English

SOFIAbot: chatbot for expanding health services during the COVID-19 pandemic

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Abstract

***Introduction**: COVID-19 has been a challenge for healthcare systems, therefore, some strategies, such as telehealth, have been implemented to expand healthcare services, using technologies such as chatbots. **Objective**: To describe access to the SOFIA Bot chatbot system for tele-screening suspected cases of COVID-19. **Methodology**: Experience report type study; Research, Development, and Innovation (RD&I) conducted at the Telehealth Center of the University Hospital of the Federal University of Maranhão. SOFIA Bot was developed, part of an automated digital platform, based on dialogues structured in algorithms, based on the symptoms reported by individuals who access the tool, provides guidance, and conduct to be adopted by the service user, classifying them, according to the risk of having COVID-19 and the severity of symptoms. The data generated was managed by the Teleconsulting Monitoring and Management System. **Results**: SOFIA Bot recorded 2,519 accesses with 27.9% classified as high, 30.6% medium and 41.5% low severity symptoms. The risk of having COVID-19 was low at 52.8%, medium at 35.1% and high risk at 12.1%. **Discussion and conclusion**: SofiaBot is understood as an incipient technology promptly developed by the NTS in response to the national and global need experienced at the beginning of the pandemic. Continuing research in the area is essential for consolidating chatbots with increasingly greater specificity and sensitivity.*

Key-words: Telehealth, Tele-screening, COVID-19, Chatbot.

Resumen

SOFIAbot: chatbot para ampliar los servicios de salud durante la pandemia de COVID-19

***Introducción:** El COVID-19 ha sido un desafío para los sistemas de salud, por ello, se han implementado algunas estrategias, como la telesalud, para ampliar los servicios de salud, utilizando tecnologías como los chatbots. **Objetivo**: Describir el acceso al sistema de chatbot SOFIA Bot para telecribado de casos sospechosos de COVID-19. **Metodología**: Estudio tipo informe de experiencia; Investigación, Desarrollo e Innovación (ID&I) realizada en el Centro de Telesalud del Hospital Universitario de la Universidad Federal de Maranhão. Fue desarrollado SOFIA Bot, parte de una plataforma digital automatizada, basada en diálogos estructurados en algoritmos, a partir de los síntomas reportados por los individuos que acceden a la herramienta, brinda orientación y conducta a adoptar por el usuario del servicio, clasificándolos, según el riesgo. de tener COVID-19 y la gravedad de los síntomas. Los datos generados fueron gestionados por el Sistema de Gestión y Seguimiento de Teleconsultas. **Resultados**: SOFIA Bot registró 2.519 accesos, 27,9% clasificados como síntomas de gravedad alta, 30,6% media y 41,5% baja. El riesgo de tener COVID-19 fue bajo con 52,8%, medio con 35,1% y alto con 12,1%. **Discusión y conclusión**: SofiaBot se entiende como una tecnología incipiente desarrollada puntualmente por el NTS en respuesta a la necesidad nacional y global vivida al inicio de la pandemia. Continuar con la investigación en el área es fundamental para consolidar chatbots con cada vez mayor especificidad y sensibilidad.*

Palabras clave: Tele-salud. Detección remota. COVID-19. Chatbot.

Resumo

SOFIAbot: chatbot para a ampliação de serviços de saúde na pandemia da COVID-19

***Introdução**: COVID-19 tem-se constituído um desafio aos sistemas de saúde, portanto, algumas estratégias, como o telessaúde, foram implantadas para ampliar os serviços de saúde, utilizando tecnologias como chatbots. **Objetivo**: Descrever o acesso ao sistema de chatbot SOFIA Bot para teletriagem de casos suspeitos de COVID-19. **Metodologia**: Estudo do tipo relato de experiência; Pesquisa, Desenvolvimento e Inovação (PD&I) conduzido no Núcleo de Telessaúde do Hospital Universitário da Universidade Federal do Maranhão. Desenvolveu-se o SOFIA Bot, parte de uma plataforma digital automatizada, baseado em diálogos estruturados em algoritmos, a partir dos sintomas referidos pelos indivíduos que acessam a ferramenta, fornece orientações e condutas a serem adotadas pelo usuário do serviço, classificando-o, segundo o risco de ter COVID-19 e da gravidade dos sintomas. Os dados gerados foram gerenciados pelo Sistema de Monitoramento e Gerenciamento de Teleconsultorias. **Resultados**: SOFIA Bot registrou 2.519 acessos com 27,9% classificados com sintomas de alta, 30,6% média e 41,5% baixa gravidade. O risco de ter COVID-19 foi baixo em 52,8%, médio 35,1% e 12,1% alto risco. **Discussão e conclusão**: Compreende-se o SofiaBot como uma tecnologia incipiente desenvolvida prontamente pelo NTS em atenção à necessidade nacional e mundial vivenciada no início da pandemia. A continuidade de pesquisas na área é essencial para consolidação de chatbots com especificidade e sensibilidade cada vez maiores.*

Palavras-chave: Telessaúde, Teletriagem, COVID-19, Chatbot.

INTRODUCTION

The pandemic of the new coronavirus has occurred in epidemic waves[1], alternating between periods of high and low transmission levels[2]. The guidelines on conduct and possible relaxation of restrictive measures took into account these contexts and the stage of vaccination in the country[3,4].

Chatbots are software programs that communicate with people through voice or text[5]. Institutions such as the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO) have begun to use telehealth through chatbots as a way of offering health services[6]. By sharing information, providing guidelines on conduct, and offering emotional support, the use of chatbots has enabled to reduce the exposure of sick people to health facilities, while also providing health care to the population during the Covid-19 pandemic[7].

For some years now, doctors have been using chatbots for health-related purposes in their work processes, in clinical anamnesis, sharing diagnostic tests and assisting patients with self-managed chronic conditions[8]. The use of this technology is currently under study and needs to be further documented. Brazil has also shown timid results in scientific production related to the digital detection, screening and tracking of diseases, especially in acute diseases[9].

Although promising, the use of chatbots can pose safety risks due to the wide variation in their responses to health questions[8]. However, using criteria such as evidence-based information, recognition of possible limitations and establishment of safety boundaries for

remote intervention, chatbots have emerged as a potentially relevant health service to help manage mild and moderate cases of COVID-19[10-12].

In Brazil, the use of telehealth and telemedicine was authorized by Law number 13,989 of April 15, 2020, and regulated by professional councils, and was subsequently regulated by Federal Law number 14,510 of December 27, 2022[13-16]. The use of chatbot technologies enables screening and monitoring of patients in home isolation due to COVID-19 with less severe manifestations, being a scalable solution that favored social distancing[1,7,17,18].

In this context, this work aimed to describe access to the SOFIA Bot (SB) chatbot system for teletriage of suspected cases of COVID-19.

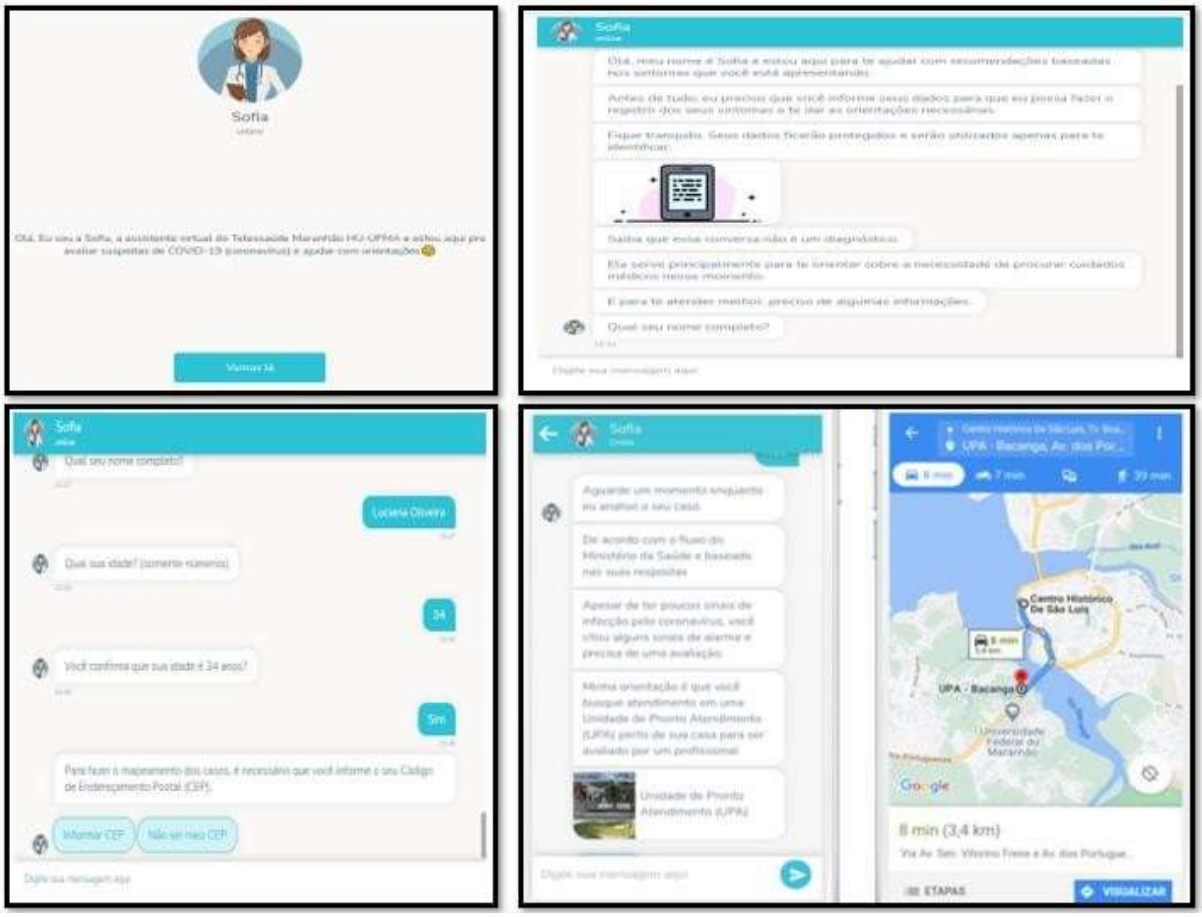
METHOD

This is a study of the experience report type; Research, Development and Innovation (RD&I)[19] applied in the development of the project "SOFIA Bot – medical assistance method for expanding access to health care during the COVID-19 pandemic", planned and executed by the Telehealth Center of the University Hospital of the Federal University of Maranhão (NTS-UFMA), as a response to the public health emergency of Covid-19, with the objective of developing and implementing a telehealth system for tele-screening and monitoring of symptoms of flu syndrome related to COVID-19 through a chatbot.

A chatbot is a software capable of conversing with users in a natural way[20] with pre-programmed actions to simulate a human dialogue in the "chat" mode in real time.

SB is a rule-based chatbot that identifies and understands what a user wants to say, based on pre-defined keywords in the software, as the user writes a message or chooses from the options offered and, simultaneously, offers pre-defined responses according to the trigger sent by the user (Figure 1).

Figure 1 – SB user interaction interface



Source: Own authorship (2023).

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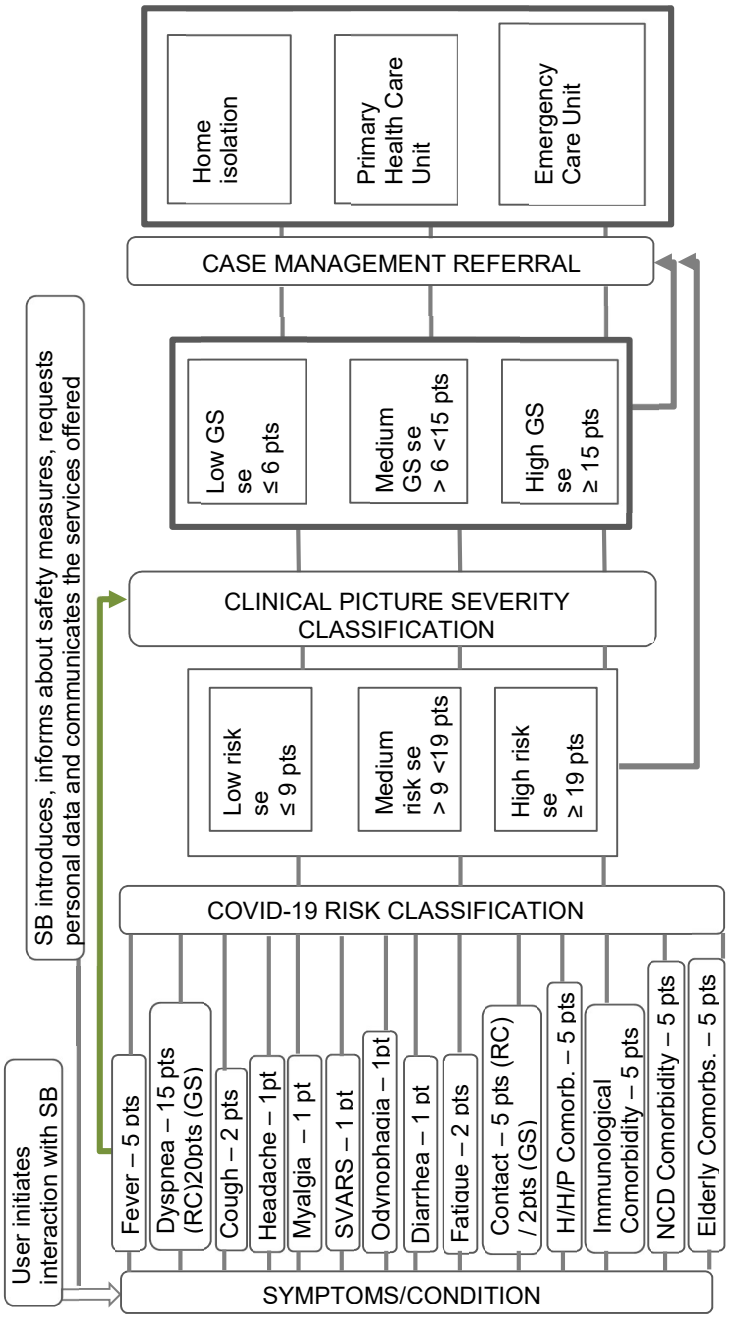
The development of the system was divided into three phases: tele-screening of symptoms, classification and guidance of the patient/user; tele-monitoring of symptoms and patient complaints; tele-consultation with a health professional.

This study aimed to develop telehealth technology and describe the first phase of development of the SOFIA Bot system.

This phase was defined and schematized as the stage of tele-screening of symptoms, classification and guidance of the patient/user. The system is based on a flow of questions submitted by the chatbot to users and their responses regarding the symptoms of flu-like syndrome related to COVID-19 (Figure 2).

Figure 2 – Tele-screening and guidance flow created by SB



Source: Own authorship (2023) – Translated.

Caption: *H/H/P - Heart/Hypertension/Pulmonary*; *GS* - Severity of symptoms; *RC* - Risk of COVID-19.

Due to the need for rapid implementation of a system to respond to the public health emergency, the team of health professionals that made up the NTS proposed the signs and symptoms adopted in the analysis of cases by SOFIA Bot, as well as the guidelines and conduct offered to users, based on scientific literature6,[18,21-23] manuals and protocols from the Ministry of Health and the State Secretariat of Maranhão[14,17,18] and guidelines from PAHO and WHO, from studies of the first cases of COVID-19.

Symptoms with the highest percentage of presence patterns among confirmed cases and those with the greatest relevance for the clinical picture and prognosis were extracted from the literature available at the time. Two classification systems were developed: one for the risk of being diagnosed with COVID-19, from which they were classified according to the severity of the reported symptoms. For this, the symptoms were stratified into scores. To classify the risk of having COVID-19, a maximum score of 20 points was established for the symptom of dyspnea, as it was considered to have the highest risk of being related to the disease. Dyspnea received the maximum score (15 points) for classifying the severity of symptoms, as it represents the most severe manifestation within the clinical picture. Symptoms and reports with a median score for the diagnosis of COVID-19 and clinical severity received 5 points. Scores of 02 and 01 were established for symptoms of lesser severity and lower specificity if analyzed separately, but when grouped in the same report, constituted classifications of higher risk and severity.

The scores were delimited according to the scores defined for each symptom (Chart 1). With this, the risk classes of COVID-19 were defined (Chart 2). The symptom scores, regarding their potential to cause more severe clinical conditions (Chart 3), defined the classification of symptom severity (Chart 4).

Chart 1 – Signs and symptoms score for COVID-19 risk.

Variable/symptoms	***Score***
Fever	05
Dyspnea (difficulty breathing)	20
Cough	02
Headache	01
Myalgia	01
Rhinorrhea, nasal obstruction, sneezing, anosmia, hyposmia and ageusia	01
Sore throat	01
Diarrhea and gastrointestinal complaints	02
Fatigue	02
Contact with a confirmed case of COVID-19	05

Source: Own authorship (2023) – Translated.

Chart 2 – COVID-19 risk classification by total score.

Category	*Score*
Low risk of COVID-19	≤ 9 points
Medium risk of COVID-19	>9 <19 points
High risk COVID-19	≥20 points

Source: Own authorship (2023) – Translated.

Chart 3 – Score for severity of reported symptoms.

Variable/symptoms	*Score de pontuação*
Fever	05
Dyspnea (difficulty breathing)	15
Cough	02
Headache	01
Myalgia	01
Rhinorrhea, nasal obstruction, sneezing, anosmia, hyposmia and ageusia	01
Sore throat	01
Diarrhea and gastrointestinal complaints	02
Fatigue	01
Contact with a confirmed case of COVID-19	02
Presence of comorbidities – cardiac, hepatic and pulmonary	05
Immunosuppression (HIV, transplant, chemotherapy, radiotherapy, corticosteroid therapy)	05
Presence of chronic diseases such as diabetes mellitus, systemic arterial hypertension and obesity	05
Adults aged 60 and over	05

Source: Own authorship (2023) – Translated.

Chart 4 – Classification of severity of reported symptoms.

Category	*Score*
Low severity of symptoms	≤ 6 points
Medium severity of symptoms	> 6 ≤15 points
High severity of symptoms	>15 points

Source: Own authorship (2023) – Translated.

The definition of the need to travel to a health unit or stay at home (with the recommendation of permanent self-observation of the evolution of symptoms) followed the criteria of the scores and classification of severity of symptoms. Cases that required travel received information on the route to the health unit closest to their addresses provided through geolocation.

This study considered all records of accesses to the SB system at the electronic address: https://telessaude.ufma.br/. The location for storage and processing of the data produced was an instance of Amazon Elastic Compute Cloud under the responsibility of NTS UFMA. Data collection took place between May 10 and September 29, 2020.

Each access record in the SB system was included as a unit of analysis. Records of users under 20 and over 100 years of age were defined as exclusion criteria.

The variables were described using mean, standard deviation, and absolute and relative frequencies. Chi-square tests were then performed to assess statistical differences in the risk categories of COVID-19 and in the severity of symptoms. The significance value (p) adopted was 0.05 and a confidence interval of 95%. STATA® software (version 14.0) was used.

All ethical procedures present in Resolution 466/2012 of the National Health Council were applied in this study, which was submitted to and approved by the Research Ethics Committee of HU-UFMA (CAAE 34018820.4.0000.5086 and Opinion No. 4,144,884).

RESULTS

There were 2,519 accesses to the SB between May 10 and September 29, 2020. After applying the criteria, 63 records were excluded due to age and 2,456 were analyzed.

There were 177 losses due to users not registering their location. The highest frequency of access was among people aged 41 to 60 (46.0%) living in the Northeast region (82.3%). The state with the highest number of accesses, considering all regions, was Maranhão (69.6%) (Table 1). June 2020 had the highest frequency of accesses (Table 2).

In the risk classification for COVID-19, 52.8% were stratified as low risk, 35.1% as medium risk and 12.1% as high risk (Table 1).

The severity of symptoms reported by users was distributed into the categories, low severity with 41.5%, medium severity with 30.6% and high severity with 27.9% (Table 2).

The system was used with a single access by 69.9% of users, two accesses by 22.2% and 7.9% performed between three or more accesses to the SB (data not shown in the table).

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Table 1 – Accesses to the SOFIA Bot system according to the risk of having COVID-19, Brazil, 2020.

	Low Risk		Medium Risk		High Risk		Total		*p-value*
	N	%	N	%	N	%	N	%	
Age									**<0.01**
20 – 40 years old	496	46.7	419	39.4	148	13.9	1,063	43.3	
41 to 60 years old	618	54.7	377	33.4	134	11.9	1,129	46.0	
Over 61 years old	182	68.9	67	25.4	15	5.7	264	10.8	
Total	1,296	52.8	863	35.1	297	12.1	2,456	100.0	
Acess location*									**<0.01**
Maranhão	844	53.9	554	34.9	189	11.9	1,587	69.6	
Mato Grosso	108	43.6	112	45.2	28	11.3	248	10.9	
Rio Grande do Norte	144	68.3	53	25.1	14	6.6	211	9.3	
Others[a]	99	42.5	93	39.9	41	17.6	233	10.2	
Total	1,195	52.4	812	35.6	272	11.9	2,279	100.0	

* The variable presented losses due to lack of information recording.

[a]: AC / AM / AP / BA / CE / DF / ES / GO / MG / MS / PA / PB / PE / PI / PR / RJ / RO / RS / SC / SP / TO

Source: Own authorship (2023) – Translated.

Table 2 – Accesses to the SOFIA Bot system according to the severity of symptoms reported related to COVID-19 and period of access, Brazil, 2020.

	Low Risk		Medium Risk		High Risk		Total		*p-value*
	N	%	n	%	N	%	n	%	
Month of access									**<0,01**
May	341	36.1	294	31.1	309	32.7	944	38.4	
June	450	44.6	319	31.6	241	23.9	1,010	41.1	
July	182	44.2	118	28.6	112	27.2	412	16.8	
August	42	50.0	19	22.6	23	27.4	84	3.4	
September	5	83.3	1	16.7	0	0.0	6	0.2	
Total	1,020	41.5	751	30.6	685	27.9	2,456	100.0	

Source: Own authorship (2023) – Translated.

DISCUSSION AND CONCLUSION

The SB recorded a frequency of daily accesses that accompanied the wave of case records in Brazil[24], with 2,519 accesses in just over four months of service provision. Regarding the classifications of COVID-19 risk and severity of symptoms, they were distributed respectively in 52.8% and 41.5%. This difference was due to the definition of the scores of the most prevalent symptoms in confirmed cases and those with the greatest impact on the clinical picture.

The SB was a response to the public health emergency quickly developed by a public service in the Northeast, one of the regions with the lowest technological investments in Brazil[25] for use throughout the country. The effort made by the NTS team in producing this service is noteworthy.

There was a marked increase in access to the tool in the first two months of its operation, followed by a decrease in August and September, when there was a reduction in transmission and incidence of cases[26]. In the country, by the end of September 2020, the accumulated cases totaled 4,810,935 and 142,921 deaths[27].

One of the strategies to mitigate the exposure of suspected cases to the social environment was to encourage the use of telehealth tools. Several technologies and systems were developed[28-32].

To understand the habits of Internet users aged 16 and over during the pandemic, the Regional Center for Studies on the Development of the Information Society (CETIC.br) in partnership with other committees designed the COVID-19 ICT Panel. This research identified that during the pandemic, the search for health-related information increased significantly. Of Internet users, 72% sought health

information[33] and one fifth used telehealth services[34]. Regarding access to some virtual screening application, 24% used the technology[33].

Although we observed a higher concentration of records of users with only one access to the SB, the guidelines offered may have influenced the timely clarification on the conduct to be followed, since more than a quarter of the accesses occurred more than once.

As identified in research by the COVID-19 ICT Panel[34], the motivation to access the SB could come from curiosity and interest in information about COVID-19 symptoms, in addition to checking possible risk of the disease. Regardless of the continuity of access by the same user, the transmission of information can be considered a gain for health services.

Chatbots have been considered the most appropriate systems for remote patient tracking[29]. With the potential to impact the reduction of the search for health services in the in-person modality, it can help to free up in-person care for moderate and severe symptomatic patients[35,36].

Although the literature does not present reports of experiences that can be used as parameters for comparison with SB due to discrepancies in the methods and technologies used, some studies have presented characteristics that are partially equivalent to SB[7,24,37].

The artificial intelligence (AI) used in chatbots allows the recognition of symptoms compatible with the disease, reduces the gap between the onset of symptoms and the identification of suspected cases, and provides guidance on remaining in home isolation or seeking care at a health service[38-42], recognized as the most notable attributions of SB.

These health technologies were intended for the general public, with no restrictions on age group or profession[38]. User engagement strategies were applied, such as the use of social networks and advertising on messaging apps[9]. These strategies were also used by SB, focusing on the states with the highest incidence rates during the period in which the services were provided.

The SB was developed at the beginning of the pandemic, when it was necessary to deal with the lack of information. The most common symptoms reported in some studies were: fever, fatigue, dry cough, myalgia, and dyspnea[43-45]. SB identified symptoms that demonstrated milder clinical conditions. These cases have greater potential to benefit from the chatbot service because they generally do not require face-to-face assistance[29].

It is important to note that telehealth services, such as SB, are not suitable for severe cases of the disease, nor for patients with impaired cognitive ability or impaired use of technologies[41,46].

It is important to mention the efficiency of chatbots in screening for risk symptoms for the disease, but they do not perform diagnosis, and therefore cannot conclusively tell a patient whether they are infected with coronavirus[46]. They can inform the chance of this occurrence, requiring the screened suspects to undergo in-person tests to identify the virus[47].

Chatbot implementation cases were researched in a study that identified six categories of chatbot use in response to the COVID-19 pandemic. Although information and guidance were provided, this study pointed to a gap in real-time guidance for users regarding the action, since no suggestions for travel routes were identified among these chatbots, if necessary, to a health service due to the lack of geolocation information[7]. The functionality of directing the user to the reference unit closest to the provided address distinguished SB from other chatbots, as it has a geolocation system that traces a route from the user's location to a health unit, enabling selective organization of the health network's demand.

Telehealth systems have played an important role as a means of searching for and obtaining information, but many are available in online stores in the form of paid applications for mobile devices, such as smartphones[48]. It should be recognized that smartphone applications and Internet connections are not accessible to the entire population, which is the main obstacle to the widespread use of chatbots[49]. The evident disparity in access to these resources is a limitation that prevents the most vulnerable portion of the population from enjoying their benefits[34].

In addition, a systematic review of the literature pointed out problems related to privacy and usability, which remain as weak points for the use of chatbots in telehealth[50].

These obstacles are mitigated by the SB system, since it uses proprietary and private information storage software. Furthermore, the tool is anchored on its platform that is freely accessible to any device with internet access, in addition to an easy-to-interact interface.

A challenge for the SB was the application of a self-reported instrument that depends on the veracity of the information recorded by the user, a method widely used in chatbot technologies[26,27,51]. In these cases, the investigation usually involves closed questions and, although they do not provide a deep understanding of the problem, they are concise, guiding the patient through the main aspects that should be reported, avoiding loss of access throughout the process and non-completion of the service.

The loss of specificity must be considered in these systems; however, the significant gain in sensitivity may characterize them as suitable for issuing alerts in health and epidemiological surveillance[9].

Telehealth is an innovative strategy with great potential in the field of the health system[42,49], and may contribute to its reorganization. It has potentially favorable results for both managers and professionals as well as users. It encompasses actions from those experienced in confronting the pandemic as well as future projections for other acute or chronic diseases[52-54].

The SB services were offered without time restrictions and throughout the country, without requiring a login to the system. The capacity for simultaneous and unlimited public service, in real time and at any date and time, is a great potential of chatbots[37].

Brazil is a scenario of great demand for telehealth

services, justified by its vast territory, as well as immense isolated and difficult-to-access areas[55,56] and also by the inequality in the distribution of doctors throughout the Brazilian territory[53,57]. TeleSUS, a telehealth service of the Brazilian Ministry of Health, offered through chatbots and teleconsultations, among other ICT tools, was widely publicized nationwide, which may have contributed to reinforcing the credibility of the use of these tools[35].

Other similar services were available with great activity in several locations[41]. The SB had the highest proportion of accesses in the Northeast region and more specifically in the state of Maranhão, headquarters of the NTS and target of campaigns, dissemination actions and provision of other services by the center.

The SB is understood as an incipient technology developed promptly by the NTS in response to the national and global need experienced at the beginning of the pandemic. However, it is important to continue improving and adapting this tool, since the evolution of digital health and artificial intelligence applied to medicine has occurred quite intensely. In just over three years of more intense exploration of these tools, chatbots have increased and we now have chatGPTs (Generative Pre-trained Transformers) available. With this, interactions that were previously based on predefined messages and keywords now configure an individualized conversation through generative artificial intelligence technology in the form of text with unique advice for professionals and users[58,59].

In view of this, telehealth can be a critical component to increase the capacity of health services. There is a need to broaden our focus on fast-growing technologies such as chatbots and the way in which these strategies can contribute to health care, highlighting the importance of implementing such tools. Chatbots in the case screening process can encourage institutions responsible for developing digital health in the country to advance in regulating the topic. Continued research in this area is essential to consolidate chatbots with increasingly greater specificity and sensitivity. Although the development of SB was conditioned by the exceptional nature of the pandemic, the results of this work indicate that there is much to be built and operationalized in the country so that telehealth can effectively occupy the various spaces and further strengthen the Unified Health System (*Sistema Único de Saúde*).

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