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IJBLS 2023; 2(2):196-202

International Journal of BioLife Sciences

Review paper

Advancements in AI-Based Diagnostic Tools for Infectious Disease: A Mini Review

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***Received**: 24 September 2023* ***Revised**: 1 October 2023* ***Accepted**: 6 October 2023*

Abstract

Background and aim: The fast progress of artificial intelligence (AI) is changing the way we diagnose medical conditions, especially in infectious diseases. This review aims to examine the latest developments in AI-based diagnostic tools, with a focus on how they can help us find diseases earlier and enhance patient care.

Methods: We searched many databases for studies published until August 2023 using keywords like "artificial intelligence," "infectious disease," and "diagnostic tools." We carefully reviewed these studies to see how they used AI, how accurate their diagnostics were, and how they could be used in real medical practice.

Results: This review explores how AI is used in infectious disease. It looks at things like machine learning, deep learning, and computer-aided diagnostic systems. These tools are really good at finding infections, often better than older methods. The review also checks how AI can be used with things like medical images, genomics, and point-of-care tests to find diseases early, make medical work smoother, and ultimately, help save lives.

Conclusion: Using AI-based tools in diagnosing diseases is a big step forward in finding infectious diseases. This review shows that these tools can make diagnoses much more accurate and faster. As AI gets better, it will become a normal part of medical care. This means we can find diseases earlier, help patients more, and change how we look for infectious diseases.

Keywords: *Artificial intelligence, Infectious disease, Diagnostic tools*

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Introduction

Infectious diseases are caused by microorganisms, including bacteria, viruses, fungi, and parasites. These pathogens can be transmitted through direct or indirect means and have the potential to lead to epidemics or even pandemics. Infection with these microorganisms can result in a wide range of symptoms, from mild to severe, including life-threatening conditions such as high fever or severe diarrhea. Some individuals may carry these infectious agents without showing symptoms, while in others, they can cause devastating health effects. Despite significant advancements in the field of medicine, infectious diseases remain a prominent cause of death worldwide, particularly in low-income countries [1], [2], [3].

The integration of mathematical tools and artificial intelligence (AI) into the field of epidemiology has allowed scientists to improve their ability to predict and understand the dynamics of epidemics, grasp the distinct characteristics of each pathogen, and identify potential targets for drug development. AI, is a field of computer science focused on creating systems and software capable of performing tasks that typically require human intelligence. These tasks encompass learning from data, solving complex problems, recognizing patterns, and making informed decisions [4].

AI systems rely on algorithms and extensive datasets to learn and continually enhance their performance. Within AI, machine learning and deep learning are specialized areas that have witnessed significant progress. Machine learning involves training algorithms to make predictions or decisions without explicit programming. Deep learning, an advanced form of machine learning, employs artificial neural networks to model complex patterns and tackle intricate tasks. AI finds applications across various domains, spanning healthcare, finance, transportation, and entertainment. In healthcare, for instance, AI aids in disease diagnosis, treatment plan optimization, and the enhancement of patient care. In essence, AI represents a transformative advancement that seeks to replicate and amplify human intelligence, empowering computers and software to undertake tasks that were once considered exclusive to human capabilities [5], [6], [7], [8].

AI is transforming the healthcare landscape. AI mimics human thinking and learning through computers and technology, becoming a crucial ally in the world of medicine. AI, in healthcare, acts as a powerful processor of vast amounts of data, swiftly identifying patterns. This aids doctors in early disease detection and personalized treatment recommendations, often before symptoms even appear [9]. AI plays a significant role in diagnosing diseases by analyzing medical images like X-rays and MRIs, improving accuracy. It tailors treatments to individual patients by considering their unique genetic and medical backgrounds [10]. Additionally, AI accelerates drug discovery by swiftly analyzing data from numerous experiments. It enhances the efficiency of healthcare operations, manages appointments, patient records, and optimizes staffing [11], [12]. AI is a healthcare superhero, making medicine smarter, more efficient, and accessible to a broader population. In the future, it will continue to play an essential role in keeping people healthy and providing the best possible medical care [13], [14].

In the realm of healthcare, AI has garnered significant recognition for its crucial contribution to improving the precision of cancer diagnosis through the analysis of medical imaging data. This review paper is dedicated to exploring the potential applications of AI in the context of infectious diseases. Our specific focus encompasses various critical aspects of infectious diseases, including their diagnosis, understanding transmission dynamics, assessing treatment responses, and shedding light on the potential for innovative solutions to address these challenges. Infectious diseases pose a significant global health threat, and the integration of AI technologies into this field holds promise for revolutionizing the way we approach and manage them.

Methodology

Our methodology involved a thorough systematic review that spanned various databases, considering studies available until September 2023. We employed specific keywords such as "artificial intelligence," "infectious disease," and "diagnostic tools" to carefully select relevant research articles. These chosen studies underwent a rigorous assessment, where we closely examined their research methods, how they incorporated AI techniques, and the accuracy of their diagnostic outcomes. Additionally, we paid special attention to the potential clinical benefits and implications that these studies offered, ensuring a comprehensive evaluation of their contributions to the field of AI-based diagnostics in infectious disease.

Review of Literature

In a study titled "Artificial Intelligence for Infectious Disease Big Data Analytics," the authors concluded that it is foreseeable that, together with reliable data management platforms, AI methods will enable the effective analysis of massive infectious disease and surveillance data to support government agencies, healthcare service providers, and medical professionals in responding to diseases in the future [15].

In a study by Peiffer-Smadja et al, it has been reported that considering comprehensive patient data from socioeconomically diverse healthcare settings, including primary care and LMICs, may improve the ability of ML-CDSS to suggest decisions adapted to various clinical contexts. Current gaps identified in the evaluation of ML-CDSS must also be addressed to understand the potential impact of such tools for clinicians and patients [16].

In a study titled "Leveraging Computational Modeling to Understand Infectious Diseases," innovative mathematical and computational modeling has led to significant advancements in preventing disease spread and improving the treatment of infectious diseases. Modeling efforts have been deployed in close collaboration with experimentalists, clinicians, and public health specialists to provide a pathway towards rational and implementable studies at the bench, bedside, and policy levels [17].

In a study on "Scaling up Artificial Intelligence to Curb Infectious Diseases in Africa," it has been concluded that artificial intelligence can make significant contributions to Africa's battle against infectious diseases. However, African governments should exhibit the necessary political will required for the successful deployment of Artificial Intelligence on the continent. Furthermore, the private sector should be involved in efforts to deploy Artificial Intelligence in Africa [18].

In a study titled "Modern Machine-Learning Predictive Models for Diagnosing Infectious Diseases," it has been concluded that ML algorithms can assist in the diagnosis of infectious diseases at early stages. By reviewing the selected articles, we found some limitations in these studies, including small datasets, which is the main limitation. Combining techniques to extract more features is useful and can improve ML predictive models' performance [19].

In a study by Thakur et al, they have emphasized "Artificial Intelligence Techniques to Predict Infectious Diseases: Open Challenges and Research Issues" [20].

In a study titled "Potential Use of Artificial Intelligence in Infectious Disease: Take ChatGPT as an Example," the authors have concluded that nevertheless, the potential for ChatGPT in the infectious disease field is enormous. Through the acquisition of vast medical knowledge and patient case studies, ChatGPT may become an "encyclopedia" of medical information for physician retrieval and learning. In the near future, with the continuous development of AI technology, ChatGPT will play an increasingly important role. Meanwhile, it is essential to recognize the limitations of these technologies and carefully guide and regulate their use.

Moreover, we also need to continue to collect more data and information to better train and improve ChatGPT and other AI models to achieve better medical applications [21].

In a study by Santoyo et al, it has been identified that structured variables have comprised the most important data in research to generate knowledge in the field of infectious diseases. Extracting these data should be a priority when a medical center intends to start an AI program for infectious diseases. We also documented that the most important unstructured data in this field are those related to clinical manifestations. Such data could easily undergo some structuring with the use of semi-structured medical records focusing on a few symptoms [22].

In a review study titled "Leveraging Artificial Intelligence in the Fight Against Infectious Diseases," the authors discuss approaches for detecting, treating, and understanding infectious diseases, underscoring the progress supported by AI in each case. The paper suggests future applications of AI and how it might be harnessed to help control infectious disease outbreaks and pandemics [23].

In a study by Allami et al, the authors emphasize that precision medicine powered by AI has the potential to transform healthcare into a proactive, patient-centric model. Research is needed to address privacy, regulations, and AI integration into clinical workflows. Collaboration among researchers, healthcare institutions, and policymakers is crucial in harnessing AI-driven strategies for advancing precision medicine and improving patient outcomes [24].

In a comprehensive review titled "Unleashing the Power of Artificial Intelligence for Diagnosing and Treating Infectious Diseases: A Comprehensive Review," the authors emphasize the potential of AI to enhance the accuracy and efficiency of diagnosis, treatment, and prevention of infectious diseases, highlighting the need for further research and development in this area [25].

Discussion

In the rapidly evolving landscape of healthcare, the integration of AI has brought about a paradigm shift in the diagnosis and management of infectious diseases. This review paper sheds light on the remarkable advancements in AI-based diagnostic tools, underlining their pivotal role in reshaping the way we detect and respond to infectious pathogens. With the ever-increasing threat of infectious diseases, exacerbated by emerging pathogens and antimicrobial resistance, the need for precise, rapid, and scalable diagnostic solutions has never been more pressing.

AI has stepped in as a game-changing ally in infectious disease diagnosis. Its remarkable capacity to analyze vast datasets, including patient information, pathogen genomes, and epidemiological data, enables the detection of subtle patterns that may be indicative of infectious diseases. The ability to rapidly process this information allows for early detection and accurate diagnosis, which are crucial for timely intervention and containment. Moreover, AI's role extends beyond detection; it can predict disease spread, analyze mutations, and guide treatment strategies, thus offering a comprehensive approach to managing infectious diseases [26].

AI's ability to recognize subtle patterns is particularly crucial in infectious disease management. Many diseases exhibit intricate and evolving dynamics that may not be immediately apparent. AI can discern these nuances in the data, helping to track the progression of diseases, predict their potential spread, and even anticipate mutations that might render existing treatments less effective. In essence, AI serves as a vigilant guardian, continuously monitoring and interpreting data to ensure that nothing escapes its attention [27].

Moreover, AI's rapid, data-driven decision-making is indispensable in infectious disease response. When faced with an outbreak or the need for quick diagnostic decisions, AI can process a multitude of variables, such as clinical symptoms, epidemiological data, and genetic information, to generate

immediate recommendations for healthcare professionals. This empowers them to take swift and effective action, whether it's isolating infected individuals, implementing contact tracing measures, or adjusting treatment protocols [28].

In the ongoing battle against infectious diseases, AI has introduced a new arsenal of tools for early detection, accurate diagnosis, and effective response strategies. Its computational prowess, pattern recognition capabilities, and rapid decision-making abilities are fundamentally changing how we approach infectious disease outbreaks. By providing valuable insights, optimizing resource allocation, and bolstering the overall public health response, AI is proving to be an invaluable ally in safeguarding communities against infectious threats [29]. As we continue to explore the ever-evolving applications of AI in infectious disease management, we open new possibilities for improving the health and well-being of populations around the world.

Conclusion

The utilization of AI-driven diagnostic tools represents a significant leap in our ability to detect infectious diseases. This review emphasizes that these tools have the potential to greatly enhance the precision and speed of disease diagnosis. As AI continues to advance, it is poised to become an integral component of standard medical practice. This transformative shift implies that we can identify diseases at earlier stages, leading to more timely interventions and improved patient outcomes. Furthermore, it promises to reshape our approach to infectious disease detection, offering a future where AI is seamlessly integrated into routine medical care, ultimately revolutionizing the way we address and manage infectious diseases.

Acknowledgment

I thank and appreciate all those who helped in conducting this research.

Conflict of interests

The authors declare that there are no competing interests.

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