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Leveraging artificial intelligence to strengthen public health emergency management in resource-constrained settings: A South African perspective

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Summary

Artificial Intelligence (AI) has emerged as a promising tool for strengthening public health systems, particularly in resource-constrained settings facing increasing burdens of communicable and non-communicable diseases, limited infrastructure, and workforce shortages. Its potential to enhance surveillance, improve decision-making, and optimise resource allocation is especially relevant for Public Health Emergency Management (PHEM). This review aims to examine the role of AI in addressing key challenges in PHEM in resource-constrained settings, with a focus on its applicability to strengthening health system performance in South Africa. A narrative review approach was used, drawing on recent peer-reviewed literature and global health reports on the applications of AI in public health, with a focus on surveillance, outbreak detection, resource optimisation, and health communication. AI applications demonstrate significant potential in improving the timeliness and efficiency of public health responses. For example, AI has been used to integrate multiple data sources for real-time disease surveillance and early outbreak detection, as well as to optimise the placement of vaccination sites during the COVID-19 pandemic. Additionally, AI-enabled telemedicine and predictive analytics can expand access to care and support decision-making in underserved areas. However, implementation remains constrained by challenges related to digital infrastructure, data quality, workforce capacity, governance, and ethical considerations, with risks of exacerbating existing inequalities if not carefully managed. To realise the benefits of AI in PHEM, resource-constrained settings should prioritise investment in digital infrastructure, workforce development, and robust governance frameworks. Sustainable implementation will require strengthening local partnerships, reducing donor dependence through co-financing models, and embedding monitoring and evaluation mechanisms. Thoughtful and context-sensitive integration of AI can enhance equitable, efficient, and resilient public health responses.

Introduction

Resource-constrained settings, particularly in low- and middle-income countries (LMICs), bear a disproportionate burden of disease.[1] It is estimated that over 80% of premature deaths from non-communicable diseases occur in LMICs.[2] These settings also remain highly vulnerable to communicable disease outbreaks, as evidenced by recurrent epidemics such as Ebola, cholera, and mpox. Exacerbating the impact of these challenges are persistent health system constraints, including critical shortages in the health workforce, particularly in sub-Saharan Africa, which carries approximately 25% of the global disease burden yet has only approximately 3% of the world's health workers[3], as well as limitations in infrastructure, data systems, and access to essential technologies. Globally, health systems face a projected shortfall of approximately 11 million health workers by 2030, with the greatest impact in LMICs.[4,5]

Public health is a dynamic and continuously evolving discipline, adapting to emerging challenges while leveraging technological innovation to protect and promote population health.[6] Artificial intelligence (AI) holds significant potential for strengthening health system functioning by enhancing efficiency, reducing costs, supporting evidence-based decision-making, and improving the delivery of services to communities.[6,7] Contemporary challenges, such as the increasing prevalence of chronic diseases, the growing burden of mental health conditions, recurrent infectious disease outbreaks, and persistent health inequalities, require innovative and sustainable solutions. In this context, AI offers a powerful set of tools to address these complex issues more effectively and in a more integrated manner.[8]

AI has the capacity to complement human efforts and holds considerable promise for strengthening preparedness, detection, and response in public health emergencies.[9] However, its effective and equitable application depends on the establishment of robust governance frameworks, sustained investment in infrastructure and skills development, and the enforcement of strong ethical safeguards.[6,10] The integration of AI into healthcare and public health offers significant potential to enhance clinical decision-making, improve the efficiency of managing large clinical datasets[11], detect patterns and trends, and forecast potential public health crises[10], particularly within the context of factors such as increasing healthcare costs, the emergence of novel pathogens, the re-emergence of previously known pathogens, and the increasing prevalence of chronic diseases pushing the limits of traditional public health strategies.[12] However, realising this potential depends on addressing critical challenges related to AI readiness, practitioner adoption, and effective integration within public health systems.[10]

Whilst a growing body of literature has explored the applications of AI in healthcare, much of this work has focused on high-income settings or on technical performance and innovation, with comparatively limited attention given to the practical challenges of implementation in resource-constrained contexts.[13] In particular, there remains a gap in the literature regarding the sustainability of AI interventions, financing mechanisms, and the integration of these technologies into existing public health systems in LMICs.

Objectives

This report seeks to address the identified gap by examining the role of AI in strengthening Public Health Emergency Management (PHEM) through a systems-oriented lens. It focuses on implementation feasibility, financing strategies, and governance considerations, offering context-sensitive insights relevant to South Africa and similar resource-constrained settings. In doing so, it advances practical, policy-relevant recommendations to support the equitable and sustainable integration of AI into public health systems. Specifically, it aims to review applications of AI in public health, examine implementation challenges in resource-constrained settings, and propose policy recommendations for sustainable integration.

Approach

This report is a narrative review of recent literature examining the application of AI in public health and healthcare delivery, with a particular focus on resource-constrained settings.

A targeted search of peer-reviewed and grey literature was conducted using databases including PubMed and Google Scholar, as well as reports from international organisations such as the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC), with search terms including combinations of "artificial intelligence," "digital health," "resource-constrained settings," "low- and middle-income countries," "public health emergency management," and "health system strengthening".

The review prioritised literature published between 2020 and 2025, with emphasis on systematic reviews, implementation studies from LMICs, and policy-relevant reports. Furthermore, the authors' experience in public health practice in South Africa informed the interpretation of the evidence and the development of contextually relevant insights and recommendations.

As a narrative review, this approach is not exhaustive and may be subject to selection bias. However, it is intended to provide a focused and contextually relevant synthesis of key themes and practical considerations for implementation.

Applications of AI in public health

Disease surveillance and early warning

Public health surveillance has traditionally relied on manual data collection and analysis, processes that are often time-intensive and error-prone.[14,15] AI has the potential to transform these activities by automating data analysis, rapidly detecting potential outbreaks, and generating timely alerts.[14] For instance, during the COVID-19 pandemic, the United States CDC applied AI to monitor the spread of disease by integrating data from multiple sources, including electronic health records, social media platforms, and news reports.[6,15]

The COVID-19 pandemic highlighted the need to minimise direct physical contact by using remote healthcare solutions, while simultaneously alleviating the burden on health systems.[16] Thus, when integrated with telemedicine technologies, AI has the potential to transform remote healthcare by offering a convenient and cost-effective alternative to traditional care.[17] By enhancing diagnostics, patient monitoring, and overall quality of care, AI can reduce the need for in-person visits and hospital admissions. Applications such as AI-enabled diagnostic tools, predictive analytics, and teleconsultation platforms enable efficient service delivery across distances and support more accessible, timely healthcare.[18] This approach is particularly important for expanding access to healthcare in underserved and remote populations. Furthermore, AI can support the monitoring of trends for risk factors associated with non-communicable diseases by analysing demographic, behavioural, and environmental data, and incorporating these into forecasting models used for planning.[19] The capacity of AI to process large datasets rapidly accelerates the flow of information to decision-makers, enabling public health authorities to respond more swiftly and effectively to emerging threats.[6]

Resource allocation and response co-ordination

AI has a critical role in enhancing the efficiency of resource allocation, both during public health emergencies, such as disease outbreaks and vaccination campaigns, and within routine healthcare systems where the equitable distribution of personnel, supplies, and services is essential.[20] For example, during the COVID-19 vaccination campaigns, AI models were used to analyse demographic data, health records, and geographical information in order to identify optimal locations for vaccination sites.[20]

Risk communication and community engagement

The significance of risk communication cannot be overemphasised, and AI has an increasingly important role in public health communication by enabling the tailoring of messages to specific populations.[21] AI tools are capable of analysing populations using demographic and behavioural data, thereby increasing the likelihood that the health messages conveyed are culturally appropriate and accessible.[21,22] In addition, AI can support the development of messages across multiple languages and health literacy levels, while also assisting in the identification of misinformation.[22]

AI-driven chatbots are an emerging tool for delivering health-related information. For example, during the COVID-19 pandemic, the WHO deployed chatbots on platforms such as WhatsApp to provide real-time updates on the virus, including guidance on symptoms, preventive measures, and vaccination.[23] Furthermore, chatbots can provide rapid responses that help counter misinformation and guide the public toward credible sources of information.[23,24]

AI-powered platforms also have the potential to promote greater patient involvement in managing their own health through features such as alerts for potential health concerns, support for monitoring personalised care plans, and improved communication with healthcare professionals.[25]

Implementation challenges

Digital infrastructure

The implementation of AI-driven health technologies is significantly constrained by limitations in digital infrastructure, particularly in resource-constrained settings. Reliable connectivity, adequate hardware, and robust health information systems are foundational requirements for the effective deployment of telemedicine and AI-enabled applications.[17,32] Variability in internet access, bandwidth limitations, and uneven distribution of digital resources can impede real-time data exchange, remote consultations, and the functioning of AI-supported tools.[17] In addition, fragmented and poorly integrated health information systems further complicate implementation.

AI applications, particularly those reliant on predictive analytics, require access to large volumes of high-quality, interoperable data.[31] In many settings, however, health data are dispersed across multiple, non-communicating platforms, limiting the ability to aggregate and analyse information effectively. This fragmentation reduces the accuracy and utility of AI-driven insights and constrains their integration into routine clinical and public health decision-making.[31]

Infrastructure challenges also extend to the technical capacity required to support and maintain digital systems.[17,32] Limited availability of skilled personnel, inadequate system maintenance, and insufficient investment in digital health infrastructure can undermine the sustainability of AI implementations.[17,31] Furthermore, the integration of diverse data sources, including electronic health records, laboratory systems, and emerging data streams such as wearable technologies, requires interoperable frameworks and standardised data architectures, which remain underdeveloped in many contexts.[30]

Collectively, these constraints highlight that without substantial investment in digital infrastructure, encompassing connectivity, interoperability, and technical capacity, the potential benefits of AI and telemedicine in improving healthcare delivery and public health outcomes may not be fully realised.

Workforce capacity

Workforce development is equally important.[33] Health professionals, data scientists, and public health managers need training in the interpretation of AI, ethical use, and governance. A study conducted in South Africa highlights that most public health students in the country feel inadequately trained to work with AI, suggesting that without investment in local capacity development, future reliance on external vendors and expertise may persist.[34]

Governance and ethics

The integration of AI into public health systems raises important governance and ethical considerations that must be addressed to ensure responsible, transparent, and equitable implementation. Significant considerations include data privacy, data security, and the ethical use of sensitive health information, particularly in contexts where regulatory frameworks and enforcement mechanisms may be underdeveloped.[35]

In addition, issues related to data quality and representativeness may introduce bias into AI models, potentially reinforcing existing health inequalities if not carefully managed.[6]

Uncertainty around accountability further complicates the use of AI in healthcare, particularly in situations where algorithm-driven outputs influence clinical or public health decision-making. Clear delineation of roles and responsibilities among developers, implementers, and end-users is therefore essential.[10] Moreover, transparency in algorithm design and decision-making processes is critical to building trust among healthcare providers and the public, particularly given concerns regarding the limited transparency of many AI systems currently deployed in healthcare settings.[10]

These challenges emphasise the need for robust governance frameworks that promote ethical AI use while safeguarding patient rights and ensuring equity. Such frameworks should include clear guidelines on data governance, mechanisms for oversight and accountability, and standards for transparency and fairness.[6] However, much of the existing guidance on AI governance is derived from high-income settings, and its applicability to resource-constrained contexts requires careful contextual adaptation.

In the South African context, strengthening regulatory capacity and aligning AI implementation with existing legal and policy instruments will be essential to support safe, effective, and socially responsible adoption of AI in public health.[7,36] Embedding governance and ethical safeguards as foundational components of AI implementation strategies will be critical to ensuring that these technologies contribute to improved health outcomes without further exacerbating existing inequities.

Limitations

This review has several limitations that should be considered when interpreting its findings and recommendations. While the narrative review approach allows for a focused and contextually relevant synthesis of the literature, it is not systematic and may not capture the full breadth of available evidence. As such, relevant studies may have been omitted, including those published in non-English languages or grey literature, introducing the potential for selection bias. Furthermore, much of the available evidence on AI in healthcare is derived from high-income settings, and the transferability of these findings to resource-constrained contexts such as South Africa is not always clear. This may limit the generalisability of some conclusions and highlights the need for context-specific validation. The rapidly evolving nature of AI technologies means that some of the evidence cited may become outdated as new developments and applications emerge.

This review primarily focuses on technical, health system, and policy considerations and does not comprehensively address broader social, cultural, and ethical dimensions of AI implementation, which warrant separate, in-depth investigation. Additionally, certain topics, such as patient-level outcomes, clinical validation of specific AI tools, and detailed economic modelling, were beyond the scope of this review.

The recommendations presented are based on currently available evidence and existing policy frameworks, which may evolve over time. Furthermore, this study did not include primary research or stakeholder engagement, which would provide valuable insights into the feasibility, acceptability, and real-world implementation of AI in South African health systems.

Finally, there remain important gaps in the evidence base, particularly regarding the cost-effectiveness, long-term sustainability, and equity implications of AI interventions in LMICs. Future research should include systematic reviews of the effectiveness of AI in LMICs, context-specific economic evaluations, and qualitative studies involving health workers and communities to better inform implementation strategies.

Conclusion

In this review, we examined the role of AI in strengthening PHEM in resource-constrained settings, with particular reference to the South African context. The findings demonstrate that AI has substantial potential to enhance disease surveillance, improve clinical decision-making, optimise resource allocation, and strengthen health communication. These applications are not only relevant to emergency response but also to broader health system strengthening, including the prevention and management of non-communicable diseases.

However, the effective implementation of AI in these settings is contingent on addressing key systemic challenges. These include fragmented digital infrastructure, limitations in data quality and interoperability, workforce capacity constraints, and the need for robust governance and ethical frameworks. Importantly, this review highlights that technological innovation alone is insufficient; successful integration requires alignment with existing health system structures and priorities.

A central theme emerging from this analysis is the importance of sustainability and financing. While donor funding and external technical support may facilitate early adoption, long-term impact depends on strengthening domestic investment, adopting co-financing models, and building local capacity for development, implementation, and oversight. Without these measures, there is a risk of fragmented implementation and limited scalability.

Moving forward, a phased and context-sensitive approach to AI integration is essential. Priority should be given to strengthening foundational elements such as digital infrastructure and workforce capacity while implementing scalable pilot projects to generate local evidence and guide broader adoption. With strategic planning, strong governance, and sustained investment, South Africa and similar resource-constrained settings can harness AI to enhance public health emergency preparedness and overall health system resilience. Priority should be given to strengthening digital infrastructure, workforce capacity, and governance frameworks as foundational requirements for AI integration.

Recommendations for policy and practice

Considering resource constraints and implementation complexities, these recommendations should be implemented in a phased and prioritised manner, with foundational actions preceding broader system investments and long-term sustainability efforts. Implementation will require sustained financial investment, the scale of which will depend on existing infrastructure and system readiness, with prioritisation of cost-effective, high-impact interventions.

Priority 1: Foundational actions - short-term: 1–2 years

1. Establish and strengthen governance and ethical frameworks:
   The National Department of Health (NDoH), in collaboration with the Information Regulator of South Africa and the Department of Justice and Constitutional Development, should develop, publish, and enforce comprehensive regulatory and ethical frameworks for AI in health, addressing data governance, accountability, transparency, and equity. A suggested target is to establish national AI governance guidelines by 2027, with a proposed indicator being the adoption and implementation of AI regulatory frameworks across national and provincial levels of health.
2. Initiate pilot AI projects in priority areas:
   The NDoH, in partnership with academic institutions and research organisations, should initiate 3-5 pilot AI projects in priority areas such as outbreak detection, maternal health risk prediction, and resource allocation. These pilots should be embedded within existing workflows to generate locally relevant evidence and inform scale-up. A proposed indicator is the number of pilot projects implemented, evaluated, and scaled.
3. Build foundational workforce capacity:
   The NDoH, academic institutions, and professional councils such as the Health Professions Council of South Africa should implement targeted training programmes to strengthen AI literacy, data interpretation, and governance capacity. A proposed indicator is the proportion of health professionals trained in AI-related competencies.

Priority 2: System Development - medium-term: 3–5 years

4. Invest in interoperable digital Infrastructure:
   The NDoH, in collaboration with the Department of Communications and Digital Technologies and the

National Treasury, should prioritise investment in interoperable digital health infrastructure. This includes developing national data standards, enhancing connectivity across health facilities, and enabling real-time data exchange to support surveillance and decision-making. These efforts should align with South Africa's National Digital Health Strategy (2019-2024)[36], which emphasises interoperability, data governance, and the strengthening of digital health systems to improve service delivery and health outcomes. Suggested targets are to establish interoperability standards for health information systems by 2027 and achieve 90% health facility connectivity by 2030.

A proposed indicator is the proportion of health facilities with interoperable digital systems and reliable connectivity.

5. Expand workforce capacity and technical expertise:
   Efforts should be scaled to develop advanced skills in AI, data science, and health informatics through partnerships with universities, research institutions, and the private sector. A proposed indicator is the number of locally trained AI and data science professionals in the health sector.
6. Strengthen strategic partnerships for local innovation:
   The NDoH should foster collaboration with academic institutions, the CSIR, and private sector partners to support the development of contextually relevant AI tools, strengthen data stewardship, and retain technical expertise within South Africa. A proposed indicator is the number of collaborative AI research and development initiatives implemented.

Priority 3: Sustainability and scale – long-term: 5–10 years

7. Promote financial sustainability through co-financing models:
   National Treasury, the NDoH, and development partners, such as the WHO, should implement phased co-financing arrangements, with a gradual transition toward domestic funding of AI initiatives. Dedicated budget allocations should be considered for system maintenance, model updates, and cybersecurity. A proposed indicator is the proportion of AI programme funding derived from domestic sources over time.
8. Institutionalise monitoring and evaluation systems:
   The NDoH, in collaboration with provincial health departments, should establish comprehensive M&E frameworks to assess cost-effectiveness, performance, and equity of AI interventions. A proposed indicator is the routine publication of national or provincial AI implementation and impact reports.
9. Align AI integration with broader health system priorities:
   AI implementation should be aligned with broader efforts to address the social determinants of health, including access to water, sanitation, nutrition, and preventive care. AI tools should complement these efforts through predictive analytics, early warning systems, and targeted health promotion strategies. A proposed indicator is the integration of AI-supported interventions within national health programmes.

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Conflicts of interest

The authors declare that they have no conflicts of interest related to this work.

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