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The Role of Artificial Intelligence in the Control and Prevention of Infectious Diseases

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Abstract

Artificial intelligence (AI) is being used more and more in a wide range of industries, including healthcare, to improve operations by examining pertinent data. The detection and treatment of infectious diseases is one area where AI is extremely helpful. To uncover trends and create predictions concerning the transmission and treatment of infectious diseases, massive amounts of data can be analyzed using AI techniques like machine learning and deep learning. These techniques can also be used to forecast the effectiveness of a vaccine and study the protein structures of viruses. AI may also be used to swiftly examine data and make choices regarding how to effectively deploy resources to fight infectious diseases. In the face of pandemics like the COVID-19 virus, it is especially crucial to be able to promptly and precisely assess data. The effective mobilization of resources and precise evaluation and forecasting of viral epidemics made possible by the application of AI in healthcare can also aid in the improvement of disease management. However, there are challenges associated with incorporating AI into infectious disease prevention due to the inherent complexity of infectious diseases and the lack of knowledge about their origins. In conclusion, artificial intelligence (AI) has the potential to be a game-changer in the fight against infectious diseases by enabling scientists to review, analyze, and decide on the issues raised by infectious data, thereby enhancing public health and saving lives.

Keywords: Artificial intelligence; control; prevention; infection; infectious diseases.

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1. Introduction

Artificial Intelligence (AI) is permeating every aspect of people's daily lives, including computer-aided mammography cancer diagnosis, voice recognition on smart speakers, such as Amazon's 'Alexa', discovering new music through streaming services, Spotify that introduce users to new artists, and finding new music. AI is a notion that was first introduced in 1956 and entails 'intelligent agents' or machines that perform to enhance processes by analyzing the specific relevant environment (Barh et al., 2020). Specifically, machine learning is a branch of mathematics that AI uses to iteratively learn patterns within training data, and when these patterns are discovered in new data, the AI interprets this into a form of judgment; for example, cancer is not cancer. Consequently, it is the intelligence displayed by machines that imitates and enhances human intelligence (Tran et al., 2021).

At present, the areas of business, society, and healthcare all depend on AI to keep a delicate balance between the facets of patient care, operational procedures, and pharmaceutical companies. AI gathers data, analyses it, and learns from it to achieve desired results, which also translates into directing disease prevention processes (Gouglas et al., 2018). Recent developments in the branch of artificial intelligence known as "deep learning" have significantly increased accuracy by utilizing novel learning methods, specialized hardware, and considerably larger datasets to find more complex and subtle patterns in the data (Barh et al., 2020). To protect millions of people from various diseases, especially infectious diseases that continue to put a strain on public health resources, AI must be made a mandatory instrument to be integrated into healthcare systems. This will enable the analysis of a wealth of information in a substantially shorter amount of time (Correa et al., 2018).

The health and economics of the global population are significantly harmed by infectious diseases. Consequently, it is critical to ensure that the healthcare system is equipped to handle any pandemic dangers. For instance, the development of an effective vaccine against the worldwide COVID-19 virus was aided by the use of digital technology, including artificial intelligent AI (Arora et al., 2020). AI methods, such as machine learning and deep learning, can explain the protein structures of viruses and forecast how well a vaccination will work to make antibodies that the body can use to combat those. Artificial neural networks (ANN) and machine learning models can be trained on a variety of big samples of the impacted cells' structured and unstructured data to forecast the most effective way to eradicate the virus (Arora et al., 2020). In general, however, the complexity of infectious diseases makes it difficult to both prioritize available resources and political will to engage in preventive and preparedness, both of which can be aided by applying AI to combat infectious diseases. AI models may also be used to look for hidden patterns in large quantities of data, which will improve scientists' ability to swiftly interpret information, speeding up the completion of hard tasks like categorization and prediction (Barh et al., 2020).

The fact that the majority of premature deaths and disabilities globally throughout the 20th century were caused by infectious diseases, warrants major attention to address this issue. Beginning at the start of the 20th Century, there was a Spanish flu outbreak, where 500 million people (one-third of the world's population) are thought to have been infected and experienced symptoms during the 1918–19 pandemic (Barh et al., 2020). Among all influenza pandemics, this one was among the deadliest; at least 50 million people are thought to have perished as a result of the virus. What is more, as nearly all cases of influenza have been brought on by mutated variations of the 1918 virus, the effects of this pandemic were not limited to the first quarter of the 20th Century (Taubenberger & Morens, 2006).

The health of the world’s population is seriously threatened by infectious diseases. According to recent flu outbreaks, rising population density and mobility are key factors in the proliferation of newly developing infectious illnesses, which have the potential to become pandemics (Bloom & Cadarette, 2019). Crowding individuals in close quarters and forming ties with sick patients may have further enhanced the risk of a disease spreading (Surya, 2018). Regional variations in population density, demography, ecosystems, and behavioral patterns have an impact on the pathogen's reproductive potential and disease transmission rates. As a result, it is crucial to research cutting-edge techniques, like AI, to help and support scientists as they evaluate, analyze, and make decisions on the problems of infectious data (Keshavamurthy et al., 2022).

2. Findings

Public health is constantly threatened by infectious diseases. Response programs require proactive disease management initiatives; however, these programs are frequently constrained by dispersed data sets and inadequate assessments. Some elements that have an impact on the infection mechanisms include incomplete data, poor information processing, a lack of comprehension of the causal components, a significant misunderstanding of the infection system, and a lack of intelligence in effective action (Rawson et al., 2022). Effective disease-management practices enable accurate evaluation and forecasting of viral epidemics. The efficient mobilization of pharmaceutical, human, and medical resources is dependent on timely evaluation, which is often limited due to the wealth of data available for analysis that requires thousands of hours of assessment (Wong et al., 2019). Additionally, AI is crucial when determining the regions where outbreaks are most likely to occur, taking into account data on the history of the infections, endemic strains, outside causes, people's dwellings, and cultures, whilst local health infrastructures may also be crucial.

In addition, infectious diseases are brought on by microorganisms such as bacteria, viruses, fungi, or parasites (He et al., 2021). These infections can result in epidemics or even pandemics and can spread directly or indirectly. Following infections may result in minor to severe symptoms, such as diarrhea or a potentially dangerous fever. Moreover, even though some people with infectious diseases may not have any symptoms, others may suffer terrible consequences, despite medical advancements, infectious diseases continue to be a primary cause of death worldwide, particularly in developing nations (He et al., 2021). With the introduction of mathematical tools, researchers are now better able to anticipate epidemics, comprehend the unique characteristics of each infection, and pinpoint possible therapeutic targets.

Numerous dynamic factors must be considered to make educated decisions on the prevention and treatment of infections, necessitating accuracy and speedy data processing (Surya, 2018). This includes considering the elements of the organism, host, and medication within the context of the local disease epidemiology and potential long-term side effects of anti-infective therapies, such as the evolution of antibiotic resistance (Barh et al., 2020). However, due to the diversity of clinical presentations brought on by the same virus, there is frequently a dearth of data to support real-time decision-making. Individual patient-specific decisions are, therefore, made based on the patient’s unique circumstances and the data that is currently available (Barh et al., 2020).

During the 1918 flu pandemic (Spanish flu) that occurred during World War I, the virus spread due to proximity, poor cleanliness, and unusually large amounts of mass movement (troops and populace), despite the distance, even the United States of America (USA) reported more than 600,000 deaths within its border (Barh et al., 2020). Many of the warring countries, though, failed to ‘communicate’ the number of influenza-related deaths to maintain public morale, this was purposefully kept quiet. While this may make sense from a military perspective, it has devastating repercussions, as the virus would spread in additional waves (Taubenberger & Morens, 2006). Viruses were not yet understood at the time, and there were only a few diagnostic, preventative, and therapeutic options. As a result, patients would experience the influenza virus itself (flu disease), as well as its effects, which include bacterial lung infections (pneumonia) in vulnerable persons (He et al., 2021). This underlined how miscommunication and improper use of pandemic data could result in the loss of millions of lives (Taubenberger & Morens, 2006). Since that time, developments have been made to track influenza A pandemics. In particular, the Global Influenza Surveillance and Response System (GISRS) of the World Health Organization (WHO) has been keeping track of the development of influenza viruses since 1952. Additionally, this organization acts as a worldwide warning system for viruses with the potential to spread globally, as was shown in

1918 (WHO, 2022).

AI can dramatically improve the world's healthcare system by being a key component of medication research, clinical diagnostics, and epidemic forecasting. The world's communities can be better prepared for disease outbreak identification, surveillance, and containment by investing in healthcare technologies with a focus on the most vulnerable population groups (Smith & Kirby, 2020). The volume of information gathered to monitor infectious diseases has increased dramatically, mandating the utilization of AI to quickly review and analyze big data to make critical public health decisions (Kartono et al., 2021). To stop the spread of the disease, data and analytics are now valuable for tracking and predicting disease trajectories through AI-enabled applications (Chang et al., 2021). Making smarter decisions during the entire outbreak is also made possible by machine learning's capacity to evaluate vast amounts of data and deliver insight, which can inform an improved understanding of illness (Wu et al., 2022). AI has also dramatically improved the world's healthcare system by being a key component of medication research, clinical diagnostics, and epidemic forecasting (Rawson et al., 2022).

To make informed decisions on the treatment of infection, many dynamic elements must be taken into account. This includes taking into account the components of the organism, host, and drug in the context of the local disease epidemiology and potential long-term effects of anti-infective treatment, such as the emergence of antibiotic resistance (Tran et al., 2021). Due to the diversity of clinical presentations brought on by the same virus, there is frequently a dearth of data to support real-time decision-making. Individual patient-specific decisions are, therefore, devised based on the patient's unique circumstances and the data that is currently available (Chang et al., 2021).

In the current period of technological innovation, AI models are frequently used to analyze huge amounts of data from a variety of infectious disease sources, including social media platforms, internet search queries, outbreak investigation reports, sentinel reporting systems, genomic databases, outbreak investigation reports, vaccine reports, and human dynamics information (Keshavamurthy et al., 2022). The massive inflow of data, the integration of that data under master data management, and knowledge extraction able AI applications to reveal latent tendencies (Rawson et al., 2022). Additionally, AI is assisting with pandemic modeling and simulations of disease propagation information, allowing decision-makers in healthcare policy to make informed decisions (Wu et al., 2022).

A large variety of AI/machine learning models have been created that attempt to anticipate the occurrence of an event in the future, often known as ‘forecasting’. The risk of colonization/infection with a multidrug-resistant pathogen (MDR) and central-line associated bloodstream infections (CLABSI) are only a few instances for which prediction models have been constructed using AI (Wu et al., 2022). In terms of tracking, forecasting, and preventing newly developing infectious diseases, a variety of innovative digital technologies that combine the internet of things (IoT) and AI are gaining popularity over traditional healthcare (Smith & Kirby, 2020). To enable risk assessment and prompt outbreak detection of public health threats, it is essential to monitor emerging infectious diseases using these digital technologies (Keshavamurthy et al., 2022). Demonstrating AI's potential as one of the most effective and promising scientific tools to help trace and protect lives against infectious diseases.

AI is undoubtedly thought to perform as well as or better than humans in many healthcare contexts. For example, radiologists are outperformed by AI components when it comes to diagnosing dangerous tumors, and AI components also help researchers to establish cohorts in expensive clinical trials (Bloom & Cadarette, 2019). AI intelligence makes use of both supervised and unsupervised learning processes, further reducing the burden of healthcare providers dealing with a large set of data to make critical decisions regarding population health (Kartono et al., 2021). Supervised learning involves training and testing to anticipate fresh data samples, whereas unsupervised learning is learning without supervision from data samples. It combines several learning techniques (including deep learning and neural networks), robotics, rule-based expert systems, natural language processing, and other key AI technologies (Wu et al., 2022).

Furthermore, the ability of AI and its components to more accurately identify specific forms of cancer from imaging data allows it to play a critical role in the prevention of infectious diseases (Smith & Kirby, 2020). Even though some infectious infections, such as the human immunodeficiency virus (HIV), are initially largely asymptomatic, they can have disastrous effects if left unchecked in time. The way infectious diseases spread differs depending on the type of bacteria, making it even more challenging to predict, prepare, and prevent infectious diseases. For instance, some viruses, like HIV, can only be spread by close physical contact (sexual or blood contact), though influenza virus infection can be spread within a few meters of each other through droplets that are released after sneezing, coughing, or speaking (Keshavamurthy et al., 2022).

Additionally, AI also supports scientists in the development, management, prevention, and analysis of clinical data, drug development (Keshavamurthy et al., 2022), epidemic prediction, and telemedicine (Rawson et al., 2022). As a result, AI is a potent tool that assists humans in resolving complicated issues, particularly when battling pandemics, like the global COVID-19 outbreak (Chang et al., 2021). Recently, an increasing number of AI researchers from a variety of disciplines—including clinical medicine, economics, infectious diseases, computer science, psychology, government management, etc.— dedicated their work to the prevention and treatment of COVID-19 (Arora et al., 2020). AI can aid in our understanding of the COVID-19 virus's protein structure and in the creation of powerful drugs that can treat patients, greatly reducing the amount of time required for the development of both drugs and vaccines (Smith & Kirby, 2020). It can also determine whether a patient is infected by studying clinical data and Computed Tomography (CT) pictures, which considerably alleviates the problem of a labor shortage and enables the implementation of measures, such as isolation and monitoring (Chang et al., 2021).

In addition, AI has also been instrumental in assisting the government track data and tracing things and people through its sophisticated algorithms. For instance, during the COVID-19 pandemic, social, and physical distancing was critical in stopping the spread of the disease. AI applications assisted decision-makers in placing appropriate control measures in place to stop the spread of COVID-19 and also provided realistic predictions and development trends of COVID-19 (Kartono et al., 2021). Finally, the involvement of AI is essential to the development of a telemedicine platform that helped save millions of patients globally during the COVID-19 pandemic, highlighting the crucial role of AI in the fight against the COVID-19 epidemic. By forecasting novel influenza outbreaks across various locations and assisting global influenza tracking platforms, AI is playing a significant role in containing the Novel COVID-19 virus. It also provides real-time insights into diseases that are spread by analyzing social media communications to track potential outbreak events. AI apps in use can assist people in adopting preventative habits to proactively stop and control the spread of infectious diseases (Kartono et al., 2021).

AI has the potential to enable the world's communities to be better prepared for disease outbreak identification, surveillance, and containment by investing in healthcare technologies with a focus on the most vulnerable population groups (Barh et al., 2020). AI and machine learning can be used to easily prevent, control, and monitor infectious diseases by using big data analysis for lethal diseases (Bin et al., 2019). In addition to establishing stronger frameworks for the patterns of trend surveillance and disease prevention, the capacity to quickly monitor, evaluate, and diagnose various infectious processes that utilize reliable data sources in real-time can also help to prevent avoidable fatalities (Chang et al., 2021).

Machine learning offers a wide range of benefits that are sufficiently versatile to be used in identifying and analyzing the nature and stages of infectious diseases (Arora et al., 2020). The large amount of data generated while analyzing the nature of the disease allows machine learning experts to quickly analyze and identify patterns that would otherwise take a long time to extract using traditional mathematical and statistical methods (Barh et al., 2020). AI-enabled data-driven decisions are a highly adaptable method for dealing with new infections based on scientific insights, due to their flexibility, adaptability, and lack of human bias to help the development of prevention interventions (Bloom &

Cadarette, 2019). However, with the increased capacity to reap benefits from large amounts of data, the need for greater quality assurance during data collection, storage, and analysis has become more important (Barh et al., 2020; Correa et al., 2018)). Additionally, standardizing population-wide data structures will allow the systems to adapt and predict the future of infectious diseases globally, which was not previously possible (Correa et al., 2018).

Even though machine learning models are becoming more common in clinical settings, they may be ineffective or inadequate to achieve the desired goals due to factors such as bias in the training data, non-stationarity of the outcome (for example, antibiotic resistance prediction leads to improved stewardship, which changes resistance patterns), changes in data structures (for example, antibiotic resistance threshold definitions change over time), and a lack of reliable diagnostic criteria (Correa et al., 2018). There has been less research, however, on ML models for hypothesis generation and identifying population-level risk variables. Traditional (non-ML-based) regression models select variables that are thought to represent population-level risk factors for a disease either a priori, requiring knowledge and assumptions regarding diseases and their features, or statistically, using methods such as stepwise selection that rely on statistical significance (Silver et al., 2017; Kartono et al., 2021). These methods have the disadvantage of injecting bias into the analysis due to preconceived notions about risk in the case of a priori selection, and in the case of stepwise procedures, they may choose spuriously related variables while excluding genuine explanatory variables (Wu et al., 2022). As variables must be defined by the research team in both cases, unknown risk factors can be completely excluded from the analysis.

When implemented properly, AI systems can enhance existing healthcare systems, increase their capacity, and avert millions of deaths through smart and efficient data analysis (Boon et al., 2018). But because data is typically undervalued in systems with AI assistance, it might be difficult to incorporate data into conventional decision-making processes (Bin et al., 2019). Data sets have proven to be invaluable based on the various electronic and social media feeds obtained particularly in recent times (Bloom & Cadarette, 2019). Moreover, various publications have been compiled and evaluated by electronic systems, resulting in a large database of information from which it is possible to learn and inform healthcare decision-making relating to decision-making (Correa et al., 2018).

Subsequently, AI has the potential to enable healthcare professionals to improve their trajectory, make more coherent use of the data gathered, and provide the necessary building blocks for intelligent health networks that assist patients in accessing healthcare, protecting themselves against infectious diseases, and managing in instances when they are exposed to infectious diseases (Surya, 2018). AI has had a huge impact on the fight against infectious illnesses through the prevention, development, implementation, and utilization of the majority of health applications, although this has frequently been more slowly than anticipated (Keshavamurthy et al., 2022). However, when it comes to battling upcoming infectious diseases, AI will spread more widely in national health systems in the coming years (Chang et al., 2021).

To conclude, as the healthcare industry is transformed for the benefit of global populations, AI systems are becoming an essential part of disease prevention and control. In addition to assuring the safety of patients, it can assist medical researchers in the development of novel medical vaccines and medications, which are critical for disease prevention (Arora et al., 2020). To combat infectious diseases, such as COVID-19, it can be crucial to apply AI through the use of both established and cutting-edge ML techniques (Barh et al., 2020). Additionally, the development of AI applications complements advances in biological research by enabling speedier analysis of large volumes of data on infectious diseases and the provision of decision-making tools to assist decision-makers in the public sector, including policymakers, healthcare providers, and institutions (Barh et al., 2020).

3. Declarations

3.1 Conflict of Interest Statement

The authors have no conflict of interests to declare.

3.2 Funding Disclosure

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