https://doi.org/10.52645/MJHS.2024.4.07

UDC: 004.89:616.98:578.834.1

REVIEW ARTICLE

The use of artificial intelligence in coordinating COVID-19 prevention measures at the territorial level

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ABSTRACT

Introduction. The Coronavirus Disease 2019 (COVID-19) pandemic presented a significant challenge for global society, leaving a profound impact across the board. Although COVID-19 cases are still reported, they are no longer at previously high levels. One of the key tools in combating the pandemic was Artificial Intelligence (AI), which played a vital and advancing role throughout the pandemic. AI contributed significantly to the gradual reduction in COVID-19 cases. Effective coordination of the pandemic response, timely management, and the integration of AI into the medical system were crucial factors in achieving success.

Materials and methods. A comprehensive literature review focusing on publications from 2019 to 2024 was conducted using Google Scholar, PubMed, and Science Direct. Twenty publications were selected for their relevance to AI in the COVID-19 response, based on criteria such as accessibility, language, and publication type.

Result. The review focused on the significant role of AI during the COVID-19 pandemic, highlighting its impact on public health and medical systems. In countries like the USA, China, and South Korea, AI was crucial in tracking the virus, predicting infection trends, and optimizing resource allocation. AI models helped identify outbreak hotspots and enabled targeted interventions, while natural language processing efficiently managed extensive data. Conversely, in countries such as Brazil, Mexico, India, and many African nations, AI was used less extensively due to limitations in technological infrastructure and data availability. The pandemic drove a closer integration of AI with medical services, streamlining processes and saving time. AI also enhanced laboratory efficiency and supported the development of new medications and vaccines. Despite its potential, the uneven adoption highlighted disparities in technological readiness and resource allocation during the crisis.

Conclusions. The COVID-19 pandemic has once again highlighted that we live in an era of advanced technology and underscores the need for closer integration between healthcare systems and artificial intelligence. This integration allows for more effective and timely management of current and future health challenges. AI contributes to a more rapid and high-quality response to emergencies, providing innovative solutions for both existing and upcoming challenges.

Keywords. Artificial Intelligence, COVID-19 response, pandemic management, machine learning.

Cite this article: Demișcan D, Lozan O. The use of artificial intelligence in coordinating COVID-19 prevention measures at the territorial level. Mold J Health Sci. 2024;11(4):44-48. https://doi.org/10.52645/MJHS.2024.4.07.

Manuscript received: 01.08.2024

Accepted for publication: 15.11.2024

Published: 10.12.2024

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Key messages

What is not yet known on the issue addressed in the submitted manuscript

AI's role in pandemic response is acknowledged; however, there is limited data on its effectiveness across various countries and its capacity to address technological disparities. This lack of data makes it unclear how AI's benefits can be applied consistently in regions with different levels of technological infrastructure.

The research hypothesis

AI significantly improves pandemic management by optimizing resource allocation, predicting infection trends, and enhancing diag-

nostics, though its effectiveness is influenced by regional technological capabilities and data availability.

The novelty added by the manuscript to the already published scientific literature

Research results underscore the advancement of AI technologies during the pandemic and their potential for future public health crises, addressing gaps in understanding AI's role in pandemic preparedness and response.

Introduction

Throughout the 21st century, numerous breakthroughs in the field of Artificial Intelligence (AI) have significantly improved our lives. With the onset of Coronavirus Disease 2019 (COVID-19), which has caused approximately 6.9 million deaths globally since its emergence in December 2019, according to the World Health Organization (WHO) [1], these technological advancements have become indispensable tools for managing and coordinating the pandemic response. COVID-19, caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has had profound impacts on public health, economies, and daily life worldwide [2].

The rapid spread of COVID-19 necessitated innovative solutions for monitoring, predicting, and controlling the outbreak. AI technologies have been pivotal in predicting infection trends, optimizing resource allocation, facilitating drug discovery, and enhancing diagnostic capabilities. For instance, machine learning algorithms have been used to forecast outbreak hotspots, while natural language processing tools have managed the overwhelming amount of data generated during the pandemic [3].

The integration of AI into the COVID-19 response has provided critical support across many fields, highlighting its potential to enhance pandemic management and prepare for future public health emergencies. Despite various challenges and controversies surrounding AI use, recent literature demonstrates the effectiveness of different AI systems in managing COVID-19. For example, these algorithms can assist doctors in designing personalized treatment plans, leading to faster patient recovery. Furthermore, AI's applications extend beyond COVID-19 management, offering improvements in handling other diseases, including non-communicable ones, and enhancing the accuracy, efficiency, and speed of medical systems [4].

This study explores the effective integration of AI into the coordination and leadership of medical systems, highlighting the advancements achieved during the COVID-19 pandemic. It illustrates how AI contributes to a more efficient medical system, not only in the context of COVID-19 but also in preparing for future medical crises.

Materials and methods

This study conducted a thorough review of existing literature using a range of key resources. Initially, Google Scholar was utilized, followed by academic databases such as PubMed and ScienceDirect (Elsevier), which were pivotal for the search.

The search strategy employed keywords including "Artificial Intelligence," "COVID-19 response," "Pandemic management," and "Machine learning". Only publications from the years 2019 to 2024 were considered, resulting in approximately 297 articles.

Articles that were not freely accessible, unavailable through the Scientific Medical Library of the *Nicolae Testemițanu* State University of Medicine and Pharmacy (SUMPh), duplicates, or inaccessible in Moldova were excluded. The remaining articles were then refined using advanced search filters to focus exclusively on English-language publications with full text, systematic reviews, and meta-analyses. This process ensured the inclusion of highly relevant and high-quality sources.

From the filtered articles, 20 studies were selected based on their relevance to the application of artificial intelligence in coordinating the COVID-19 response. These studies were meticulously analyzed to evaluate their contributions and insights into how AI technologies were employed during the pandemic.

Result

AI use in COVID-19 management. During the COVID-19 pandemic, countries like the United States of America (USA), China, and South Korea extensively used AI for tracking the virus, predicting infection trends, optimizing resources, and enhancing diagnostics. AI models forecasted outbreak hotspots, enabling targeted interventions, while natural language processing managed vast amounts of data, improving information extraction. Conversely, countries such as Brazil, Mexico, India, and many African nations used AI to a lesser extent or not at all. This disparity is due to differences in technological infrastructure, data availability, and governmental support [5, 6].

Initial limitations of AI. While AI provided significant support, it is important to note that it was not fully prepared for such a global health crisis initially. Until the end of 2020, AI was not fully utilized for tracking and predicting COVID-19 cases due to the lack of large amounts of historical data necessary for training AI models. Consequently, early studies published shortly after the global COVID-19 outbreak reported results of limited relevance, primarily due to insufficient data for adequately training AI techniques and the poor quality of the available data [7].

Preparation for future pandemics. It is surprising that the world had already received a stark warning about the need for better pandemic preparedness. In 2015, in the wake of the Ebola epidemic, Bill Gates, through the Gates Foundation, emphasized the critical need for global warning and response mechanisms to more effectively prepare for future pandemics. However, this call to action went

largely unheeded. It seems that the Ebola crisis, despite its severity, was not enough to galvanize global action. The world required an even more catastrophic event–the COVID-19 pandemic–to fully grasp the importance of AI and advanced technological preparedness in managing global health crises [8].

AI evolution and impact. The rapid spread of COVID-19 meant that sufficient data and extensive labeled datasets were initially unavailable. Training models on unrepresentative datasets led to poor and misleading results, as the fast-evolving nature of the problem made it difficult to make informed model and parameter selections. This significantly affected the performance and accuracy of prediction models. However, today, the availability of COVID-19 surveillance data, such as daily and cumulative numbers of cases, deaths, and recoveries, is no longer an issue. In fact, years after the COVID-19 outbreak, multiple collections of detailed data are available from different sources, such as those gathered by the Johns Hopkins University Coronavirus Resource Center. These data are essential for improving the accuracy and performance of AI models, highlighting the crucial importance of AI in pandemic management [7].

Machine Learning (ML), a subfield of AI, was extensively used during the COVID-19 pandemic. ML involves developing algorithms that allow computers to learn and make predictions or decisions based on data. Initially, existing AI-based facial recognition software and cameras were used to identify individuals who were not adhering to self-isolation or quarantine guidelines. Over time, these technologies evolved, leading to the creation of new systems capable of independently identifying individuals wearing masks versus those who were not and determining whether social distancing guidelines of one meter were being followed. Similar computer vision systems were developed for hospitals to monitor interactions with bedridden COVID-19 patients, document the healthcare workers who entered the rooms, and track the duration and proximity of these interactions [9].

AI was utilized on a broad scale at various levels and proved valuable for decision makers. ML was employed to help decision-makers understand adherence to non-pharmaceutical interventions in near real-time. While AI usage was prevalent in developed and some developing countries, the high costs associated with these systems were not necessarily a barrier. Some system creators allowed the release of the complete code stack and system design, enabling others to quickly replicate and improve the systems. This approach was particularly beneficial in resource-limited settings and low- to middle-income countries. These opportunities were available from the early stages of the pandemic, indicating that the primary reasons for not using AI were not necessarily due to prohibitive costs but rather other regional or territorial factors [9, 10].

Challenges and solutions. Despite AI's potential to protect vulnerable communities in low-income countries by providing timely access to care, addressing structural and systemic barriers to AI implementation is a necessary step in these settings. This is especially critical as global efforts are made to prevent the reemergence of COVID-19 and its variants [11, 12].

As mentioned, AI played a leading role in coordinating COVID-19 responses; however, the previously discussed systems alone are insufficient for successful pandemic management. While AI automated tasks that would have been impossible to manage manually in a short time, it is important to recognize that AI systems in healthcare were implemented to support decision-making processes. There remains a gap in developing data analysis and AI methods for better healthcare supply chain management. These supply chains were disrupted at an incredible speed during the pandemic, creating numerous bottlenecks. It is essential to address these issues when operating in rapidly changing environments. This is particularly true for inventory planning in healthcare supply chains, which significantly impacted healthcare services during the pandemic [13, 14].

An exemplary case of effective management is represented by Swedish Health Services, a healthcare organization in the USA, which developed a platform for healthcare workers to report real-time data on COVID-19 patient volumes, personal protective equipment, staffing, ventilator usage, and other resource information. This data was shared among its hospitals to monitor unit status, allocate healthcare resources, and increase hospital bed capacity [15, 16].

In the fight against the COVID-19 pandemic, the rapid development of vaccines has been astonishing, due in part to AI. Numerous research laboratories continuously worked to create vaccines and medications against COVID-19 during the pandemic. AI was employed to evaluate existing drug compounds and determine their efficacy in combating the coronavirus. Countries such as South Korea and the United States utilized AI-based systems to discover repurposed drugs with potential for treating COVID-19 [17, 18].

Although the pandemic has caused global stagnation, it has paradoxically accelerated modernization and advancements in healthcare. Future plans include the enhanced automation of medical systems, primarily aimed at protecting and facilitating human work. For example, several types of robots have been developed to meet specific needs. Cylindrical robots are designed to move through hospital corridors, assisting healthcare workers by checking the temperature, blood pressure, and oxygen saturation of COVID-19 patients on ventilators. Another type of robot, designed to move vertically, disinfects hospital interiors using UV rays. Some remote-controlled drones transport infectious samples to external laboratories for testing. Currently, research laboratories and medical companies are developing remote-controlled robots capable of collecting blood samples and oral swabs for COVID-19 testing without human contact. Additionally, in various hospitals and nursing homes, robots are used to interact with patients,

maintaining a safe distance. Although a range of robots is already in use, future plans include expanding automation in the medical system, which is expected to play a crucial role in pandemic coordination [19, 20].

Discussion

The COVID-19 pandemic showcased the transformative potential of AI in enhancing public health management. This study highlights AI's crucial role in predicting infection trends, optimizing healthcare resource allocation, and supporting real-time decision-making. By integrating AI technologies, public health systems were able to respond more swiftly, improve patient outcomes, and reduce strain on healthcare resources.

An additional example of AI's application is the UK Government's Bluetooth-based app, which alerted the non-infected population about potential exposure to high-risk areas or COVID-positive individuals. This tool demonstrated AI's value in infection prevention, but it also revealed challenges, such as data privacy concerns and the need for improved technological infrastructure in certain regions [17].

Ultimately, the study underscores the importance of expanding AI's use in future health crises, addressing gaps in technology access, and ensuring ethical governance for broader and more equitable implementation.

Conclusions

The extensive use of AI during the COVID-19 pandemic significantly facilitated more efficient and rapid coordination of the response. AI technology helped avoid mass errors in database management and prevented additional cases of illness among healthcare workers. The implementation of AI proved to be a valuable asset, particularly by enabling robust management of the pandemic and preventing larger-scale crises.

Competing interests

None declared.

Authors' contributions

DD contributed significantly to the conception and design of the review, the analysis and interpretation of the literature, as well as drafting and revising the manuscript. OL actively participated in the literature search, critically reviewed the scientific content, and provided essential contributions to the final conclusions.

Acknowledgements and funding

No external funding.

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