International Journal of Clinical Studies & Medical Case Reports
ISSN 2692-5877
DOI: 10.46998/IJCMCR.2026.58.001447

Mini Review

Control of Viral Pandemics by the Use of Artificial Intelligence

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Received: March 20, 2026 Published: May 29, 2026

Abstract

Epidemics involving infectious diseases, cause the emergence of new pathogens and changed disease dynamics that can be handled well via Artificial Intelligence (AI). Viral infectious diseases have the potential of becoming pandemics and can create several challenges for public health and emergency management. One of the most important objective of a pandemic response is to ensure access to resources and AI technologies have proven to be effective for predicting and detecting the spread of viral infectious diseases due to their capability for data processing and pattern recognition. The recent COVID-19 pandemic specially prompted the integration of AI into public health systems.

Introduction

Artificial Intelligence (AI) comprises a set of techniques developed in the 1950s that allow a machine to simulate certain human cognitive functions. Since the 2010s, AI has undergone major revival with the progress in machine learning, supported by advances in computing and the availability of large and diverse datasets via the internet [1]. AI tools offer the capacity to rapidly process large volumes of heterogeneous data to support clinical decision-making and to guide public health strategies **(Figure 1)**.

Machine learning models are used by many applications. In machine learning, the model learns directly from labeled or unlabeled data. Deep learning is a subcategory of machine learning that relies on neural networks. These networks enable the construction of complex representations of data through multiple layers of processing [2]. In recent years, there has been an emergence of generative artificial intelligence models particularly Large Language Models (LLMs) such as ChatGPT.

Surveillance of Infectious Diseases:

AI-powered systems handle data-sets by the use of search engines such as Google Trends, Baidu Index, etc., social media activity, climate records and traditional laboratory-based reporting systems [3,4]. An example is the Google Flu Trend (GFT) analysis, which was developed during the 2009 H1N1 pandemic as an alternative method to estimate influenza-like illness (ILI) in the general population [5]. AI models can detect infections like pneumonia or tuberculosis (TB) using chest radiographs and CT scans. For instance, in COVID-19-linked pneumonia, deep learning methods have achieved sensitivities of 60–95 % on test datasets, comparable to human radiologists (range 42–100 %) [6].

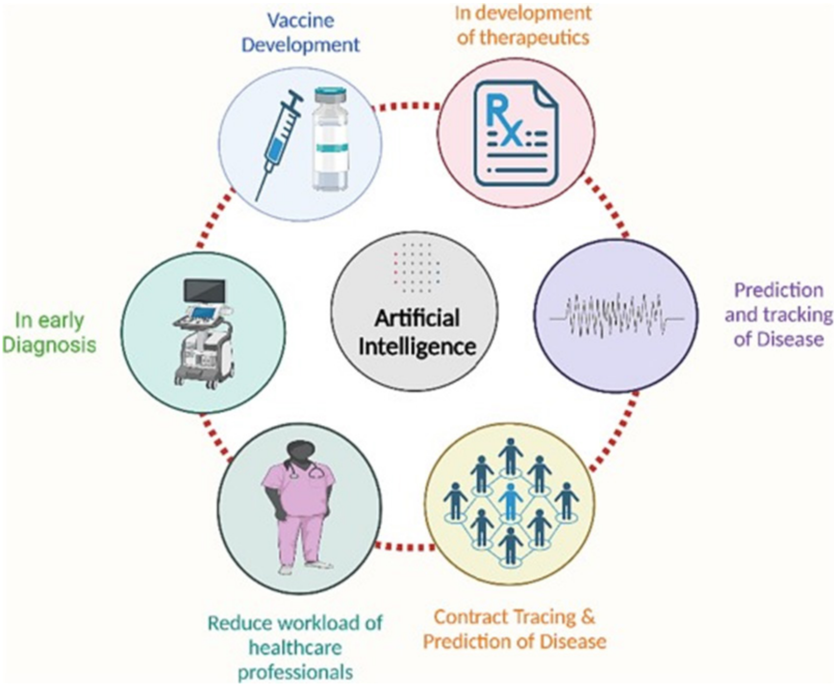
Use of AI for Risk Prediction:

AI technologies can be used very effectively to improve public health [7]. AI employs epidemiological data to trace infected individuals and simulate transmission patterns. It can identify potential hotspots and notify individuals who have been in close proximity to confirmed cases. It can also identify those using a mask in public spaces. HealthMap [8], developed by Boston Children's Hospital, uses language processing to extract such information from data sources such as news reports and official announcements, etc [9].

Monitoring of Resource Allocation:

AI-driven vaccine distribution was shown to successfully identify high-risk regions and to be able to maximize resource allocation during pandemics [10]. In a recent systematic review comprising 80 studies and over 1.3 million patients, machine learning (ML) models were shown to be efficient in handling Antimicrobial Stewardship (AMS) [11]. These studies covered

Figure 1: Application of AI in the healthcare industry.



prediction of resistance patterns and assessment of the treatment methods.

Drug Discovery:
Molecular docking is a technique used to virtually screen to predict ligands to determine how they will bind to a biological target. For example, a study analyzing the binding affinity of 33 compounds with inhibitory activity against the HIV-1 protease led to the development of a model capable of identifying a new molecule with activity against HIV-1 protease [12].

Vaccine Development:
AI has helped in the selection of vaccine candidates by the use of algorithms such as XGBoost. AI can also play a role in vaccine development through the prediction of the viral mutations [13]. AI can help in the vaccine development process by screening compound libraries and predicting epitopes with high accuracy.

Studies by Floresta et al [14], Wang et al. (2021) [15] and Kaushik et al. (2023) [16] used ML techniques to identify vaccine candidates. Additionally, multiple ML methods contributed to epitope scoring. These approaches have advanced the identification of epitopic regions on the viral coat that are capable of eliciting immune responses [17,18]. A COVID-19 vaccine was successfully developed using ML-predicted B-cell and T-cell epitopes, demonstrating both efficacy and safety [19]. Deep learning models such as AlphaFold, have helped

Table 1: AI technologies introduced in China during the COVID-19 pandemic.

AI Technology	Provider	AI Methodology	Functionality/ Application	Integration in Public Health
AI-driven diagnostic platforms	Alibaba (DAMO Academy)	Machine learning, computer vision	Fast and accurate CT scan analysis for COVID-19 diagnosis	Used in over 100 hospitals; integrated with hospital data systems for real-time diagnostics
AI-based thermal imaging cameras	Baidu	Computer vision, thermal imaging	Fever detection in transportation hubs to identify symptomatic individuals	Screened millions of travelers per day; deployed in major cities; data linked to health monitoring systems for immediate response
AI-powered Chatbots	Tencent, Alibaba	Natural language Processing	Provide real-time information, health recommendations, and self-assessment tools	Interfaced with public health websites and hotlines to provide accurate information; handled over 200,000 interactions daily
Intelligent monitoring systems	SenseTime	Machine learning, facial recognition	Enforcement of quarantine measures using facial recognition and temperature detection	Monitored movements of millions during lockdown; data used to monitor quarantine compliance and track public movements
AI-enabled drones	DJI	Machine learning, computer vision	Disinfection of public areas and broadcast of public health measures	Used in rural areas and cities; programmed to cover specific high-risk areas and support sanitation efforts

Table 2: Comparison of various AI Technologies used in Public Health by different Countries.

Country	AI technologies used	Public health Policies	AI adoption levels	Outcomes
United States	Predictive analytics, patient monitoring	Decentralized, state-level	High	Enhanced data-driven healthcare
United Kingdom	Data management, resource allocation	Centralized, NHS-Driven	Moderate	Improved resource management
Sweden	Epidemiological research	Less stringent, health advisory	Low	Limited direct patient impact
Germany	Diagnostics, robot-assisted care	Robust, focused on Innovation	High	High efficiency in patient care
Italy	Telemedicine, diagnostics	Centralized but Overwhelmed	Moderate	Improvements post-initial struggle
Japan	Contact tracing, mobile Monitoring	High surveillance Acceptance	High	Effective containment measures
South Africa	Mobile clinics, diagnostics	Targeted, rural Focus	Low	Accessible healthcare in rural areas
Ecuador	Limited AI use due to Infrastructure	Minimal, Underdeveloped	Very Low	Minimal impact
China	Comprehensive AI use in diagnostics, contact tracing and enforcement	Centralized, government-driven	Very High	Comprehensive containment and management

Table 3: Various national, regional, and international efforts to regulate AI.

China	Personal Information Protection Law (PIPL)	Mandates strict data handling and consent Protocols
United Kingdom	Bletchley AI Safety Summit	A summit aimed at leading global discussions and developing safety protocols for AI technologies
United States	Executive Order #14110	Outlines a coordinated, federal government-wide approach to govern AI development and use
European Union	EU AI Act	A comprehensive framework categorizing AI systems based on rules for high-risk applications

design the mRNA vaccine by accurately predicting three-dimensional protein structures.

Use of AI during COVID-19 Pandemic

AI was widely integrated into China's healthcare ecosystem by mid-2020s **(Table 1)** [20]. In densely populated provinces like Guangdong and Zhejiang, numerous local healthcare facilities implemented AI applications, demonstrating extensive geographic and demographic reach. Various studies showed that AI adoption in healthcare not only increased significantly during the initial months of the pandemic but also diversified in its applications.

A comparative analysis of AI technologies used by various countries during the COVID-19 pandemic is presented in **Table 2**. The table outlines variations in public health policies and AI use in China, United States, United Kingdom, Sweden, Germany, Italy, Japan, South Africa, and Ecuador.

Regulations Introduced for Ethical Use of AI:

In the European Union, the European AI Office has set strict guidelines regarding the use of personal health data. In 2025, the AI Act introduced new regulations for clinical decision-making (Table 3) [21]. These include transparency, human oversight, post-market monitoring, and proof that the AI system performs safely and fairly. Hospitals that use AI have to ensure their tools are properly classified, documented, and monitored.

Conclusion

Artificial intelligence is reshaping how infections are diagnosed and treated. AI proved this during the recent COVID-19 pandemic that it can turn a huge amount of clinical data into prognosis and diagnosis at a rapid speed that is required to control evolving microbes during global pandemic outbreaks. The future use of AI will depend on an increase in data-science literacy among medical practitioners and the establishment of interdisciplinary clinical teams. Presently, regulatory legislation such as the EU AI Act have provided different guidelines. However, clinicians, data scientists, and software engineers will have to share the responsibility to implement these principles into up-datable models that can remain clinically relevant as the dynamics of viral epidemics shift.

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