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Literature Review: Artificial Intelligence in Public Health: Opportunities, Challenges, and Policy Implications

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Abstract

Artificial intelligence (AI) has emerged as a transformative technology with substantial potential to improve public health systems and research. AI technologies are capable of rapidly processing extensive and complex datasets, generating predictive insights, supporting evidence-based decision making, and increasing efficiency in tasks involving text, image, and data analysis. In public health, AI applications include disease surveillance, epidemiological modeling, health communication, resource allocation, and automation of administrative processes. Despite these promising advantages, the implementation of AI in public health is accompanied by important ethical, technical, and regulatory concerns. Major challenges include algorithmic bias, inequitable data representation, threats to privacy and cybersecurity, inadequate digital infrastructures, and insufficient workforce preparedness. Furthermore, excessive reliance on AI systems may weaken critical human judgment and create accountability issues. Policy makers and public health institutions therefore play a critical role in ensuring that AI technologies are implemented responsibly and ethically. Strong regulatory frameworks, transparent governance systems, workforce training, equitable data practices, and cybersecurity measures are essential to maximize the benefits of AI while minimizing its risks. This review discusses the major opportunities and challenges of AI in public health and highlights policy considerations necessary for sustainable and equitable implementation.

Keyword: Artificial Intelligence; Public Health; Digital Health; Epidemiology; Health Policy; Machine Learning; Data Governance

1. Introduction

Artificial intelligence (AI) has increasingly become one of the most influential technological developments in modern healthcare and public health systems. The World Health Organization (WHO) defines AI as the ability of computer systems to perform tasks that are generally linked to human intelligence. AI technologies are able to analyze large volumes of structured and unstructured data, generate predictive outputs, support decision making, and automate complex analytical processes. These capabilities have attracted significant attention from governments, healthcare institutions, and international organizations because of their potential to enhance health systems and support improvements in public health services (1).

The growing interest in AI has been particularly evident in the field of public health, where rapid data analysis and timely decision making are essential. AI applications have expanded from clinical medicine into broader public health functions, including disease surveillance, epidemiological analysis, risk prediction, behavioral monitoring, and health communication (2–5). During recent global health emergencies, including the COVID-19 pandemic, AI technologies demonstrated their ability to support outbreak detection, track disease spread, and optimize healthcare resource allocation.

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Despite these promising developments, the incorporation of AI technologies into public health systems also introduces several ethical, social, and technical challenges. Concerns regarding algorithmic bias, data privacy, cybersecurity, transparency, accountability, and unequal access to digital technologies continue to generate debate among researchers and policy makers. Furthermore, many public health systems still lack adequate infrastructure and trained personnel to implement AI technologies effectively (2–5).

This literature review aims to explore the current role of AI in public health by discussing its major applications, challenges, policy implications, and institutional considerations. In addition, this review highlights the importance of ethical governance and equitable implementation to ensure that AI contributes positively to public health outcomes.

2. Applications of Artificial Intelligence in Public Health

Artificial intelligence (AI) has increasingly transformed various aspects of public health practice by improving surveillance systems, epidemiological analysis, environmental monitoring, health communication, and administrative efficiency. Traditional public health surveillance systems have historically relied on manual methods of data collection and analysis, which are often time-consuming and susceptible to delays and human error. AI technologies offer substantial improvements in this area by automating data analysis and rapidly identifying emerging public health threats through machine learning algorithms and predictive analytics (6). These systems are capable of detecting unusual disease patterns, generating early warning signals, and supporting timely public health interventions. During the COVID-19 pandemic, AI technologies were widely utilized to monitor disease transmission through the integration of multiple data sources, including electronic health records, social media activity, and online news reports (7). In addition to infectious disease surveillance, AI-based systems can also support the monitoring of non-communicable diseases by analyzing demographic, behavioral, and environmental datasets. This capability enables public health authorities to identify trends more effectively and make evidence-based decisions regarding disease prevention and control. Another important advantage of AI in surveillance is its ability to process free-text information. AI systems can analyze death certificates, clinical documentation, and other unstructured data to identify drug-related mortality or emerging health threats before conventional coding systems are completed (3). Consequently, public health institutions are able to respond more rapidly to evolving health challenges.

Beyond surveillance activities, AI technologies have become increasingly valuable in behavioral epidemiology by facilitating the analysis of data generated from social media platforms, wearable devices, and mobile health applications. These data sources provide important insights into health-related behaviors such as physical activity, dietary patterns, sleep quality, and mobility trends (8). Machine learning algorithms can identify behavioral patterns and evaluate the effectiveness of interventions aimed at improving public health behaviors. Furthermore, AI tools are capable of modeling the potential outcomes and trade-offs associated with public health policies and interventions (9). Sentiment analysis techniques have also been applied to examine emotional responses, beliefs, and public perceptions through social media interactions, particularly in the field of mental health research (10,11).

Environmental health is another important area in which AI applications have demonstrated substantial potential. AI-powered technologies using machine learning and sensor-based systems can continuously monitor environmental indicators such as air quality, pollution levels, and temperature changes (12). These technologies allow public health authorities to identify environmental risks more efficiently and develop preventive strategies aimed at reducing exposure-related health problems.

In addition, AI has been increasingly utilized in healthcare logistics, resource allocation, and health planning. During vaccination campaigns, AI models were applied to analyze demographic characteristics, geographical distribution, and healthcare utilization patterns in order to determine optimal vaccination site locations (13). By improving planning efficiency and supporting evidence-based allocation strategies, AI technologies can contribute to more equitable and effective distribution of healthcare resources.

Public health communication has also benefited significantly from AI implementation. AI systems are capable of segmenting populations according to demographic and behavioral characteristics, thereby improving the targeting and personalization of public health messages (14). This approach increases the probability that health communication strategies are culturally appropriate, accessible, and effective for specific populations. AI technologies can additionally generate multilingual content and adapt information according to varying levels of health literacy. Moreover, AI tools can identify and analyze misinformation circulating on digital platforms, allowing public health authorities to respond more effectively to false or misleading information (15). Throughout the COVID-19 pandemic, AI-powered chatbots became an important communication tool. The World Health Organization utilized chatbot systems through communication platforms such as WhatsApp to deliver real-time information regarding symptoms, preventive

measures, and vaccination guidance (16). Studies have suggested that chatbot technologies can improve access to reliable health information while simultaneously reducing misinformation among the public (17).

Another practical application of AI in public health involves the automation of repetitive administrative and analytical tasks. AI systems are capable of summarizing regulations, scientific reports, and clinical guidelines, thereby reducing administrative burden and improving operational efficiency (2,3,6). Through automation of routine processes, public health professionals are able to dedicate more time to strategic activities such as policy development, program planning, and implementation of public health interventions.

3. Challenges in Implementing Artificial Intelligence in Public Health

Although artificial intelligence (AI) provides considerable opportunities for improving public health, several challenges still hinder its broader implementation. One significant issue relates to algorithmic bias, which may occur when AI systems are developed using datasets that fail to adequately reflect diverse populations. Since AI models depend heavily on the quality and composition of training data, incomplete or unbalanced datasets may unintentionally reinforce existing health disparities and contribute to discriminatory outcomes (18). In practice, this problem may disproportionately affect marginalized and vulnerable groups, resulting in unequal healthcare delivery and unfair distribution of public health resources. In some cases, socioeconomic conditions and demographic characteristics may indirectly shape algorithmic outputs and influence decision-making processes in biased ways (19). For this reason, developing training datasets that are diverse, inclusive, and representative remains essential to reducing disparities and improving fairness in AI-based public health applications. Furthermore, equity in AI is not limited to minimizing algorithmic bias alone. It also requires ensuring that the benefits and resources generated through AI technologies are distributed fairly across populations (20). However, defining fairness in algorithmic decision making remains difficult because stakeholders often hold different ethical viewpoints, priorities, and expectations regarding equitable outcomes (21).

Another important challenge related to AI implementation concerns transparency and explainability. Trust plays a critical role in the successful adoption of AI technologies within public health settings. Public health professionals and policy makers need sufficient confidence in AI systems to apply them effectively while still being able to critically assess outputs that may be inaccurate or misleading. This issue has encouraged the development of explainable artificial intelligence (XAI), an approach intended to improve transparency by clarifying how algorithms produce predictions and decisions (22). Through clearer explanations of algorithmic reasoning, XAI may strengthen accountability and help users better understand how AI systems operate. Even so, explainable AI cannot fully prevent errors, inaccurate conclusions, or false interpretations. Therefore, continuous human supervision remains necessary throughout the processes of AI development, implementation, and evaluation.

Data privacy and cybersecurity also continue to be major concerns in the incorporation of AI into public health systems. AI technologies commonly rely on the collection and analysis of large datasets obtained from various sources, including personal health records, demographic data, and behavioral information. The extensive use of sensitive data increases the possibility of re-identification, unauthorized access, and misuse of information (1). In addition, healthcare databases are increasingly targeted by cyberattacks because medical information holds significant economic and strategic value. As a result, public health institutions need to establish strong cybersecurity protections and comprehensive data governance frameworks to maintain confidentiality, data integrity, and responsible data-sharing practices. Reliable and secure digital infrastructures are therefore essential for protecting sensitive information while still supporting the effectiveness of AI-driven public health applications.

Infrastructure limitations also represent a significant obstacle to AI implementation in many public health systems. Many institutions still depend on outdated digital infrastructures that are not capable of supporting large-scale AI technologies or advanced data analytics. At the same time, limited interoperability among health information systems often restricts efficient data integration and data sharing, which can reduce the effectiveness of AI applications in public health environments (23). Consequently, substantial investment in digital infrastructure, interoperable data platforms, secure cloud systems, and advanced computational technologies is required to support the successful adoption of AI-based public health initiatives.

Beyond technical challenges, workforce preparedness and professional training remain critical issues. Many public health professionals still lack sufficient knowledge and practical competencies in artificial intelligence, machine learning, data science, and digital health technologies (23). Although educational materials and training opportunities are becoming more accessible, the rapid advancement of AI technologies demands ongoing learning and continuous professional adaptation. Therefore, public health institutions should prioritize workforce development,

interdisciplinary collaboration, and capacity-building efforts to ensure that healthcare professionals are able to apply AI technologies appropriately, ethically, and effectively within real-world public health practice (24,25).

4. Policy Implications and Regulatory Considerations

The growing use of AI in healthcare and public health has increased the urgency for comprehensive regulatory frameworks that can ensure safety, transparency, and ethical implementation. World Health Organization (WHO) has introduced several principles for AI governance, highlighting the importance of transparency, risk management, stakeholder involvement, and continuous oversight throughout the entire lifecycle of AI technologies (26).

Within the European Union, the Artificial Intelligence Act is considered one of the most comprehensive regulatory frameworks developed for AI technologies (28). The legislation applies a risk-based approach and establishes stricter regulatory requirements for high-risk AI systems, especially those implemented in healthcare and public health contexts (29).

Ethical considerations also remain a fundamental aspect of AI governance. WHO and various international organizations continue to emphasize that AI technologies should uphold human rights, protect patient autonomy, and support the broader public interest (1,30). In addition, ethical AI implementation requires transparency, accountability, and participatory decision-making processes that involve multiple stakeholders.

Collaboration among governments, academic institutions, healthcare organizations, and private sector actors is essential to maximize the potential benefits of AI while minimizing associated risks. Ultimately, public trust in AI technologies will largely depend on whether institutions can demonstrate responsible, transparent, and equitable AI practices.

5. Considerations for Public Health Institutions

Public health institutions play a central role in guiding the responsible implementation of AI technologies. First, institutions must ensure that their workforce understands relevant legal, ethical, and regulatory frameworks governing AI use.

Second, equity should remain a priority throughout AI development and implementation. Public health institutions must ensure that training datasets represent diverse populations and that AI systems do not reinforce existing health inequalities (35).

Third, institutions should invest in secure digital infrastructures capable of processing large-scale datasets while maintaining strong cybersecurity protections. Data governance systems must be continuously updated to address emerging AI-related risks.

Fourth, workforce development is essential. Public health organizations should provide ongoing education and recruit professionals with expertise in AI, epidemiology, and digital health (36).

Finally, institutions must also consider the environmental impact associated with AI technologies, including energy consumption and computational demands (37). Sustainable implementation strategies are therefore necessary to ensure that AI supports both public health and planetary health objectives.

6. Conclusion

Artificial intelligence has substantial potential to transform public health practice by improving surveillance systems, enhancing epidemiological research, supporting resource allocation, strengthening health communication, and increasing operational efficiency. AI technologies can process large and complex datasets rapidly, allowing public health institutions to respond more efficiently to emerging public health threats.

Despite these opportunities, the implementation of AI in public health is associated with important ethical, technical, and organizational challenges. Algorithmic bias, inequitable access, lack of transparency, cybersecurity threats, inadequate infrastructure, and workforce limitations remain significant barriers to successful implementation.

To maximize the benefits of AI while minimizing risks, strong regulatory frameworks, ethical governance systems, investment in digital infrastructure, and continuous workforce development are essential. Public health institutions must prioritize equity, accountability, transparency, and data security to ensure that AI technologies contribute positively to population health outcomes.

Overall, AI represents a promising tool for advancing modern public health systems. However, responsible implementation and interdisciplinary collaboration are necessary to ensure that these technologies are implemented ethically, sustainably, and equitably.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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