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Digital health and Covid-19 in BRICS nations: bibliometric analysis

Saúde digital e covid-19 nos países BRICS: análise bibliométrica

Salud digital y Covid-19 en los países BRICS: análisis bibliométrico

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Abstract

Objective: to analyze the state-of-the-art digital health solutions developed and implemented by BRICS nations for fighting the Covid-19 pandemic. Method: bibliometric analysis based on a scoping review conducted in the Medline/Pubmed, Lilacs, Scopus, and Web of Science databases in August 2022. Results: 430 final records were included, presenting digital solutions in one of the BRICS nations, focusing on Covid-19 surveillance, prevention/control, or clinical management. China and India, along with researchers from these countries, stood out in terms of number of publications. The relevance of artificial intelligence in predicting the pandemic's evolution, guiding governmental measures, and aiding in diagnosis was notable. Conclusion: the trend of Chinese and Indian leadership is confirmed, and collaboration is advocated to leverage digital health in the other nations of the group.

Keywords: COVID-19; Biomedical Technology; Developing Countries

Resumo

Objetivo: analisar o estado da arte quanto às soluções de saúde digital para o enfrentamento da Covid-19 desenvolvidas e implementadas pelos países BRICS. Método: análise bibliométrica a partir da revisão de escopo realizada nas bases de dados *Medline/Pubmed, Lilacs, Scopus* e *Web of Science* em agosto de 2022. Resultados: foram incluídos 430 registros que apresentavam soluções digitais em um dos países BRICS, com foco na vigilância, prevenção/controle, ou manejo clínico da Covid-19. China e Índia e pesquisadores desses países se destacam em número de publicações. Foi relevante o uso da inteligência artificial na previsão da evolução da pandemia, direcionamento de medidas governamentais, e apoio diagnóstico. Conclusão: confirma-se a tendência de liderança chinesa e indiana e defende-se a colaboração para alavancar a saúde digital nos demais países do grupo.

Descritores: COVID-19; Tecnologia Biomédica; Países em Desenvolvimento

Resumen

Objetivo: analizar el estado del arte en cuanto a las soluciones de salud digital para hacer frente a la Covid-19 desarrolladas e implementadas por los países del BRICS. Método: análisis bibliométrico basado en una revisión de alcance realizada en las bases de datos Medline/Pubmed, Lilacs, Scopus y Web of Science en agosto de 2022. Resultados: se incluyeron 430 registros que presentaban soluciones digitales en uno de los países del BRICS, centrándose en la vigilancia, prevención/control o manejo clínico de la Covid-19. China e India, junto con investigadores de estos países, destacaron en términos de número de publicaciones. Fue relevante el uso de inteligencia artificial para prever la evolución de la pandemia, orientar medidas gubernamentales y apoyar el diagnóstico. Conclusión: se confirma la tendencia de liderazgo chino e indio y se aboga por la colaboración para aprovechar la salud digital en los demás países del grupo.

Descriptores: COVID-19; Tecnología Biomédica; Países en Desarrollo

Introduction

In late 2019, the world was alerted to an outbreak of pneumonia caused by a new coronavirus in Wuhan, China. The previously unknown virus required countries to adopt innovative approaches to manage public health and control its health, social, and economic repercussions. As the first epidemic to achieve pandemic status in a virtually connected society, information and communication technologies (ICT) played a prominent role in tackling Covid-19. [1]

Currently named as digital health (DH), the use of ICT in health includes a variety of other terminologies such as electronic health (eHealth), mobile health (mHealth), artificial intelligence (AI), big data, wearable devices, robotics, and the Internet of Things (IoT). [2,3] In recent decades, the use of these and other technologies has proven to be a viable option for reducing inequalities and increasing access to health, also contributing to the higher quality of care provided. [4,5]

Due to its transformative potential, the development of DH represents a strategic path, especially in emerging nations that face challenges in universalizing health, such as Brazil, Russia, India, China, and South Africa (BRICS). Besides significant regional and global influence, this group of nations accounts for more than 40% of the world's population [6] and plays a significant role in collectively addressing health challenges. [7]

With the emergence of the pandemic, countries worldwide mobilized to develop and implement ICT in their national health systems and services. Two BRICS members, China and India, led this ranking among countries with high disease prevalence, behind only the United States. [1] In this context, DH solutions supported information dissemination, surveillance, diagnosis, and monitoring actions, as well as resource management. In terms of technology types, eHealth, along with data analysis, including big data and AI, stands out. [8]

It is noteworthy that the development and implementation of these technologies did not occur uniformly across the globe. More developed regions with well-established DH regulation experienced the positive impact of ICT earlier. [9] Conversely, less developed countries with lower technological maturity level faced difficulties due to weak government policies and insufficient investment in the sector. [10,11]

This observed disparity shows that pre-pandemic DH development influenced how technologies were employed to manage Covid-19. A bibliometric analysis of BRICS publications from 1999 to 2018 highlighted the nations' growing interest in themes such as "medical informatics" and "telemedicine." During this period, China and India were already the group's countries with the highest levels of research on the topic, particularly in mHealth. [12]

The previous context reveals the nations' attitudes towards DH and motivates analyzing how these countries behaved in using technologies against Covid-19. Regarding the pandemic period, as far as we know, there are no reviews analyzing the use of digital solutions for fighting Covid-19 in BRICS from a comparative perspective. Generally, studies focus on only one member of the group and emphasize a specific type of technology. [13-15]

Given the above, this study aims to analyze the state-of-the-art digital health solutions developed and implemented by BRICS nations for fighting the Covid-19 pandemic. By addressing this gap in the literature, the present study will contribute to a better understanding of scientific production on digital health and Covid-19 in BRICS nations during the pandemic, highlighting the focus on different types of technology to encompass the broad scope of DH.

Method

This is a bibliometric analysis that integrates the review entitled "Digital health solutions for fighting Covid-19 in BRICS nations: a scoping review." This review was guided by the methodology proposed by the Joanna Briggs Institute. [16] Therefore, five steps were followed: (1) identifying the research question, (2) identifying relevant studies, (3) study selection, (4) charting the data, and (5) collecting, summarizing and reporting the results. This text is in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) reporting guidelines. [17]

Step 1: Identifying the research question

To formulate the main question, the PCC elements were incorporated: population, concept, and context. [16] The population refers to the BRICS member

nations in 2022 (Brazil, Russia, India, China, and South Africa); the concept is represented by DH solutions; and the context is the Covid-19 pandemic. Therefore, the main question adopted was: "What are the state-of-the-art digital health solutions for surveillance, prevention/control, and clinical management of Covid-19 developed and implemented by BRICS nations?"

Moreover, this review has four specific questions, detailed in the protocol registered on the Open Science Framework platform on October 4, 2022 (https://osf.io/j6h8w/). In this bibliometric analysis, we specifically aim to answer one of them: "Regarding our review topic, how is the scientific field characterized concerning the country, authors and affiliation, source and date of publication, keywords, document type and study method?"

Step 2: Identifying relevant studies

Initially, relevant databases were selected for the search: Medline/Pubmed, Lilacs, Scopus, and Web of Science. To retrieve the most relevant studies, descriptors (MeSH Terms) and synonyms were employed to construct the search string. Table 1 provides, as an example, the terms and the strategy adopted in MEDLINE/PubMed, locating publications up to August 12th, 2022.

Table 1 - Terms and search strategy adopted in MEDLINE/PubMed

Terms and search strategy in MEDLINE/ PubMed on August 12th, 2022, which resulted in 887 records	("artificial intelligence"[MeSH Terms] OR "digital technology"[MeSH Terms] OR "biomedical technology"[MeSH Terms] OR "internet of things"[MeSH Terms] OR "mobile applications"[MeSH Terms] OR "remote consultation"[MeSH Terms] OR "telemedicine"[MeSH Terms] OR "wearable electronic devices"[MeSH Terms] OR "big data"[MeSH Terms] OR "technological innovations"[Text Word] OR "connected health"[Text Word] OR "digital health"[Text Word] OR "ehealth"[Text Word] OR "eletronic health"[Text Word] OR "health care technology"[Text Word] OR "health innovations"[Text Word] OR "health technology"[Text Word] OR "mhealth"[Text Word] OR "mobile health"[Text Word] OR "telecare"[Text Word] OR "teleconsultation"[Text Word] OR "telediagnosis"[Text Word] OR "telehealth"[Text Word] OR "virtual healthcare"[Text Word]) AND ("sars-cov-2"[MeSH Terms] OR "covid-19"[MeSH Terms] OR "2019-ncov"[Text Word] OR "2019 novel coronavirus disease"[Text Word] OR "coronavirus disease 2019"[Text Word] OR "covid 19 pandemic"[Text Word]) AND ("brics"[Text Word] OR "brazil"[Text Word] OR "russia"[Text Word] OR "india"[Text Word] OR "china"[Text Word] OR "south africa"[Text Word])

Step 3: Study selection

After identifying relevant studies, the screening process began. The first step was the removal of duplicates using the online tool EndNote. Subsequently, the

records were transferred to the reference manager Rayann, through which the study selection was conducted. In this stage, the researchers applied the eligibility criteria to determine the inclusion or rejection of the documents, initially examining titles and abstracts and, later, making the final decision upon accessing the full records. The entire process was conducted by two independent reviewers, and disagreements were resolved by a third reviewer, all of whom had a background in health.

The inclusion criteria were: 1) referring to at least one of the BRICS nations, 2) presenting DH solutions (product or service) aimed at people, professionals, managers, and data services, according to the World Health Organization classification, [18] 3) focusing on the surveillance, prevention/control, or clinical management of Covid-19. The exclusion criteria were: 1) not specifying the country, 2) not presenting solutions in one of the following types: eHealth (including mHealth), AI, health big data, IoT, robotics, and wearable devices, 3) lacking sufficient information to describe the solution and characterize its type, focus, and target population.

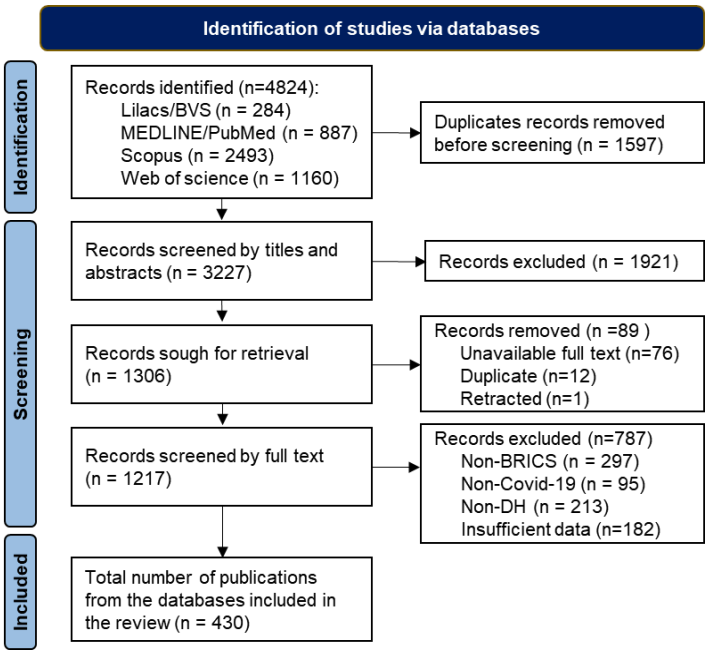
Steps 4 and 5: Charting the data, collating, summarizing and reporting the results

For this bibliometric analysis, general information about the documents (title, authors and affiliation, reference country, source and date of publication, keywords, type of document, and study method) was specifically collected using a spreadsheet. The data were analyzed with the help of R statistical software. To characterize the scientific production, descriptive results were presented through tables, graphs, and figures, complemented by a narrative summary.

Results and Discussion

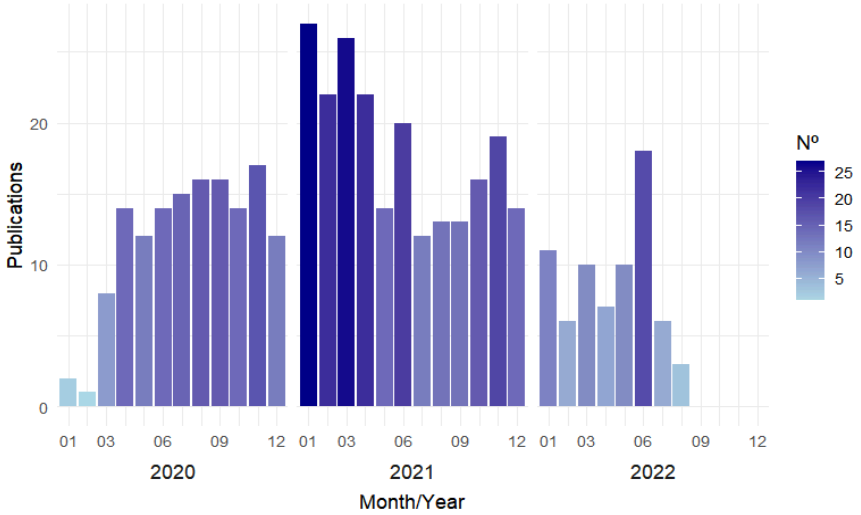
The initial search resulted in 4,824 records from the databases. After the automated removal of duplicates, the screening process was conducted. Initially, titles and abstracts were reviewed, followed by the full texts. Finally, 430 records were included (see PRISMA flowchart in Figure 1).

Figure 1 - PRISMA Flowchart for the identification of records via databases



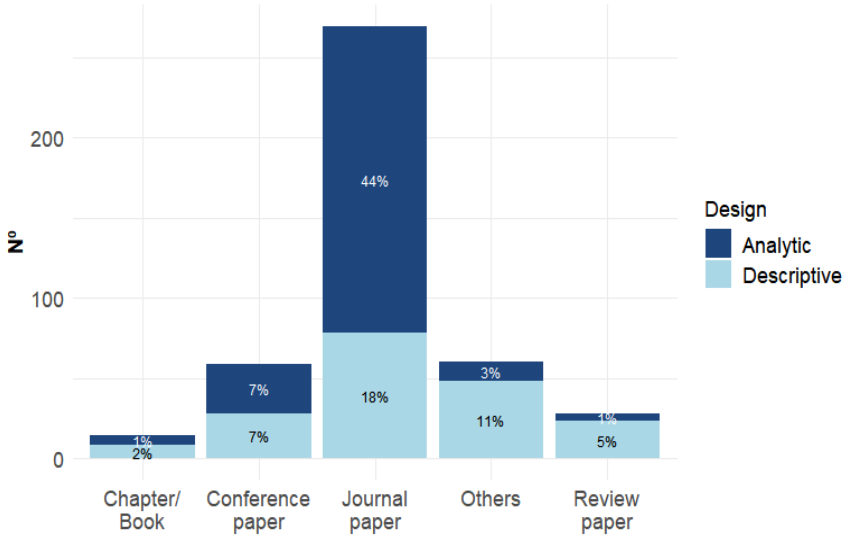
The first cases of Covid-19 emerged at the end of 2019, and according to our results, related publications began to appear as early as the beginning of 2020, consistent with other review studies. [1,8] Graph 1 represents the distribution of publications over the analyzed period, with an emphasis on the year 2021, which had 218 records (51%). It is interesting to note that the number of publications in 2022 is relatively lower compared to the previous year, which can be attributed to the 'normalization' of the epidemic, leading to a decrease in interest in the topic.

Graph 1 - Distribution of records according to the date of publication



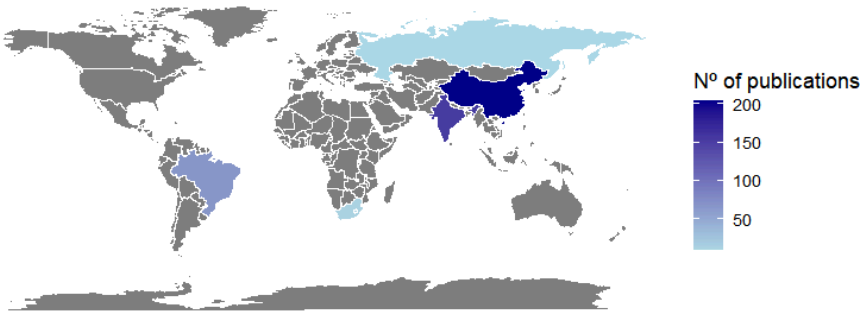
Regarding the sources of publication, the following stand out: IEEE Xplore (39), Springer (17), Scientific Reports (11), and Journal of Medical Internet Research (10), with impact factors of 3.8 and 5.8, respectively, according to the Journal Citation Reports in 2023. Of the 430 publications included in this review, original articles published in scientific journals comprise the largest number, totaling 62%, followed by articles published in conference proceedings (14%). In terms of study design, 56% are analytical. For original articles published in journals or conferences, analytical design exceeds descriptive ones, while for other types, the opposite occurs. Graph 2 illustrates the distribution of studies according to design, by type of publication.

Graph 2 - Distribution of studies according to design, by type of publication



About the spatial distribution of the 430 final studies, Figure 2 highlights in darker tones the nations with the highest number of publications. China was in the lead, being the focus of almost half of the studies (47%). Following are India and Brazil, respectively, in 36% and 16% of the records. South Africa and Russia were behind, together accounting for only 5%. Therefore, it is possible to observe a high scientific production on the topic, especially in China and India, where they have received more attention, as observed prior to the pandemic. [12] Note that some studies address more than one country, hence the total exceeds 100%.

Figure 2 - Distribution of publications by BRICS nation



Similarly, concerning the number of publications, researchers from these two countries rank highest. Table 1 highlights the main authors, each contributing three publications. Among them, four are affiliated with the University of Jammu in India, while the other two are from Chinese universities: Wuhan University and Guangzhou Medical University.

Table 1 - Top authors by number of publications, affiliated institution, and country

Top authors	Nº of publications	Affiliation	Country
Haibo Xu	03	Wuhan University	China
Nanshan Zhong	03	Guangzhou Medical University	China
Kuljeet Singh	03	University of Jammu	India
Sachin Kumar	03	University of Jammu	India
Sourabh Shastri	03	University of Jammu	India
Vibhakar Mansotra	03	University of Jammu	India

The four Indian authors share the same published studies, essentially focusing on the application of AI. The 'LiteCovidNet' model was used for the binary classification of patients (Covid-19 or normal) based on X-ray images, assisting professionals in identifying infection at early stages. [19] Additionally, AI supported managers in understanding epidemic behavior, predicting Covid-19 cases and deaths weeks in advance. [20]

In China, specifically in Wuhan, the integration of AI with other types of technology was proposed. For example, the mobile CT cabin equipped with 5G technology and AI is presented. Besides mobility and flexibility, it provides network connectivity, which facilitates the screening process. Additionally, it incorporates

intelligent software to guide the exam execution and imaging auxiliary diagnosis, ensuring distancing and preventing cross-infection. [21]

At the University of Guangzhou, China, AI was used to predict epidemic peaks. Through the analysis of population migration and Covid-19 datasets, the essential role of containment measures adopted during the annual spring festival in early 2020, which coincided with the outbreak of the disease in the country, was demonstrated. [22] Another study provided an online epidemic prediction system integrated with a big data platform to support monitoring and decision-making in China and other countries. [23] Additionally, the use of robotics was represented by semi-automatic collection of oropharyngeal swabs. [24]

Regarding the total publications, the keyword 'covid-19' was the most cited, appearing 242 times. Synonyms such as 'pandemic' (32), 'coronavirus' (22), and 'sars-cov-2' (20) also stand out. Another prominent group relates to AI, with 'machine learning' mentioned 42 times and 'deep learning' 32 times. Following is the group related to telemedicine and telehealth, mentioned 40 and 11 times, respectively. The prominence of AI contributes to the comprehensive understanding of DH, beyond eHealth, as observed previously. [12]

Conclusion

Following the pre-pandemic trend, the present analysis confirms the prominent position of China and India, as well as researchers from these respective countries, in the development and implementation of DH solutions. Moreover, it reveals the peak in publications that occurred in the year 2021. The role of AI in predicting the evolution of the pandemic and guiding governmental measures is evident, as well as its use for imaging auxiliary diagnosis. Finally, it is argued that collaboration between nations can significantly benefit Brazil, South Africa, and Russia in leveraging DH in their realities, whether in managing transmissible infections like Covid-19 or in other public health scenarios.

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