Advancements of AI in Public Health and Epidemiology

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Abstract

Artificial intelligence is a rapidly growing tool due to which the sector of public health has undergone a paradigm shift in different domains. AI has been employed in various sectors of public health and health care systems as AI makes the analysis of big data much easier in comparison to conventional methods. The use of AI tools such as algorithms of machine learning, deep learning, natural language processes, and chatbots to mimic human intelligence has made the process of health care less labor-intensive and time saving. This chapter aims to explore the uses of AI in the various fields of public health such as public health surveillance, medical diagnosis, and medical drug discovery. It also discussed the advancements of various procedures and the enormous role of AI in the field of public health and epidemiology as promised by the AI tools. It explores the techniques used to control and detect different illnesses such as COVID-19 and influenza.

Keywords: Artificial intelligence, Public health, Public health surveillance, Medical diagnosis and Drug discovery.

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Introduction

Artificial intelligence becomes an important tool in the achievement of several public health procedures as it offers novel solutions (Tshimula et al., 2024). Prediction analysis using AI tools plays a significant role in monitoring epidemiological trends which help the public health professionals to be prepared for the potential outbreaks (Chukwunweike et al., 2024a). One of the most popular examples of public health surveillance using AI was the use of machine learning algorithms through the platform of BlueDot, the platform was very much useful as it detected the signs of COVID-19 outbreak even before the publication of official reports (Babanejaddehaki et al., 2025). Machine learning models identify signals of early warning of the outbreaks as it analyzes unstructured and structured data driven from large sources including genomic sequences, clinical records, internet research queries, and social media posts (Debbadi & Boateng, 2025). The different models of machine learning have the potential to process huge amounts of data very efficiently as compared to the traditional methods of epidemiology, and also provide real-time insights (Jeyakumar et al., 2023a). One of the examples of this model is the tracking of influenza activity by analyzing the Google search queries (such as flu symptoms) trend through AI algorithms has been used successfully. Besides the critical role of AI in public health surveillance, it also plays a significant role during the pandemics as it helps to optimize health care operations (Chukwunweike et al., 2024b). The predictive models have been used in hospital capacity planning, allocation of resources for intensive care units and the distribution of ventilators (Ajayi, 2023). Another achievement of the AI is the deployment of AI chatbots and virtual assistants to help the public by providing accurate health information as a result reducing the burden of call centers in hospitals and other health care systems (Chukwunweike et al., 2024c). During the pandemic of COVID-19, AI-supported radiology tools were used for the detection of pneumonia in chest X-rays to accelerate the process of diagnosis for patients (Marandi & Deep, 2024). Although there are various achievements of AI use in public health, there are still several challenges present including transparency, reliability, and ethical considerations (Chukwunweike et al., 2024d).

Public Health and History of AI

The beginning of the era of AI started in the 1960s and the very first goal of it was the development of a system that can mimic human intelligence (Garg, 2021). In the field of health care, the focus of the AI applications was on the production of expert systems, as these systems use the knowledge from human specialists which will assist the decision of medical diagnosis and treatment. Until the 1990s, the main focus of the health care systems was the development of expert systems through AI research, but other tools such as natural language processing and machine learning were also investigated (Davenport & Kalakota, 2019). In the field of health care, the researchers were able to examine the potential of AI in different areas including public health surveillance, medical diagnosis, and drug discovery which was

possible due to the availability of mass databases of medical data and advanced computer systems. After all these discoveries, in the 2000s many advancements were seen in computer vision, machine learning, and natural language processing and all these advancements help researchers to build complex AI systems which are able to evaluate enormous amounts of data and predict future outcomes (Pramod et al., 2021). This provide a path for further development of AI-based diagnostic tools to assist the process of interpretation of medical images to identify the disease such as cancer. Furthermore, the advancements of various tools of AI such as the natural language processing and text mining methods, helps in the evaluation of large amount of unstructured data for example electronic health records and acquire insightful conclusions for academics. Recently, there has been an increased use of AI tool in the domains of public health surveillance and predictive modeling. The best example of this is use of AI algorithms to foresee the spread of different infectious diseases such as influenza and COVID-19 (Malik et al., 2021), which provide beneficial information to develop preventive strategies. These AI-based technological systems used to monitor the large amount of data from social media and other potential sources and warned against outbreaks and spread of diseases. The potential benefits of AI in various public health fields also include emerging fields such as personalized treatment and drug development (Lee & Yoon, 2021) which is usually the result of availability and accessibility of huge data and computing resources. It can be concluded that there has been a huge difference between the expert systems and the advanced systems of public health due to the evolution of the AI as it can discern large amount of data and make predictions. Despite the fact that AI offers a large number of advantages, there are several limitations associated with the use of AI as it includes both legal and ethical concerns such as data privacy and surveillance, transparency, safety, biases of algorithms, and fairness of algorithms (Gerke et al., 2020; Sunarti et al., 2021; Naik et al., 2022). These concerns should be considered and solved to use AI as an assistance in different domains of public health.

AI and Public Health Surveillance

The traditional methods and systems of public health surveillance have always depended on manual data collection with higher chances of error, labor intensive, and interpretation (Cheng et al., 2023). AI tools have become an integral part of the public health surveillance (Wahl et al., 2018; Shaw et al., 2019) especially after the increase in the amount of data related to health systems production including sensor data, electronic health records, and data from various social media platforms (Jayaraman et al., 2020; Ariffin et al., 2021). In comparison to the previously used old methods, AI integration within the field of public health surveillance offer a number of advantages such as fast evaluation of large amounts of data, and also identify trends, give early warnings of disease epidemics and outbreaks (Mourya & Idrees, 2019). To monitor the spread of COVID-19, the Centers of Disease Control and Prevention (CDC) is currently using AI systems. For this purpose, by using AI, CDC has developed a system to analyze data from different forums such as social media, electronic health records, and travel data. This developed system by CDC has the potential to predict the risk of any outbreaks and track the spread of viral agents in real time (Chen & See, 2020; Chettri et al., 2020). The data related to infodemiology and infoveillance, which is gathered with the help of AI mining techniques, provides information about the analysis of communication patterns on social media, search behavior, and publication trends. These AI based methods such as AI mining techniques give real time insights into public misinformation, sentiments, and disease trends. Public health authorities can beef this information for various useful purposes including response planning, early detention, and effective communication strategies (Eysenbach, 2009; Merchant & Lurie, 2020; Pennycook et al., 2020). One of the best advantages of the use of AI techniques for public health surveillance include detection of patterns and trends, evaluation of large amounts of data, and forecast (Ahmed et al., 2020; Johnson et al., 2021). The ultimate advantage is the guide for policy makers regarding several initiatives of public health and control of infectious diseases (Davenport & Kalakota, 2019). Additionally, another potential use of AI in public health surveillance is the enhancement of effectiveness for various measures such as prediction and precision (Morley et al., 2020) ultimately producing potential health outcomes for both communities and at individual level. The data used for public health surveillance comes from various sources and may also have different formats so it is difficult to compile and manage this huge amount of data (Wang et al., 2018; Aiello et al., 2020; Tawalbeh et al., 2020). This may affect the accuracy of the predictions as it is a tough task to combine such huge amount of data and the verification of the consistency of this data. Furthermore, there are also chances of bias and discrimination as we use AI in public health surveillance (Blasimme & Vayena, 2019; Smith et al., 2020). This can be understood by the fact that the data used to train algorithms of various AI tools are skewed, so if the data is skewed the predictions of this algorithm are more likely to be skewed. This could be of greater concerns especially in case of public health surveillance because wrong predictions may lead to the uneven distribution of the resources producing detrimental outcomes (Murphy et al., 2021).

AI and Medical Diagnosis

AI tools such as machine learning and deep learning, play significant role in the field of medical diagnosis (Esmaeilzadeh, 2020; Islam et al., 2021). Different applications of AI extensively cover the fields of clinical research, basic biomedical research, and translation research (Yu et al., 2018). Going further deep there are several applications of AI in the field of clinical practice include genome interpretation, automated surgery, monitoring patients, treatment selection, and disease diagnosis. In the field of biomedical research, the applications of AI are automated data collection, automated experiments, simulation of molecular dynamics, literature mining, gene function annotations, and so on. Similarly, in translation research, the AI applications are used for drug-target prioritization, drug discovery, drug repurposing, prediction of chemical toxicity, genetic variant annotation, and biomarker discovery (Davenport & Kalakota, 2019). Furthermore, human errors can be eliminated through AI systems and the process of diagnosis can be done in a very short time (Ichikawa et al., 2016; Islam et al., 2021). Available data are used to train these AI systems (Li et al., 2020). There are two types of healthcare data. The first type of data is called structured data including genetic and electrophysiological data, computed tomography scan images, etc. While the second type of data is called unstructured data which includes clinical data, medical examination results, medication and all other data in the text form which help in the process of diagnosis (Jiang et al., 2017). The unstructured data is processed using AI tools such as Natural Language Processing techniques, concert data into structured format such as electronic medical records which then interpret using machine learning and deep learning techniques for diagnostic purposes (Jiang et al., 2017). The availability of a large amount of healthcare information combined with the fast development techniques of big data

analytic techniques have floored the path to develop applications of AI in healthcare successfully. AI also assists medical physicians in many ways including elimination of problems associated with humans such as fatigue and habituation as a result of which diagnosis is achieved rapidly in real-time. As it is evident that different medical specialties for instance radiology (Liew, 2018), ophthalmology, pathology, and dermatology majorly depend on image based diagnoses (Yu et al., 2018). In health care,there has been a lot of search done in AI especially focusing on diseases including neurology, cancer, and cardiology. One of the highlighted examples of this is the use of IBM Watson, an AI system, a pioneered system used in the field of oncology with promising advancements (Jiang et al., 2017). There are several wearable devices used to record biomedical signals through embedded sensors such as heart rate, tremor, voice, and limb movement. The best use of these biomedical signals is the interpretation of health conditions and detection of diseases. It is reported in a study that the heart rate data and skin temperature data can be used to detect inflammatory responses and signs of disease in early stages, another advantage of these wearable devices (Li et al., 2017). Photoplethysmography sensors, another example of the sensors embedded in the wearable devices, is a useful source of data related to pulmonary diseases, cardiovascular diseases, sleep apnea, and anemia (Majumder et al., 2017; Yu et al., 2018). One of the potential use of these sensors in the patients of Parkinson's disease to detect symptoms such as tremors, gait, lessened hand movement, speech, and posture as early detection leads to early treatment (Yu et al., 2018). The ultimate goal of use of AI diagnostic tool used for the early detection of COVID-19 is to prevent and control disease at a certain level to decrease the burden of disease on health care systems. According to the analysis of the Verified Market Research team, the share of AI driven medical diagnostic tools was US$1000 million in 2019 and it is projected to achieve a share of US$ 6,000,000,000 by 2027 in the global market (Lepakshi, 2022).

AI and Drug Discovery

AI has played a significant role in the medication discovery and development, treatment, and therapy personalization (Bohr & Memarzadeh, 2020). For the pharmaceutical sector, the application of AI has promising advancements in medication research and discovery. As a vital collaborator in the field of drug research, AI helps to find out suitable therapeutic candidates (Singh et al., 2020; Jiménez-Luna et al., 2021; Kannan & Subbaram, 2023). With the application of machine learning algorithms, enormous datasets analyzed painstakingly, also forecast the effectiveness of various substances and accelerate the preliminary phases of different screening tests of drugs (Vora et al., 2023). Other advantages of this method is that it is not time consuming and also cuts down expenses related to the introduction of a novel medication to the market, and also speeds up the identification process (Singh et al., 2020; Koutroumpa et al., 2023). AI also helps to optimize the process of drug development through a series of actions including enabling effective clinical trials, identifying possible adverse effects and groups of population showing best results towards a particular drug (Bohr & Memarzadeh, 2020; Singh et al., 2020; Nag et al., 2022). By handling complex datasets, AI increased the chances of conversion of scientific discoveries into practical treatment options (Johnson et al., 2021; Al Kuwaiti et al., 2023; Vora et al., 2023). There has been a revolution in the field of drug discovery due to AI tools as it shifts from a time-consuming and labor-intensive approach to a more efficient approach (Bohr & Memarzadeh, 2020; Han et al., 2023; Philip et al., 2023). With the continuous evolution of AI algorithms, there is a potential for improving treatment efficacy and discovering innovative therapies (Jeyakumar et al., 2023b; Vora et al., 2023).

Conclusion

The concept of integration of AI in public health is not novel but the rapid growth of AI in the recent decade is promising as it is described by development in the AI algorithms for different techniques such as machine learning, deep learning, and natural language processing for the analysis of big data, and the enhanced computational power of latest systems. AI has played a tremendous role to enhance the capacity of several public health domains such as public health surveillance, medical diagnosis, and drug discovery. Using the techniques of machine learning and deep learning, AI facilitates the interpretation of large data which helps in early detection of disease, treatment optimization and management of resources. The enhanced deployment of AI in public health systems comes up with several serious concerns related to ethical and legal challenges and implications. So there is a need for a more integrated approach to make policies.

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