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The Role of Artificial Intelligence in Infectious Diseases: A Review of Mathematical Modeling Approach and Awareness.

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Abstract

This paper focuses on the role of Artificial Intelligence (AI) of infectious diseases. AI is the intelligence of machines or computers that enables them to imitate human capabilities. Infectious diseases are illnesses caused by harmful agents such as bacteria, viruses, fungi, and parasites. Mathematical modeling approach is considered since it is an important tool in scientific research which enables researcher to describe, test, predict and gain deeper understanding. Public enlightment or awareness of infectious diseases is crucial for prevention, early detection and effective treatment.

Keywords: Artificial Intelligence, Infectious disease, Mathematical modelling,

Introduction

Artificial intelligence (AI) is a tool or instrument used for prediction. AI is the study and development of algorithms (machines) that imitate (mimic) human intelligence. AI has been used in various fields which include computer vision, spasm filtering, robotics, fraud detection, online advertising and so on (Mohamadou et al, 2022). Furthermore, AI involves the development of computer systems capable of performing tasks that typically demand human intelligence, such as understanding natural language recognizing patterns, making decisions and learning from experience. (Dwiredi et al, 2021, Pavaloaia & Necula, 2023, Faj & Zaman, 2023). In healthcare, including infectious diseases, AI has gained attention in terms of diseases detention, treatment selection, patient monitoring, drug delivery, gene function annotation, automated experiments, automated data collection etc. (Mohamadou et al, 2022). On the other hand, infectious diseases are disorders caused by pathogenic micro-organisms such as bacteria, viruses, parasites or fungi that can be spread directly or indirectly from one individual to another. Infectious diseases include, pneumonia, cholera, influenza (Flu), HIV/AIDS, malaria, tuberculosis, covid-19, monkey pox, chicken pox etc.

Mathematical modelling has been used for several years in the epidemiological studies (Mohamadou et al, 2022). The process of mathematical modeling involves translating real life situations into mathematical terms, solving them and interpreting the results back in the context of the original problem. Mathematical modelling approaches have been crucial to provide basic frame works in order to understand the transmission dynamics of infectious diseases (Teklu et al 2023). In attempting to create awareness of infectious diseases there is need for public enlightenment programme. In this paper a review of mathematical modeling, the role of artificial intelligence and infectious diseases is considered.

Implementations of Ai in Infectious Diseases

The application of AI has been used mostly for medical image segmentation and diagnosis to classify whether a patient has been infected or what is the level of the infection. The following are some of the areas in which the Artificial Intelligence is applied.

Detection of diseases; AI has provided a platform in diagnosing, detecting diseases and providing workable treatment to individual patients. For instance, computed tomography (CT) takes the idea if X-

ray radiography further by taking X-ray images of the body from multiple angles to produce cross-sectional images without dissecting the body. Also, AI can identify tumors in mammograms, detect lung cancer with high accuracy and access diabetic retinopathy from retinal images. As part of the advantage, we have improved accuracy, faster automating analysis, ability to earlier detect diseases and reduction of workload and errors on the part of health professionals. AI enhances real-time surveillance systems allowing for efficient data analysis and early outbreak detection.

Predictive ability: AI application has the ability to predict diseases risk based on analyzing ability of patient's data and medical histories, Machine learning and AI algorithms have a great ability in predicting the spread of infectious diseases, AI models have the ability to analyze previous data on a particular disease occurrence, environmental factors, population demographics and real time data to forecast future outbreaks. AI has the potential to trace the routes of infectious diseases by analyzing data from available means such as social lab, lab reports, electronic health records

Treatment of infectious diseases: AI plays an important part in drug discovery and delivery systems. It aids in formulation of drug and predicting treatment outcomes. Machine learning models can analyze large data sets to uncover new antibiotic resistance mechanisms. AI's role in vaccine development is transformative, promising, quicker and more effective responses to emerging infectious diseases.

AI algorithms can analyze difficult biological data to identify potential vaccine candidates. Through the study of genetic, molecular and structural characteristics of pathogens, AI can predict which components are the most likely to elicit a strong immune response. This computational approach streamlines the identification of antigens, reducing the time and resources needed compared to traditional methods. (Sharma et al, 2023). AI tools can assist in drug discovery and design, expediting the development of effective treatments. (Chunhui Li et al, 2024).

Management of infectious diseases AI models are utilized to predict epidemic trends and understand pathogens behavior, which is crucial for managing outbreaks. They can analyze vast data sets to identify potential targets for drug development and asses the effectiveness of interventions (Chu et al, 2023). It provides an efficient way of tracking, tracing of infected individuals and their contacts which is essential for controlling the spread of infectious diseases. AI algorithms can analyze

wide datasets, such as electronic health records and social media, to predict disease outbreaks and identify potential hotspots. It accelerates vaccine research by modeling immune responses and predicting vaccine efficacy, thus aiding in the rapid development of effective vaccines as against emerging infectious diseases. (Ajayi, et al, 2024)

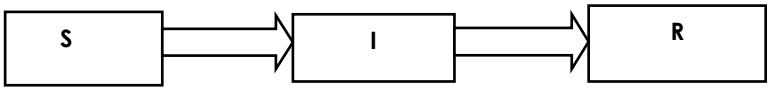
Mathematical Modeling

Mathematical modeling is a concept that provides abstract description of a concrete system using mathematical concepts and language. It is used in applied mathematics, natural science (Physics, biology, chemistry, earth science), engineering disciplines, and social sciences (Economics, psychology, sociology and political science).
The process of mathematical modeling involves translating real-life situations into mathematical terms, solving them and interpreting the results back in the context of the original problem. The modeling process involves identifying the real-world scenario to be modeled, mathematical techniques to solve the equations or run the simulations, creating mathematical equations or simulation that represent the systems.

Mathematical Modeling and infectious diseases Mathematical modeling approaches have been crucial to provide basic frame works in order to understand the transmission dynamics or infectious diseases. (Teklu et al, 2023).

Mathematical modeling mostly is based on the Susceptible- Exposed- Infected- Removed (SEIR) model and the Susceptible-Infected-Recovered (SIR) model

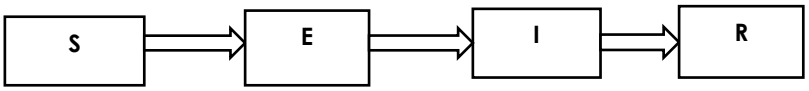
In SIR model the schematic diagram is represented as follows



The objective of a mathematical model of an infectious disease is to describe the transmission process of the disease, which can be expressed as follows:

When infectious individuals are introduced into a population of susceptible, the disease is passed to other individuals through its modes of transmission thus spreading in the population (M.Y. Li, 2018)

In SEIR model the schematic diagram is represented as follows



The SEIR model was adopted to investigate the potential community-wide impact of public use if face masks on the transmission dynamics and control of the covid-19 pandemic. It was suggested that face masks should be used nationwide and implemented immediately (Mohamadou et al, 2020).

Awareness of infectious diseases.

Public enlightenment is crucial to create awareness concerning infectious diseases. A disease outbreak occurs when the number of cases rises above the usual average within a short period of time, whereas when the disease spreads quickly to many people, it is an epidemic. When the epidemic persist and the infection remain in the population a long period of time, the disease is said to be endemic. However, if the disease spreads spatially on a global scale to many countries and continents, a pandemic occurs.

Awareness of infectious diseases is crucial for prevention, early detection and effective treatment. Awareness of a disease and its symptoms encourages people to take preventive measures or action, get screened, and seek immediate medical care.

In raising awareness, the following approach can be adopted, public campaigns and enlightenment of the population community, synergy between non-governmental organizations (NGO's), provision of adequate information about diseases and treatment opportunities, promoting preventive behaviors which include; social distancing, use of face masks, quarantine isolation, vaccination and effective treatment of infectious diseases. Other methods include understanding the causes and the preventive ways which include, vaccination for prevention, need for improved health education particularly in schools and integration of comprehensive health education into school curriculum, public awareness in rural areas, and global efforts i.e. organizations like World Health Organization (WHO) should emphasize prevention of infectious diseases

Challenges of Ai In Infectious Diseases

The application of artificial intelligence (AI) despite its lucrative usage is not without some challenges it faced despite its potential advantages

Scarce resources: The operation of AI technologies often requires enormous resources which may not be available in all healthcare settings particularly in low-resources environment.
Ethical and privacy incentives: The use of AI raises ethical issues concerning data ownership, consent, permission and privacy particularly when standards and data protection is crucial for public trust. (Zoie S.Y. Wong et al. 2019).

Availability and quality of data: AI application requires high quality comprehensive datasets for training. However, cases such as restricted data availability and inaccuracy in the existing datasets hinder the effectiveness of AI applications in healthcare (Kulpatwattana S, et al 2024)

Complexity of interpretability: Many AI algorithms are complex and opaque, making it difficult for healthcare personnels to comprehend how decisions were made. This lack of openers can lead to distrust among stakeholders, impacting the adoption of AI solutions. (Chu et al,2023)

Integration into clinical operation: The application of AI tools into existing clinical workflows can be challenging. AI must be designed to complement the decision-making processes of health care personnels rather than complicate them. (Chu et al, 2023).

Recommendations

The use of mathematical modeling and AI in infectious diseases awareness will increase our knowledge on the propagation, evaluation and preventive measures as well as early accurate detection of the disease in patients.

To overcome the challenges and enjoy the maximum benefits of artificial intelligence (AI) in dealing with infectious diseases there is need to implement a set of strategic recommendations. There is need to make available sufficient resources since AI technologies often require enormous resources particularly in low-resource environment. Ensure ethical and privacy of data is necessary. Issues concerning data ownership, consent, permission are essential. There is need to ensure ethical standards and data protection for public trust.

Availability and quality of data is required for effective application of AI in tackling infectious diseases. Restriction to needed data should be removed

AI algorithms should be made less cumbersome to the healthcare personnels. There is need to avoid complexity and difficult interpretation.

Complementary nature of AI: The interplay between AI and healthcare professionals should be complementary rather than complicating.

Conclusion

In a nutshell we see that mathematical modeling and AI is a dependable instrument in tackling infectious diseases. As earlier mentioned, the model was based on the Susceptible- Exposed-infected- Recovered (SEIR) model and Susceptible- Infected-Recovered (SIR) model for infectious disease. Regardless of the challenges occasioned by AI, it holds to a large extent ability to transform patient care, diagnostic accuracy, improved public health surveillance, personal treatment plans etc.

There is need for concerted effort of health personnel to update and upgrade their knowledge particularly on AI's abilities and limitations.

The issue of infectious diseases poses a serious impact to public health hence there is need for creating awareness about occurrence, spread, prevention, detection and effective management. Such as awareness can be done through educational campaigns, media outreach, community-based enlightenment, collaboration with health care providers and professionals.

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