist users, chatbots can fill forms and generate situation reports that include various data and metadata such as user personal information, and user responses with recorded timestamps and length of conversations. For example, the chatbot application in (13) was able to generate an entry pass for the employees who were evaluated as not infected nor suspected to be infected with COVID-19. This screening process is simpler and more efficient than traditional screening employees at the workplace entry points. It also provided health officials with complete and real-time data for making informed decisions to manage suspected cases.

4.2.5. Health chatbots take simple actions

Lastly, our review found that chatbots can take actions based on the users' responses (10). For example, after assigning a severity rating for a user who is experiencing symptoms, a chatbot could determine the subsequent necessary actions to best assist. These personalized actions may include providing customized advice and recommendations about COVID-19, or automatically connecting the user to a health specialist if their input symptom rating exceeded a specific pre-designed threshold (1, 3). In an emergency,

some chatbots can provide more details about the user's location, symptoms and infection severity score to the users' doctors or nearby health centers in a timely manner (1, 14).

4.3. Applications of health chatbots

Our literature review identified five health chatbot applications (Table 1). The following paragraphs present these applications in an order based on their frequency of appearance in our review.

Firstly, the most prevalent purpose was disseminating health information and knowledge (1-3, 10-12, 14). Health chatbots were equipped with various health educational materials and information about COVID-19 symptoms, medication, precautionary measures (e.g. cleaning hands, wearing face masks, etc.). These educational materials and information were offered in different formats like texts or medical catalogue, audio or animated clips, and maps (3, 12).

Secondly, health chatbots were utilized as self-triage and personal risk assessment tools during the COVID-19 pandemic (1, 2, 10-13). For example, a chatbot developed in Brazil (12) was used for self-screening based on measures suggested by WHO and local health officials before ultimately recommending or concluding the need for inpatient care. In another instance, the chatbot in (13) was used for employees' self-screening in order to assess the risk of COVID-19 infection before entering their workplaces. Additionally, health chatbots show nearby medical services (e.g. drive-through testing centers) and list emergency or hotline numbers for further personal risk assessment.

Thirdly, chatbots were designed for monitoring exposure to the Coronavirus and providing notifications (1, 2, 10, 13, 14). For example, the Japanese government built COOPERA (COVID-19 Operation for Personalized Empowerment to Rendersmart Prevention And care seeking) to support the prefectural government in assessing the epidemiological situation as well as monitoring and following up with the high-risk group within the country (10).

Fourthly, health chatbots were developed to track health symptoms and mental well-being characteristics associated with the pandemic. For example, an application with a chatbot was developed to record health factors such as nutrition, physical activity, etc. during mandated self-isolation periods (9, 10, 12, 14). Health chatbots were also used for tracking mood status to mitigate the psychological effects of COVID-19 such as anxiety, distress, and depression that could increase due to self-isolation, fear of becoming infected with the Coronavirus, or the stigma of contracting COVID-19 (9).

Fifthly, health chatbots were used to combat misinformation and fake news about COVID-19 (2, 3, 12). For example, the WHO's chatbot was developed to provide reliable information on a wide range of topics related to COVID-19. This factual information included active cases statistics and advice on the recommended best medical practices to prevent the Coronavirus from spreading (3). Another chatbot called "COVID-19 Preventable" (2) was designed and used in Thailand to disseminate timely information to the public on how to protect oneself from COVID-19 and distinguish fake news when prompted.

Applications of health chatbots	Reference article	N (9)	%
Disseminating health information & knowledge (e.g., COVID-19 symptoms, precautionary measures, and medical treatments)	[1-3,10-12,14]	7	77.7
Self-triage and personal risk assessment	[1,2,10-13]	6	66.6
Monitoring exposure and notifications	[1,2,10,12,14]	5	55.5
Tracking COVID-19 symptoms and health aspects (e.g., mental and physical status and activities)	[9,10,12,14]	4	44.4
Combating misinformation and fake news (e.g., news, the number of active cases)	[2,3,12]	3	33.3

Table 1. Summary of the applications of health chatbots

4.4. Challenges of using health chatbots

Our review found that the use of health chatbots posed many challenges social and technical system levels. At the social system level, some health chatbots became virtually inactive due to the lack of interest from the community (2). In addition, there was a mismatch between how users perceived these technologies in comparison to the actual abilities provided by health chatbots (2, 9). Users' negative perceptions about the chatbot integrity, benevolence, ability to provide accurate information, and ability to preserve their privacy may hinder their acceptance to use health chatbots (9). Furthermore, people with no access to technology or the Internet may not benefit from these technologies, leading to missing information encompassing the whole population and reducing the accuracy of discovering and predicting infected cases (2, 14).

At the technical system level, fact-checking of information while simultaneously being deployed is challenging for a chatbot as plenty of information is updated on a daily basis. A chatbot ability to process and deliver correct and up-to-date information sometimes requires the intervention of multidisciplinary teams (2). This can a challenge to chatbots in itself; information from multiple sources may not be coherent, leaving the users looking for answers confused (2). Additionally, current chatbots may not be developmentally equipped to effectively assist with sensitive topics such as mental health. For instance, the use of Empathetic Natural Language Generation is not yet considered to be sophisticated – as such, health chatbots may not be suitable for handling people with nervous breakdown or thoughts of suicide. These serious issues are common during pandemics, and a chatbot inability to offer appropriate advice may leave the user at high risk of self-harm or other disordered thinking

(1, 2, 13). Other concerns include the need for medical translation from "health service provider" to "layman" to avoid jargon. This pandemic is novel, which means people may use different words for describing the same condition, causing misunderstanding and misleading users to take inappropriate actions (2, 13).

5. DISCUSSION

Principal findings

Our literature review identified 6 studies focusing on the development and architecture of chatbots and only 3 detailing the user experience. In addition, the review found no relevant publications from Australia, Africa and the Middle East. Moreover, there were few studies from Asia and South America. These results indicate a need for more studies conducted in developing countries. Recent scoping reviews (15, 16) on using conversational agents in healthcare noted a lack of empirical studies for investigating these emerging technologies and their effects on the end-users. These conclusions correspond to our findings, where not only were only three studies were found to be related to the user experience, but the overall search pool was limited in proportional geographical distribution of relevant research.

These novel technologies are currently being used most for basic tasks such as asking/answering FAQ, automatically completing forms for users, and automatically connecting the users with their doctors in the emergency cases. In addition, health chatbots enable long-term data collection for tracking COVID-19 symptoms (15). This suggests that these technologies are continuously evolving from conducting basic tasks to more often engaging end-users through symptoms tracking and generating reports.

Our review found that the five most common applications of health chatbots were: disseminating health information and knowledge; self-triage and personal risk assessment; monitoring exposure and notifications; combating misinformation and fake news; and tracking COVID-19 symptoms and health aspects. Understanding the feasibility, safety, and effectiveness of health chatbots to achieve these five purposes is lacking; therefore, further research is needed to address this gap and resolve the mismatch between the users' perceptions of health chatbots and the actual applications of these tools (5). Even so, certain populations such as the geriatric population may need further investigation on how to best utilize chatbots due to their vulnerability to social isolation imposed by pandemics (14), and their limited abilities to type on small keypads on smartphones (15).

Moreover, our findings indicate that the lack of consumers' interest to use these technologies is posing a challenge; thus, further evaluation of the population's acceptance of using health chatbots to combat pandemics or future widespread illness is needed. In addition, to best reach a large number of people in a short period of time, it is imperative that these health chatbots be integrated with investigation of the integration of health chatbots with messaging apps such as WhatsApp and Facebook that are popular within the target population. Statistics have shown that the use of messaging apps is often associated with high interest rates and utilization (16), which may assist in resolving the issue of lack of use in some settings and improve the long-term adoption of health chatbots due to the popularity of the hosting apps.

Limitations of the study

In this scoping review, the classification health chatbots' characteristics and applications was based on the narrative analysis of included studies; however, no quality assessment of these articles was conducted. Performing quality assessments is not frequently undertaken in this type of research (17) due to the heterogeneity of designs and methodologies of the included articles as shown in Appendix 1. Furthermore, the exploratory nature of such reviews is not concerned with comprehensive coverage rather than on a particular evidence (18). To overcome this limitation, the inclusion criteria was limited to peer-reviewed articles as well as the details and description of the included study aims, design and provided key outcomes.

6. CONCLUSION

This paper presents the characteristics and applications of health chatbots and discusses related challenges of using these emergent technologies during pandemics. The use of health chatbots to combat COVID-19 is still in its infancy. We believe that our work will help researchers to gain better understanding of these novel technologies' design and applications, which are needed for continuous improvement in health chatbots' functionalities and uses for combating COVID-19.

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- **Conflicts of interest:** None declared.
- **Financial support and sponsorship:** Nil.

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1st Author [#Ref]	Country	Domain/ Areas	Study Objectives	Study Design	Chatbot Description	Key Outcomes / Results
Battineni [1]	Italy	Telehealth	To design framework of an AI chatbot for the diagnostic evaluation of COVID, recommending measures and connecting patients with consultants	Review of the design and performance evaluation for AI/NLP based standalone chatbot applications	AI conversational agents that use NLP, identifies message patterns with artificial intelligence markup language	Chatbot for remote patients to act as medical consultant, to identify symptoms based on user responses, determines severity and makes decision either to contact health specialist or suggest preventive actions
Rodsawang [2]	Thailand	Public health surveillance by health officials	To design an official interactive channels (chatbot) used by the DDC for disseminating COVID related information to the general public	Presenting the CDC Thailand's experience for the design, development, and evaluation of 'COVID-19 Preventable' chatbot	'Kor-Ror Ok' later known as 'COVID-19 Preventable' chatbot, AI technology that mimics human-like conversation through speech or text chats built on a LINE messaging platform, deployed using Dialog flow on Google cloud. It contains 262 pre-programmed questions in Thai.	Chatbots could provide support to government, disseminating information, relieving call center burden, delivers official risk communication, Bi-lingual, with WHO and other official sources
Walwema [3]	USA	Preventive care and risk communication	To examine the WHOs WhatsApp based chatbot application Health Alert	Cognitive walk-through method to mimic the actions of the user	'Health Alert' - WhatsApp based chatbot with text, videos and emojis, provides statistics, FAQs, have options of selecting preferred languages	Multilingual chatbot with extensive user base, consisting of visually appealing animation content, explaining detailed and specific steps of preventive measures
Dennis [9]	USA	Preventive care and risk communication	To understand the users' response to COVID 19 screening chatbots	Online experiment with 371 participants who viewed screening session between patient and hotline agent (either a chatbot or human)	Applications that conduct real time conversation in natural language via typed text or voice commands	Participants perceived the chatbot to have significantly less ability, integrity, and benevolence
Yoneoka [10]	Japan	Public health surveillance by health officials	To describe a large-scale monitoring system with chatbot functionality, and to evaluate its validity	Study of chatbot through testing it with over 200,000 participants in three prefectures in Japan	'COOPERA', a chatbot built on LINE messenger platform, allows for follow-up of high-risk groups	Significant correlation between the user interactions of the chatbot based system with PCR confirmed cases indicating likely benefits
Bharti [11]	India	Telehealth	To introduce a chatbot application integrated in telehealth system, acting as a personal virtual doctor for use in a post COVID era	Design architecture and development description of 'Aapka Chikitsak' chatbot	'Aapka Chikitsak', built on Google Cloud Platform and Firebase Cloud Functions, serverless architecture, conversational telehealth agent	Multilingual chatbot, especially focusing on rural populations providing generic healthcare information, preventive measures and other ailments.
Ferreira [12]	Brazil	Preventive care and risk communication	To introduce a virtual assistant chatbot and describe its design architecture	Description of the chatbot, it's design architecture	'ANA' - a chatbot developed using BLiP, available on WhatsApp, color codes the user based on symptom criteria, offers educational sessions based on FAQs	A chatbot in Brazilian Portuguese for the purpose of screening suspected cases and communication of relevant information, with a way to prioritize users based on symptoms.
Judson [13]	USA	Workplace health and safety	To develop an efficient, reliable and dynamic tool for daily screening of healthcare workers to prevent the spread of COVID-19 in the healthcare setting	Multiple methods: Design research by direct observation, service design blueprint, design prototyping, remote usability testing, survey about user experience.	A web-based chatbot with branching logic questions based on screening criteria.	A digital employee screening tool that was designed to minimize friction in the daily screening process
Meinert [14]	UK	Care of the elderly	To provide a chatbot based tool for older people and their families to improve their well-being during and after regulated social distancing	Case study, to develop, evaluate the effectiveness and acceptability of the proposed app	ADAPT CAFÉ – mobile app with voice enabled conversational AI built on open source framework (Amazon Lex)	Proposed medium for social interaction and analytics platform for reporting potential COVID cases, data about user movements and symptoms occurrence in older age group

Appendix I