



# AI IN PUBLIC HEALTH: MODELLING DISEASE SPREAD AND MANAGEMENT STRATEGIES

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## ABSTRACT

This study explores the integration of AI into public health practices, focusing on disease spread modelling and management strategies. It discusses the historical evolution of AI in public health, from early expert systems to modern applications in predictive modelling, disease forecasting, risk prediction, spatial modelling, electronic health records (EHRs), and public health surveillance. The potential of AI to enhance health education, promote self-care for chronic conditions, and provide personalized health advice is highlighted.

The study emphasizes the role of AI in improving public health decision-making, efficiency, accessibility, and research collaboration. However, ethical and social concerns, such as bias, transparency, and data privacy, are acknowledged as challenges. AI has been significantly impacting the prediction and management of infectious diseases, particularly during the COVID-19 pandemic. It analyses vast datasets, identifies patterns and makes accurate predictions about disease transmission. AI systems can also improve efficiency and accuracy in diagnosis, treatment planning, and disease management.

Challenges associated with AI implementation in public health include ethical considerations, data security, and transparency. The study suggests collaborative initiatives, emphasizing data cooperation and sharing through methods like federated learning, to address privacy concerns while maximizing AI's benefits in public health.

**KEYWORDS:** AI, Public Health, Disease Modelling, Predictive Modelling, Electronic Health Records (EHRs)

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## INTRODUCTION

Artificial intelligence (AI) refers to computer programs that, when spoken with via online platforms like chat rooms, websites, or mobile apps, may mimic human conversational abilities, such as understanding context and responding appropriately. From a public health perspective, it offers interactive, easily accessible, and reasonably priced solutions that might improve health promotion and education. By assisting with semi-automated recording and monitoring of health data, symptoms, and medications, AIs may help with self-care for chronic disorders like diabetes, hypertension, and asthma, as well as with access to remote or automated healthcare services, tests, diagnosis, and therapy.

One use of personalization is to remind people to take their vaccines or get their blood tested. Another is to give them personalized health advice based on their unique medical history, lifestyle choices, and preferences. Lastly, personalization can encourage people to regularly get their recommended checkups and provide them personalized educational materials about health, like advice on healthy eating and exercise. Users are able to access health information and make educated decisions about their health with the help of these solutions.

There is encouraging evidence that AI applications may have positive public health effects, particularly in the areas of customized health promotion, disease prevention, rehabilitation, and management. The scientific



community is only beginning to explore the potential of AI as a virtual assistant for personal usage. Through the automation of data processing, pattern recognition, and prediction, AI may greatly enhance research capacity. It also facilitates data processing and retrieval of information, encourages the invention of new techniques and tools, and more.

The integration of AI into academic higher education has garnered significant interest due to its potential to provide both challenges and possibilities. A significant concern is the possibility of AI systems sustaining prejudice and discrimination unless they are appropriately constructed and supervised. There is also a potential risk of less interpersonal connection and a decline in critical thinking abilities.

AI technology can customize learning experiences and adjust to the specific demands of each student, resulting in a more streamlined and impactful education. It can mechanize repetitive chores, allowing educators to allocate their attention towards more significant teaching and mentoring responsibilities. Additionally, AI may provide students the opportunity to access a broader array of educational materials and lifelong learning prospects, regardless of their geographical location or socio-economic background.

#### **RESEARCH OBJECTIVE**

This research aims to trace the historical evolution of AI in public health, assess its impact on health education, analyze its role in disease spread modelling, explore its applications in electronic health records, investigate ethical implications, propose collaborative initiatives, and provide actionable recommendations for responsible AI integration in public health practices.

#### **RESEARCH METHODS**

We searched relevant online databases including PubMed, Scopus, and Web of Science for relevant articles regarding AI and public health using appropriate keywords and limited language phrases. The search for potentially relevant publications began with a cursory review of the titles and abstracts. We used the established inclusion and exclusion

criteria to evaluate each article from the selected research. Inclusion criteria were only English-language studies that investigated the use of AI to public health care. Exclusion criteria were studies without full-text availability, published in languages other than English, and those without a public health relevance. A descriptive language was used to emphasize important themes, trends, and patterns in the data, which were aggregated and related to AI's utility in improving public health. Next, we discussed how these findings may affect future public health initiatives.

#### **HISTORY OF AI IN PUBLIC HEALTH**

The field of AI was established in the 1960s with the initial goal of developing systems capable of imitating human intellect. The first uses of AI in healthcare mainly focused on expert systems, which relied on the expertise of human professionals to aid in medical diagnostic and treatment planning decisions. Research on AI mostly focused on expert systems in the 1980s and 1990s, despite the fact that the healthcare sector was also studying ML and natural language processing. Public health monitoring, drug development, and medical diagnostics are just a few sectors that potentially benefit from AI, especially with the availability of large databases of medical information and powerful computers.<sup>i</sup> Improvements in computer vision, NLP, and ML in the 2000s allowed scientists to build ever more complex AI systems capable of analyzing massive datasets and foretelling future results. This led to the development of AI-powered diagnostic tools, such as those that can examine medical pictures and aid in the diagnosis of cancer and other disorders. Advances in text mining and natural language processing have also made it possible for researchers to use AI to sift through mountains of unstructured data, like EHRs, and draw valuable findings.<sup>ii</sup>

Predictive modelling and public health monitoring are two areas where AI has recently attracted a lot of attention from the public health community. For example, public health professionals have used AI algorithms to predict the development of infectious illnesses such as COVID-19 or influenza, allowing them to implement preventative

measures. Additionally, they have been used to sift through mountains of social media and other data in search of possible epidemics and to track the progression of illnesses. The expansion of AI's use in public health into areas such as medication creation and individualized therapy has been driven by the democratization of big data and the availability of powerful computer resources. From simple expert systems to complex systems that can sift through mountains of data and provide predictions, the use of AI in public health has progressed over the years. While there are many potential public health benefits to implementing AI into healthcare systems, there are also many ethical and legal considerations to bear in mind, including data privacy and surveillance, safety, transparency, algorithmic biases and unfairness, and the philosophical dilemma of how to account for human judgment.<sup>iii</sup>

## PREDICTIVE MODELLING

Predictive modelling integrates statistical models with machine learning approaches to analyze data and make predictions about future events. One use of predictive modelling in public health is the forecasting of the transmission of infectious illnesses such as COVID-19 and influenza. Public health interventions may be guided by patterns and trends discovered by predictive models that examine data on past epidemics and other relevant aspects, such as demography and weather patterns. Predictive modelling is a crucial use of AI in public health, since it has the potential to enhance our capacity to anticipate the transmission of infectious illnesses and guide public health actions. See Figure 1 for an AI predictive modelling methodology for public health.<sup>iv</sup>

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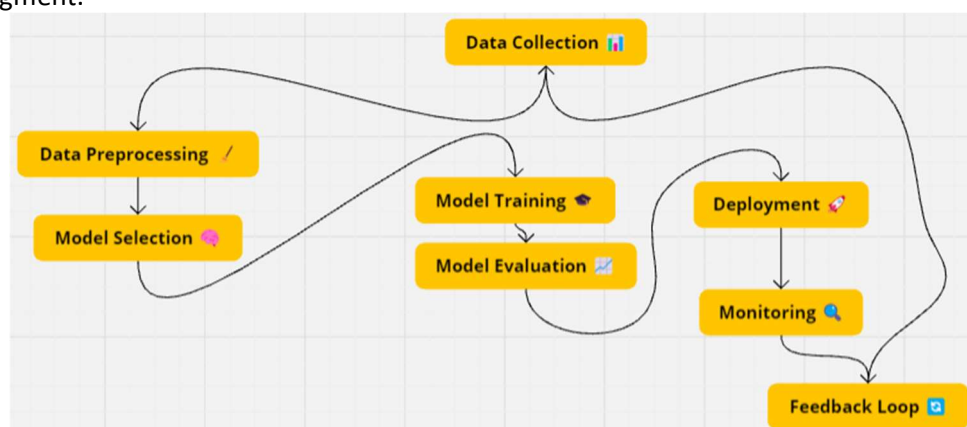


Figure 1

Improving the precision, effectiveness, and practical knowledge in public health decision-making is the fundamental issue that AI for predictive modelling aims to address. This includes illness forecasting, risk prediction, and spatial modelling. When dealing with complicated data, recognizing patterns, and producing reliable forecasts, traditional approaches in these fields often fall short. Here, AI steps in as a game-changer, allowing us to overcome these obstacles and produce better results.

Informative decision-making, efficiency, accessibility, and research cooperation in the area of public health are impeded by the lack of precise classification and summarizing of conventional and AI methodologies for

predictive modelling, including illness forecasting, risk prediction, and spatial modelling. Method selection becomes more complex, implementation is delayed, and broader adoption is discouraged due to the absence of hierarchical categorization. To improve the field's advancement, practitioners must have a uniform taxonomy and brief explanations of each strategy. This will allow them to explore methodologies effectively, speed up decision-making, and make research cooperation easier.<sup>v</sup>

## DISEASE FORECASTING

One use of AI in public health is disease forecasting, which may help us better anticipate the development of infectious illnesses and direct our public health

initiatives accordingly. This is essential as it allows authorities to take swift action in case of epidemics or avoid them altogether. AI has become better at using more complicated algorithms that look at more types of data to make better predictions. One prominent development in AI for illness prediction is the use of machine learning algorithms, which can scour various data sources, such as electronic health records and social media, to identify trends and predict the spread of illnesses.

The increasing availability of massive data and state-of-the-art computer resources is another advancement in AI for disease forecasting. This lays the groundwork for analyzing various and expansive data sources, including EHRs, social media, and sensor data, which in turn improves future prediction and pattern identification. AI has the ability to sift through mountains of data, identify patterns and trends, and foretell future events; this might help public health officials focus their efforts and reduce the spread of infectious diseases.

Finding high-quality data and taking legal and ethical considerations into account are two limits of employing AI for illness forecasting in public health. The integration of geographical data utilizing GIS technology, novel explainable AI approaches, and the convergence of AI with other developing technologies are all potential future developments in AI for disease forecasting.

Due to complicated dynamics and shifting patterns, conventional methods may fail to accurately estimate the spread and impact of diseases, which is the fundamental problem with disease forecasting. Ideas for mitigating the effects of disease outbreaks, early warnings, and practical insights may be generated by using machine learning and deep learning algorithms to efficiently analyze large datasets, reveal hidden relationships, and detect intricate patterns.

#### **RISK PREDICTION**

Risk prediction is an essential part of public health as it allows for targeted disease management and preventative efforts. Manual calculations using demographic and clinical data are examples of traditional risk prediction methods; nevertheless, they may

be time-consuming and don't guarantee accurate results. AI may improve public health by making risk projections more effective and precise. Machine learning algorithms can sift through mountains of data, such as EHRs, to identify trends and make illness predictions. Additional complex data, such as genetics and medical pictures, may be analyzed by these algorithms to determine the probability of disease.

It's conceivable that public health AI risk prediction may go even further. By combining AI with other technologies, such as genomics and wearable devices, more accurate and real-time data may be provided, leading to better predictions. Further, by disclosing the decision-making process of algorithms, explainable AI (XAI) technologies may improve confidence in AI's use in healthcare by making AI-based systems more transparent and accountable.

Finding people with a high probability of getting a particular illness is the main challenge with risk prediction. Conventional methods depend on analyzing demographic and clinical data, which could miss nuanced risk factors or changing health situations. Machine learning, NLP, and other AI techniques improve risk prediction by discovering hidden patterns non-linear correlations, and integrating disparate data sources. Improving tailored healthcare tactics, allocating resources, and tailoring therapies are all part of the plan. The likelihood of medical emergencies, including heart attacks, strokes, and automobile accidents, may be foretold with the help of AI. For instance, a model that can anticipate the likelihood of a heart attack with 90% accuracy was created by IBM Watson Health.

#### **SPATIAL MODELLING**

To allow the localization of treatments to regions with the most significant illness burden, spatial modelling analyzes geographic information to identify trends and patterns in health outcomes; this makes it a crucial component of public health. Traditional methods of spatial modelling, such as manually collecting and analyzing data, may be laborious and error-prone. Public health outcomes may be enhanced with the use of AI

by making spatial modelling more effective and precise.<sup>vi</sup>

In order to predict the spread of illnesses, machine learning algorithms may examine large-scale geographic data, such as satellite photos, for patterns. For example, dengue fever risk factors, including mosquito bite rate and dengue cases, rates, peak times, and intensities, have both been predicted using these methods. Using AI for public health spatial modelling goes beyond just integrating GIS. The analysis of vast and varied data sets in a geographical context, including information derived from electronic health records and social media, might help us better predict the future and uncover previously unseen trends. Public health spatial modelling using deep learning algorithms is another recent advancement in artificial intelligence. In order to identify patterns that may indicate the risk of illness in certain areas, these algorithms may sift through complex data sets, such as genetics and medical pictures. One research utilized this to look at the possible connections between different areas of the brain and neurological diseases. Taking audio recordings of patients' coughs together with symptom reports improved the identification of respiratory illnesses in another trial.<sup>vii</sup>

In response to the COVID-19 pandemic, Gunasekeran et al. performed a comprehensive scoping assessment of digital health apps. The importance of AI in forecasting models is highlighted in their review. Using AI algorithms, prediction models may sift through mountains of data, such as medical histories, demographic information, and environmental variables. Disease transmission predictions, high-risk population identification, and the creation of tailored therapies are all made possible by these models.<sup>viii</sup>

Locating trends and patterns in health outcomes across different regions is the central challenge in spatial modelling. When dealing with complicated geographical data, identifying relationships, and making accurate forecasts at the local level, traditional approaches often fall short. By combining GIS with AI, which employs machine learning and

deep learning methods, answers may be offered. This facilitates data-driven decision-making for focused treatments and allows for the detection of complex geographical patterns like illness clusters. A number of events, including the global spread of illnesses, are being modelled using AI. For instance, a model that may predict how far flames would spread was created by researchers at the University of California, Berkeley.

#### **ELECTRONIC HEALTH RECORDS**

Electronic health records (EHRs) are crucial for public health research and practice, as they store digital copies of patients' medical data, including diagnoses, treatments, test findings, and medication use. However, human analysis can be challenging due to the massive amounts of data in EHRs, necessitating new technology to extract conclusions from the data. AI has the potential to increase efficiency and accuracy, leading to better public health results.<sup>ix</sup>

AI for EHRs in public health includes machine learning algorithms, which can detect patterns and predict the spread of illnesses by sifting through mountains of data. Natural language processing (NLP) methodology is another advancement in AI for EHRs, extracting data from sources that are not organized, such as doctor's notes. Deep learning algorithms are increasingly being used in EHR analysis to analyze complicated data and provide accurate predictions. These formulas can inform public health policy, predict patient outcomes like hospital readmissions, and determine which populations would benefit most from targeted interventions like vaccines against diseases that are more common in specific populations.

AI systems can sift through mountains of EHR data in search of patterns and insights, helping with the early detection of epidemics, the development of individualized treatment plans, and the recognition of illness trends. Healthcare providers may improve decision-making and treatment optimization by using AI for EHR data analysis. However, there are several obstacles to implementing AI into public health EHRs, including the need for high-quality data, compliance with regulations

like the “Health Insurance Portability and Accountability Act” (HIPAA), and the complexity of data in EHRs, including unstructured text, images, and time series data.<sup>x</sup>

AI will play a pivotal role in the future of EHRs in the public health sector, particularly in customized medicine. Algorithms in this sector can analyze data from various sources to predict a patient's risk of illness and direct their treatment choices. Future research should focus on algorithm efficiency, accuracy, ethical and legal considerations, and EHR platform standardization.

#### **PUBLIC HEALTH SURVEILLANCE**

The collection and analysis of data for public health monitoring have traditionally been a labour-intensive and prone-to-error manual process. As the volume of health-related data generated by sources such as social media, sensors, and electronic health records (EHRs) continues to expand, AI has emerged as a powerful tool for public health monitoring. AI systems can analyze massive volumes of data far more quickly than traditional methods, spot patterns, and alert us to possible epidemics and outbreaks of illness in advance. AI technology is helping the CDC monitor the spread of the COVID-19 virus. Electronic health records, social media, and travel data are just a few of the sources that the CDC's AI-powered system may sift through. Possible outbreaks may be detected, and the virus's spread monitored in real time using this approach.<sup>xi</sup>

The fields of infodemiology and infoveillance are able to analyze trends in publishing, social media communication patterns, and search activity thanks to data mining and AI. These technologies powered by AI provide up-to-the-minute insights into public attitudes, illness patterns, and disinformation. This data may be used by public health officials to better communicate with the public, organize responses, and spot diseases early.<sup>xii</sup>

Public health monitoring might benefit from AI's capacity to analyze large datasets, spot trends and patterns, and make predictions. This has the potential to direct public health efforts and halt or lessen the transmission of contagious diseases. Better individual and

community health outcomes may be possible as a consequence of increased prediction efficacy and accuracy made possible by using AI in public health monitoring. Integration and administration of data may be challenging when used for public health monitoring since data often comes from various sources and may have different forms. Since it may be challenging to merge the data and ensure its consistency, the prediction accuracy can take a hit. The use of AI for public health monitoring also raises the possibility of prejudice and bias. The predictions made by an algorithm, for example, are likely to be skewed if the data used to train it is skewed. For public health monitoring in particular, this poses a severe challenge since unfair resource allocation might stem from erroneous estimates, which disproportionately affect already vulnerable populations.

#### **PUBLIC HEALTH CHALLENGES OF AI**

Several challenges need to be addressed before this AI can be safely and effectively used in public health. Ethical and legal considerations, especially those pertaining to personal information and data security, fall under this category. Building confidence in the use of AI to support healthcare policy and practice requires ensuring data privacy, which is emphasized by regulations such as HIPAA in the US, the General Data Protection Regulation (GDPR) and the Data Protection Act of 2018, in the EU and the UK, respectively. Also concerning are the ethical ramifications of issues like prejudice and bias in AI-based systems, which have the potential to impact disadvantaged populations disproportionately.<sup>xiii</sup>

Conversely, AI-based systems' efficacy and precision are dependent on the correctness and comprehensiveness of the data used to train the algorithms. One of the main challenges with AI in public health is the lack of clarity and openness in AI-based solutions. This might lead to cynicism about the use of AI in public health and make it difficult for policymakers to understand how the algorithm arrived at its results.

Yet, COVID-19 did provide a number of recommendations that may serve as a starting point for public health AI initiatives. Among

these standards is the World Health Organization's (WHO) Pillars document, which offers a structure for nations to follow in the event of a public health emergency and serves as a guide for operational preparation and assistance. Several parts of this deal with AI's potential benefits to public health. The first pillar, "Coordination, Planning, and Monitoring at the National Level," suggests using AI to monitor disease transmission, spot possible outbreaks, and organize the reaction to a public health disaster. The second pillar delves into the use of AI to monitor disease outbreaks, locate and analyze cases, and measure the efficacy of treatments. It also examines quick-reaction teams and case investigations.<sup>xiv</sup>

This year's AI for Health Global Summit also addressed related topics. Some of the many suggestions for using AI in public health that came out of the summit include increasing training and education on the topic and advocating for the appropriate and ethical use of AI in this field. Strategies like this should be grounded on research that has been supported by evidence and should be in line with the WHO pillars statement. Considered a resource for the use of AI for public health, these are only a few of the several recommendations that have arisen from COVID-19. These recommendations show how AI may help with public health and provide nations with a framework for when a public health emergency happens.

For AI to be helpful in public health, data security and privacy protection must be top priorities. Robust and generalizable AI models will inevitably make use of patient data from many locations; nonetheless, protecting the privacy and security of this data is of the utmost importance. One possible approach to tackling these difficulties is via collaborative initiatives that include data cooperation and sharing using methods such as federated learning. By combining patient records from different facilities, we can increase the variety and depth of AI models, which in turn makes for more precise and flexible algorithms. Strict data de-identification, aggregation, and anonymization procedures are necessary to accompany this technique and protect patient

privacy. Strict adherence to laws like HIPAA guarantees the proper security of confidential patient data.<sup>xiv</sup> Without storing sensitive information in one place, data sharing and cooperation allow for the combination of insights from many sources. Federated learning is a decentralized method that enables many centres to train AI models independently of each other without exchanging any raw data. To avoid or reduce privacy concerns, models are instead jointly updated using data kept locally. This method helps build a robust community AI model while keeping data within the original organization. Problems with communication inefficiencies, handling dataset heterogeneity, and guaranteeing model convergence are just a few of the obstacles that federated learning must overcome. Scientists are putting a lot of effort into developing better algorithms to solve these problems.<sup>xivi</sup>

#### **CONCLUSION**

The use of AI in public health practices is a crucial and revolutionary force in the quest for a healthier global society. This paper has thoroughly examined the diverse and complex function of AI, including its historical development, current uses, ethical implications, and collaborative efforts. The results emphasize the potential of AI to transform public health while recognizing the need for appropriate application.

The historical progression of artificial intelligence in the field of public health demonstrates an extraordinary evolution. AI has seen significant advancements, progressing from early expert systems in the 1960s to the present age of predictive modelling, illness forecasting, risk prediction, and spatial modelling. This evolution has transformed AI into a revolutionary force. The emergence of sophisticated technologies such as GPT-3 and ChatGPT showcases the ease of use and adaptability of AI in tackling intricate issues in public health decision-making.

The influence of AI on health education and promotion is significant. The research emphasizes the capacity of AI to provide accessible, economical, and engaging solutions. AI solutions provide self-care, remote healthcare services, and individualized

coaching in the management of chronic illnesses, such as diabetes and hypertension. The capacity to improve health outcomes and empower people with personalized guidance represents a fundamental change in health education and promotion tactics.

AI has exceptional proficiency in the field of disease spread modelling. The promise of AI-driven predictive modelling in controlling infectious illnesses is highlighted by its accuracy, efficiency, and ability to expand knowledge, particularly in the context of the COVID-19 pandemic. The use of GPT-3 and ChatGPT in the modelling and control of disease transmission demonstrates a harmonious combination of state-of-the-art technology with public health priorities.

Utilizing AI to examine electronic health records (EHRs) enhances diagnostic precision, treatment strategizing, and illness control to an unparalleled degree of efficiency. Machine learning algorithms and natural language processing methods analyze extensive electronic health record information, yielding valuable insights. AI's ability to better healthcare decision-making, customize medicines, and improve patient outcomes makes it a powerful driver of advancement in public health.

Nevertheless, the research openly acknowledges the ethical and societal consequences that come with the incorporation of AI. Transparency, protection of data privacy, and the presence of prejudice are identified as crucial problems. To ensure fair access to benefits and prevent the worsening of gaps, it is crucial to pay careful attention to these challenges and adhere to responsible AI practices. The report promotes a balanced strategy that optimizes the potential of AI while limiting any unforeseen repercussions.

Collaborative endeavours, such as federated learning and data sharing, provide hopeful resolutions to tackle privacy apprehensions. These efforts facilitate the development of strong community AI models by integrating knowledge from many sources and giving priority to patient privacy. However, the difficulties of communication inefficiencies and guaranteeing model convergence

highlight the intricate nature of applying collaborative techniques in public health.

Ultimately, the research provides a thorough comprehension of the ever-changing environment where artificial intelligence and public health converge. The revolutionary potential of AI is apparent, but it requires a thoughtful and cooperative approach. The future trajectory entails the implementation of conscientious AI methods, continuous research, and joint endeavours to address ethical concerns and unleash the whole range of advantages for worldwide public health. The convergence of AI and public health offers the potential for a better and more resilient future as the globe confronts ongoing health concerns.

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