Ghana Journal of Nursing and Midwifery (GJNMID)
https://doi.org/10.69600/gjnmid.2024.v01.i04.16-29 https://gjnmid.com ISSN: 3057-3602 (Online)
Article history: Received date: 11th September 2024; Revision received: 1st October 2024; Accepted for publication: 30th October 2024

# The role of AI in Enhancing Disease Surveillance and Outbreak Response in Developing Countries

Rebecca Boatemaa,[1*] Solomon Ossom Asare,[2] Stephen Cosmos Akabadin,[3] Victor Agyabeng,[4] Alfred Addy[5]
[1]Senior Health Tutor, Assinman Nursing and Midwifery Training College, Assin Fosu
[2]Principal Health Tutor, Assinman Nursing and Midwifery Training College, Assin Fosu
[3]Senior Health Tutor, Assinman Nursing and Midwifery Training College, Assin Fosu
[4]Health Tutor, Assinman Nursing and Midwifery Training College, Assin Fosu
[5]Vice Principal, Assinman Nursing and Midwifery Training College, Assin Fosu
[*]Corresponding author

**Abstract**

This paper examines the potential of AI in enhancing disease surveillance and outbreak response in developing countries. Through a comprehensive literature review, the study assesses the current state of AI applications, identifies challenges and opportunities, and proposes an implementation framework. Findings reveal that AI technologies offer significant advantages in speed, accuracy, and predictive capabilities for disease surveillance. However, challenges such as data quality issues, infrastructure limitations, and ethical concerns persist. The study proposes a framework emphasizing robust data systems, ethical guidelines, and collaborative approaches for effective AI integration. Recommendations include investing in AI infrastructure and capacity building, developing context-specific AI solutions, and fostering international partnerships. The paper concludes that while AI holds immense potential for improving public health surveillance in developing countries, success requires sustained commitment, ethical considerations, and adaptive strategies.

**Keywords**: Artificial Intelligence, Disease Surveillance, Developing Countries, Public Health, Outbreak Response

*Cite this paper as:*

*Boatemaa, R., Asare, S. O., Akabadin, S. C., Agyabeng, V. & Addy, A. (2024). The role of AI in enhancing disease surveillance and outbreak response in developing countries. Ghana Journal of Nursing and Midwifery (GJNMID), 2024 (4).*

*https://doi.org/10.69600/gjnmid.2024.v01.i04.16-29*

## Introduction and Background

The landscape of public health surveillance in developing countries is undergoing a significant transformation, driven by the pressing need for more efficient, accurate, and timely detection of infectious disease outbreaks. Traditional surveillance methods, while foundational, often struggle to keep pace with the rapid spread of diseases in an increasingly interconnected world. This gap has led to a growing interest in leveraging artificial intelligence (AI) to enhance disease surveillance and outbreak response capabilities [1, 2].

The incorporation of AI into public health systems presents a promising solution to many of the challenges faced

Ghana Journal of Nursing and Midwifery (GJNMID)
https://doi.org/10.69600/gjnmid.2024.v01.i04.16-29 https://gjnmid.com ISSN: 3057-3602 (Online)
Article history: Received date: 11th September 2024; Revision received: 1st October 2024; Accepted for publication: 30th October 2024

by developing countries. These nations often grapple with limited resources, inadequate healthcare infrastructure, and a shortage of trained personnel, which can hinder effective disease monitoring and control [3, 4]. AI technologies offer the potential to overcome these barriers by providing tools for early detection, predictive modeling, and data-driven decision-making [5, 6].

Several developing countries have already begun to explore the applications of AI in their public health strategies. In Africa, for instance, initiatives are underway to utilize AI for analyzing large datasets to identify disease patterns and predict outbreaks [1, 4]. Similarly, in parts of Asia, AI-powered systems are being employed to enhance surveillance of vector-borne diseases and support rapid response mechanisms [3, 16].

The potential benefits of fully integrating AI into public health surveillance are manifold. AI systems can process vast amounts of data from diverse sources, including social media, satellite imagery, and electronic health records, to detect anomalies that might indicate an emerging outbreak [7, 10]. This capability not only improves the speed and accuracy of outbreak detection but also enables more targeted and efficient allocation of limited resources [13, 19].

Moreover, the scalability and cost-effectiveness of AI solutions make them particularly attractive for developing countries [7, 20]. By automating certain aspects of surveillance and analysis, AI can help address the chronic shortage of trained epidemiologists and public health professionals in many resource-limited settings [4, 8].

The purpose of this paper is to examine the potential of AI in enhancing disease surveillance and outbreak response in developing countries. Specifically, this study aims to:

1. Assess the current state of AI applications in disease surveillance across developing countries.

2. Identify key challenges and opportunities for integrating AI into public health systems in resource-limited settings.

3. Propose a framework for ethical and effective implementation of AI-driven surveillance in developing countries.

**Significance of the paper**

The significance of this research lies in its potential to inform public health policy and practice in developing nations. By synthesizing current evidence and proposing practical frameworks, this paper aims to guide decision-makers in harnessing the power of AI to strengthen their health systems [14, 21]. Furthermore, it addresses critical gaps in knowledge regarding the implementation of AI in resource-constrained environments, contributing to the broader discourse on global health equity and technological innovation [15, 25].

**Contribution of the paper**

The scientific and novelty contribution of this paper is threefold. First, it provides a comprehensive synthesis of current evidence on AI applications in disease surveillance, with a specific focus on developing country contexts. Second, it proposes a novel framework for AI integration that takes into account the unique challenges and

Ghana Journal of Nursing and Midwifery (GJNMID)
https://doi.org/10.69600/gjnmid.2024.v01.i04.16-29 https://gjnmid.com ISSN: 3057-3602 (Online)
Article history: Received date: 11th September 2024; Revision received: 1st October 2024; Accepted for publication: 30th October 2024

opportunities present in resource-limited settings. Finally, it explores the ethical considerations specific to the use of AI in public health surveillance in developing countries, an area that has received limited attention in existing literature [15, 25].

As the global community continues to face emerging and re-emerging infectious disease threats, the integration of AI into public health surveillance systems represents a critical step towards building more resilient and responsive health systems in developing countries. This paper aims to contribute to this important endeavor by providing a comprehensive analysis of the current landscape, challenges, and future directions for AI-driven disease surveillance in resource-limited settings.

**Methods**

To address the objectives of this study, a comprehensive literature review was conducted using a systematic approach. The search strategy encompassed multiple databases, including Google Scholar, ResearchGate, PubMed, Scopus, and Web of Science, to ensure a broad coverage of relevant literature. Search terms included combinations of keywords such as "artificial intelligence," "machine learning," "disease surveillance," "outbreak response," and "developing countries." The inclusion criteria focused on peer-reviewed articles, conference proceedings, and reputable gray literature published between 2019 and 2024, with a primary focus on studies conducted in or relevant to developing country contexts [19, 22].

Data extraction and analysis followed a thematic approach, with key information organized according to the study's specific objectives [14, 21]. The quality of included studies was assessed using established criteria for evaluating AI and public health research. A synthesis of findings across studies was performed to identify common themes, trends, and gaps in the current knowledge base.

To ensure validity and reliability, the review process adhered to established systematic review methodologies [19, 22]. Multiple researchers were involved in the screening and data extraction processes to minimize bias. Additionally, expert consultation was sought to validate the findings and interpretations.

The replicability of this study is ensured through detailed documentation of the search strategy, inclusion/exclusion criteria, and analysis process. Limitations and potential biases are transparently reported, and where possible, data and analysis tools are made available for further scrutiny and replication [19, 22].

**Results and Discussion**

A. Current State of AI in Disease Surveillance (Objective 1)

The integration of artificial intelligence (AI) into disease surveillance systems represents a significant advancement in public health practices, particularly in developing countries where traditional surveillance

Ghana Journal of Nursing and Midwifery (GJNMID)
https://doi.org/10.69600/gjnmid.2024.v01.i04.16-29 https://gjnmid.com ISSN: 3057-3602 (Online)
Article history: Received date: 11th September 2024; Revision received: 1st October 2024; Accepted for publication: 30th October 2024

methods often face substantial challenges. AI technologies are being applied across various aspects of disease surveillance, leveraging their capacity to process vast amounts of data rapidly and identify patterns that might elude human analysts [2, 6]. Key applications include early warning systems, syndromic surveillance, image analysis, natural language processing, and predictive modeling.

Early warning systems utilizing AI algorithms are being developed to analyze diverse data sources, including social media posts, search engine queries, and climatic data, to detect early signs of disease outbreaks [11]. For instance, machine learning models have shown promise in predicting dengue outbreaks in Southeast Asia by analyzing weather patterns and historical disease data [3]. In the realm of syndromic surveillance, AI-powered systems are enhancing the ability to detect unusual clusters of symptoms that might indicate an emerging outbreak. These systems can analyze electronic health records, emergency department visits, and over-the-counter medication sales to identify anomalies [6].

The application of deep learning algorithms in image analysis has proven particularly valuable in resource-limited settings where expert radiologists may be scarce. These algorithms can rapidly analyze medical images for the diagnosis of infectious diseases, potentially accelerating the detection of outbreaks [28]. Natural language processing techniques are being employed to extract relevant information from unstructured text data, such as clinical notes and scientific literature, further supporting surveillance efforts [11]. Additionally, predictive modeling using AI is being developed to forecast disease spread and identify high-risk areas, enabling more targeted interventions and resource allocation [2].

When comparing AI-driven surveillance methods to traditional approaches, several advantages become apparent. AI systems can process and analyze vast amounts of data in real-time, significantly reducing the time between data collection and actionable insights [10]. This speed and scale of analysis represent a marked improvement over traditional methods, which often involve time-consuming manual data entry and analysis, leading to delays in outbreak detection. Furthermore, AI algorithms can maintain consistent performance over time and across large datasets, potentially reducing human errors and biases that may occur in manual surveillance processes [5].

The ability of AI-driven systems to easily incorporate and analyze data from multiple sources, including non-traditional ones like social media and environmental sensors, provides a more comprehensive view of potential health threats [7]. This integration of diverse data sources is often challenging with traditional surveillance methods. Moreover, while traditional surveillance is largely reactive, AI models can provide predictive insights, allowing for proactive measures to be taken before an outbreak occurs [2].

From a cost perspective, although initial implementation costs for AI systems may be high, they can potentially reduce long-term surveillance costs by automating many labour-intensive processes [7]. However, it's important to note that AI-driven methods also face challenges, particularly in developing country contexts. These include issues related to data quality and availability, the need for specialized technical expertise, and potential biases in AI algorithms [14, 23].

Several developing countries have made significant strides in implementing AI-driven surveillance systems, demonstrating the potential of these technologies in resource-limited settings. In Uganda, an AI-powered system

Ghana Journal of Nursing and Midwifery (GJNMID)
https://doi.org/10.69600/gjnmid.2024.v01.i04.16-29 https://gjnmid.com ISSN: 3057-3602 (Online)
Article history: Received date: 11th September 2024; Revision received: 1st October 2024; Accepted for publication: 30th October 2024

has been implemented that analyzes social media data and news reports to detect early signs of disease outbreaks. This system has shown promise in providing early warnings for diseases like Ebola and cholera [1]. India has developed an AI-based forecasting model to predict dengue outbreaks in various regions of the country. The model incorporates climate data, population density, and historical disease patterns to provide accurate predictions up to three months in advance [3].

In Brazil, researchers have developed an AI system that uses satellite imagery and climate data to predict areas at high risk for Zika virus transmission. This system has helped authorities target vector control efforts more effectively [4]. Thailand has implemented an AI-powered chatbot to collect syndromic data from the general population, showing potential in detecting unusual health trends that might indicate an emerging outbreak [9].

These case studies demonstrate the potential of AI to enhance disease surveillance capabilities in resource-limited settings. However, they also highlight the importance of adapting AI solutions to local contexts and integrating them with existing health systems for maximum effectiveness. As the field continues to evolve, ongoing research and evaluation will be crucial to ensure that AI-driven surveillance systems effectively serve the public health needs of developing countries.

B. Challenges and Opportunities (Objective 2)

The integration of AI into disease surveillance systems in developing countries presents both significant challenges and promising opportunities. One of the primary technical challenges is the issue of data quality and availability [14]. Many developing nations lack robust health information systems, resulting in incomplete, inconsistent, or outdated data. AI models require large amounts of high-quality, representative data to function effectively and avoid biased or inaccurate outputs [23]. To address this challenge, there is a need for investment in data infrastructure and standardization efforts [14]. Additionally, developing AI models that can work with sparse or noisy data and leveraging alternative data sources, such as mobile phone data or satellite imagery, can help supplement traditional health data [17, 23].

Infrastructure limitations pose another significant hurdle in many developing countries. Unreliable electricity supply, limited internet connectivity, and inadequate computing resources can hinder the deployment and operation of AI-driven surveillance systems, particularly in rural or remote areas [14]. Potential solutions include developing AI systems that can operate offline or with intermittent connectivity [23], leveraging cloud computing services to reduce local infrastructure requirements [10], and exploring partnerships with telecommunication companies to improve connectivity in underserved areas [20].

Interoperability and integration of AI systems with existing health information systems and workflows present additional challenges, especially when dealing with legacy systems or diverse data formats [14]. Adopting open standards and APIs to facilitate data exchange [7], developing modular AI solutions that can be easily integrated with existing systems [27], and promoting collaborative efforts between AI developers and health system stakeholders can help ensure seamless integration [9].

The use of AI in public health surveillance also raises important ethical and legal questions, particularly in the context of developing countries where regulatory frameworks may be less developed [15, 25]. The collection and

Ghana Journal of Nursing and Midwifery (GJNMID)
https://doi.org/10.69600/gjnmid.2024.v01.i04.16-29 https://gjnmid.com ISSN: 3057-3602 (Online)
Article history: Received date: 11th September 2024; Revision received: 1st October 2024; Accepted for publication: 30th October 2024

analysis of large-scale health data for AI-driven surveillance raise concerns about individual privacy and data protection [15]. Many developing countries lack comprehensive data protection laws, potentially exposing individuals to privacy risks. To address these concerns, it is crucial to develop and implement robust data governance frameworks [25], employ privacy-preserving AI techniques such as federated learning or differential privacy [15], and engage in public dialogue and education about the benefits and risks of AI in health surveillance [25].

Algorithmic bias and fairness present another significant ethical challenge. AI systems may inadvertently perpetuate or exacerbate existing health disparities if they are trained on biased data or fail to account for the diverse contexts in developing countries [15]. Ensuring diverse representation in AI development teams [25], implementing rigorous testing and auditing processes to detect and mitigate biases [15], and developing context-specific AI models that account for local health disparities and social determinants of health [8] are essential steps in addressing this challenge.

The "black box" nature of some AI algorithms can make it difficult to understand and explain their decision-making processes, raising concerns about accountability and trust [25]. Promoting the use of explainable AI techniques [15], establishing clear guidelines for the use and interpretation of AI-generated insights in public health decision-making [25], and implementing robust monitoring and evaluation frameworks for AI-driven surveillance systems [7] can help address these transparency and accountability issues.

Capacity building and human resource needs present another set of challenges in implementing AI-driven surveillance systems. Many developing countries face a significant shortage of professionals with expertise in AI and data science, particularly in the context of public health [8]. Investing in education and training programs focused on AI and health informatics [20], establishing partnerships with academic institutions and tech companies for knowledge transfer [9], and developing user-friendly AI tools that require minimal specialized knowledge to operate [27] can help address this shortage.

The introduction of AI systems may also face resistance from health workers who are accustomed to traditional surveillance methods or who fear job displacement [20]. Engaging health workers in the design and implementation of AI systems [8], providing training and support to help health workers adapt to new technologies [20], and emphasizing the role of AI as a tool to augment human capabilities rather than replace them [7] can help overcome this resistance.

Despite these challenges, the integration of AI into disease surveillance systems presents significant opportunities for innovation and leapfrogging in developing countries [17, 24]. AI can help overcome resource constraints by automating labor-intensive surveillance tasks and enabling more efficient use of limited public health resources [24]. AI-driven systems can enable faster detection and response to emerging health threats, potentially preventing large-scale outbreaks [17].

The development of AI solutions tailored to the specific needs and contexts of developing countries can lead to innovative approaches that may have global applications [24]. The widespread adoption of mobile phones in developing countries provides a unique opportunity to implement AI-driven surveillance systems that leverage

Ghana Journal of Nursing and Midwifery (GJNMID)
https://doi.org/10.69600/gjnmid.2024.v01.i04.16-29 https://gjnmid.com ISSN: 3057-3602 (Online)
Article history: Received date: 11th September 2024; Revision received: 1st October 2024; Accepted for publication: 30th October 2024

mobile data and engage citizens in participatory surveillance efforts [17]. Furthermore, the implementation of AI in public health surveillance can catalyze collaboration between the health sector, technology industry, and academia, fostering innovation ecosystems in developing countries [24].

By addressing these challenges and capitalizing on the opportunities, developing countries can harness the power of AI to significantly enhance their disease surveillance capabilities and contribute to global health security. The next section will propose a framework for implementing AI in disease surveillance systems that addresses these challenges and leverages the identified opportunities.

C. Framework for AI Implementation (Objective 3)

To effectively integrate AI into disease surveillance systems in developing countries, a comprehensive framework is necessary. This framework should address the unique challenges and opportunities present in resource-limited settings while ensuring ethical and sustainable implementation.

An effective AI-driven surveillance system for developing countries should incorporate several key components [5, 7, 27]. Firstly, robust data collection and integration mechanisms are essential. These should be capable of capturing diverse data types, including clinical, environmental, and social media data. Data integration platforms that can harmonize information from multiple sources are crucial, as is ensuring data quality through validation and cleaning processes.

The AI analytics engine forms the core of the surveillance system. It should deploy machine learning algorithms capable of detecting anomalies and predicting outbreaks, implement natural language processing tools for analyzing unstructured data, and develop visualization tools for presenting insights in an easily understandable format. An early warning and alert system is another critical component, creating automated alert mechanisms for notifying relevant stakeholders of potential outbreaks, implementing risk stratification models to prioritize responses, and developing user-friendly interfaces for public health officials to access and interpret AI-generated insights.

A response coordination platform should integrate the AI system with existing emergency response protocols, develop decision support tools to guide resource allocation and intervention strategies, and implement communication channels for coordinating multi-sectoral responses. Finally, mechanisms for continuous learning and improvement are essential, establishing feedback loops to update and improve AI models based on new data and outcomes, implementing performance monitoring tools to assess the system's accuracy and effectiveness, and developing mechanisms for incorporating expert knowledge and local context into the AI models.

Implementing AI-driven surveillance systems in resource-limited settings requires innovative approaches to overcome constraints [4, 10]. Cloud-based solutions can be leveraged to reduce local infrastructure requirements, while serverless architectures can minimize maintenance needs and costs. A mobile-first approach, developing mobile applications for data collection and dissemination of alerts, and utilizing SMS and USSD platforms for data collection in areas with limited internet connectivity, can help overcome connectivity challenges.

Utilizing open-source AI frameworks and tools can reduce licensing costs, while encouraging the development

Ghana Journal of Nursing and Midwifery (GJNMID)
https://doi.org/10.69600/gjnmid.2024.v01.i04.16-29 https://gjnmid.com ISSN: 3057-3602 (Online)
Article history: Received date: 11th September 2024; Revision received: 1st October 2024; Accepted for publication: 30th October 2024

of open-source AI models tailored for public health surveillance in developing countries can foster innovation and knowledge sharing. A modular and scalable design approach allows for incremental implementation and scaling, prioritizing essential functionalities for initial deployment with the ability to add features over time.

Local capacity building is crucial for sustainable implementation. Investing in training local personnel to develop, maintain, and operate AI systems, and establishing partnerships with local universities to foster a pipeline of AI talent can help address the skills gap. Public-private partnerships, collaborating with tech companies to access advanced AI technologies and expertise, and engaging telecommunication companies to improve connectivity in underserved areas, can help overcome resource constraints.

To ensure responsible and equitable use of AI in disease surveillance, ethical guidelines must be incorporated into the implementation framework [15, 25]. These should address privacy and data protection, implementing robust data anonymization and encryption techniques, establishing clear data governance policies, and adhering to international standards for health data protection. Transparency and explainability are crucial, using interpretable AI models when possible, especially for high-stakes decisions, and providing clear explanations of how AI-generated insights are derived and their limitations.

Fairness and non-discrimination must be prioritized, regularly assessing AI models for potential biases and taking corrective actions, ensuring diverse representation in training data and AI development teams, and implementing fairness constraints in AI algorithms to prevent discriminatory outcomes. Clear lines of accountability and liability should be established, developing protocols for addressing and rectifying errors or unintended consequences, and implementing robust audit trails for AI system actions and decisions.

Community engagement and consent are essential ethical considerations. Engaging local communities in the design and implementation of AI surveillance systems, obtaining community-level consent for data collection and use, and providing mechanisms for community feedback and grievance redressal can help build trust and ensure that AI systems serve the needs of the communities they are intended to benefit.

Successful implementation of AI-driven surveillance systems in developing countries requires strong collaborative approaches and international partnerships [9, 20]. South-South collaboration can foster knowledge sharing and technology transfer between developing countries, establish regional centers of excellence for AI in public health, and develop shared data repositories and AI models tailored to regional health challenges. North-South partnerships can engage with advanced research institutions for capacity building and knowledge transfer, collaborate with international tech companies to access cutting-edge AI technologies, and leverage funding and technical assistance from international development agencies.

Multi-sectoral collaboration is crucial, establishing partnerships between health ministries, academic institutions, and the private sector, engaging civil society organizations to ensure community representation and trust-building, and collaborating with telecommunication and tech companies for data access and infrastructure support. Participation in global health security initiatives can help share best practices and resources, contribute to the development of international standards for AI in disease surveillance, and engage in cross-border collaborations for monitoring and responding to transnational health threats.

Ghana Journal of Nursing and Midwifery (GJNMID)
https://doi.org/10.69600/gjnmid.2024.v01.i04.16-29 https://gjnmid.com ISSN: 3057-3602 (Online)
Article history: Received date: 11th September 2024; Revision received: 1st October 2024; Accepted for publication: 30th October 2024

Open innovation platforms can create challenges to crowd-source AI solutions for specific health surveillance problems, establish online platforms for sharing AI models, datasets, and best practices, and encourage the development of a global community of practice for AI in public health surveillance.

By implementing this comprehensive framework, developing countries can harness the power of AI to enhance their disease surveillance capabilities while addressing ethical concerns and resource constraints. The framework emphasizes the importance of tailoring AI solutions to local contexts, building sustainable capacities, and fostering international collaboration to achieve robust and equitable public health surveillance systems. As the field continues to evolve, ongoing research, evaluation, and adaptation of this framework will be crucial to ensure that AI-driven surveillance systems effectively serve the public health needs of developing countries while upholding principles of equity, privacy, and human rights.

**Conclusion and Recommendations**

A. Summary of Key Findings

The integration of artificial intelligence (AI) into disease surveillance and outbreak response systems in developing countries presents both significant opportunities and challenges. This study has examined the current state of AI applications in public health surveillance, identified key challenges and opportunities, and proposed a framework for ethical and effective implementation.

1. Current State of AI in Disease Surveillance:

- AI technologies are being successfully applied in various aspects of disease surveillance, including early warning systems, syndromic surveillance, image analysis, and predictive modeling [2, 6, 11].
- AI-driven approaches offer advantages over traditional surveillance methods in terms of speed, scale, accuracy, and predictive capabilities [5, 7, 10].
- Several developing countries have implemented promising AI-powered surveillance systems, demonstrating the potential for these technologies in resource-limited settings [1, 3, 4, 9].

2. Major Challenges and Opportunities:

- Technical challenges include issues related to data quality and availability, infrastructure limitations, and interoperability with existing systems [14, 23].
- Ethical and legal considerations encompass privacy concerns, potential algorithmic biases, and the need for transparency and accountability [15, 25].
- Capacity building and human resource needs present significant hurdles, including the shortage of AI expertise and potential resistance to change [8, 20].
- Despite these challenges, AI offers opportunities for innovation, leapfrogging traditional surveillance methods, and addressing unique local health challenges [17, 24].

3. Critical Elements of the Proposed Implementation Framework:

- Key components of an effective AI surveillance system include robust data collection and integration,

Ghana Journal of Nursing and Midwifery (GJNMID)
https://doi.org/10.69600/gjnmid.2024.v01.i04.16-29 https://gjnmid.com ISSN: 3057-3602 (Online)
Article history: Received date: 11th September 2024; Revision received: 1st October 2024; Accepted for publication: 30th October 2024

advanced analytics engines, early warning systems, response coordination platforms, and mechanisms for continuous learning [5, 7, 27].

- Strategies for overcoming resource constraints involve leveraging cloud-based solutions, adopting mobile-first approaches, utilizing open-source technologies, and fostering public-private partnerships [4, 10].
- Ethical guidelines emphasize the importance of privacy protection, transparency, fairness, accountability, and community engagement [15, 25].
- Collaborative approaches and international partnerships are crucial for successful implementation, including South-South collaboration, North-South partnerships, and multi-sectoral engagement [9, 20].

B. Recommendations

Based on these findings, the following recommendations are proposed for various stakeholders involved in the implementation of AI-driven disease surveillance systems in developing countries:

1. For Policymakers and Health Officials:

a) Invest in AI infrastructure and capacity building:

- Allocate resources for developing robust data collection and management systems [1, 4].
- Establish national strategies for AI in public health, with clear objectives and funding mechanisms [9].
- Invest in education and training programs to build local AI expertise [20].

b) Develop ethical guidelines and regulatory frameworks:

- Enact comprehensive data protection laws that address the specific challenges of AI in healthcare [15, 25].
- Establish national ethics committees to oversee the development and deployment of AI in public health [25].
- Develop clear guidelines for the responsible use of AI in disease surveillance and outbreak response [15].

c) Foster enabling environments for AI innovation:

- Create incentives for private sector involvement in AI-driven public health initiatives [20].
- Establish regulatory sandboxes to test innovative AI solutions in controlled environments [4].
- Promote cross-sector collaboration between health, technology, and academic sectors [9].

2. For Researchers and Developers:

a) Focus on context-specific AI solutions:

- Develop AI models that can operate effectively with limited or noisy data [3, 8].
- Create user-friendly interfaces that account for varying levels of technical expertise among users [27].
- Incorporate local knowledge and cultural factors into AI model development [8].

Ghana Journal of Nursing and Midwifery (GJNMID)
https://doi.org/10.69600/gjnmid.2024.v01.i04.16-29 https://gjnmid.com ISSN: 3057-3602 (Online)
Article history: Received date: 11th September 2024; Revision received: 1st October 2024; Accepted for publication: 30th October 2024

b) Prioritize data privacy and security:

- Implement privacy-preserving AI techniques, such as federated learning and differential privacy [15].
- Develop robust data anonymization and encryption protocols [25].
- Create transparent audit trails for AI decision-making processes [15].

c) Enhance model interpretability and fairness:

- Develop explainable AI models that can provide clear rationales for their outputs [15].
- Implement rigorous testing protocols to identify and mitigate potential biases [25].
- Create diverse development teams to ensure multiple perspectives are considered [8].

3. For International Organizations and Donors:

a) Support AI initiatives in developing countries:

- Provide funding and technical assistance for AI-driven surveillance projects [9, 20].
- Facilitate partnerships between developed and developing countries for knowledge transfer [1, 4].
- Invest in regional centers of excellence for AI in public health [20].

b) Facilitate knowledge sharing and technology transfer:

- Establish platforms for sharing best practices, AI models, and datasets [9].
- Support open-source initiatives that can benefit multiple countries [20].
- Foster communities of practice for AI in global health security [1].

c) Promote global standards and ethical frameworks:

- Develop international guidelines for the ethical use of AI in public health surveillance [15, 25].
- Create mechanisms for independent evaluation and certification of AI systems [25].
- Support the development of global health data sharing protocols [9].

In conclusion, the integration of AI into disease surveillance and outbreak response systems holds immense potential for enhancing public health capabilities in developing countries. By addressing the identified challenges, leveraging opportunities, and following the proposed implementation framework, these nations can harness the power of AI to build more resilient and responsive health systems. However, success will require sustained commitment, collaborative efforts, and a strong focus on ethical and context-appropriate solutions. As the field continues to evolve, ongoing research and evaluation will be crucial to ensure that AI-driven surveillance systems effectively serve the public health needs of developing countries while upholding principles of equity, privacy, and human rights.

Ghana Journal of Nursing and Midwifery (GJNMID)
https://doi.org/10.69600/gjnmid.2024.v01.i04.16-29 https://gjnmid.com ISSN: 3057-3602 (Online)
Article history: Received date: 11th September 2024; Revision received: 1st October 2024; Accepted for publication: 30th October 2024

**References**

[1] Tanui, C. K., Ndembi, N., Kebede, Y. & Tessema, S. K. (2024). Artificial intelligence to transform public health in Africa. The Lancet Infectious Diseases e542, 24-9. https://doi.org/10.1016/S1473-3099(24)00435-3.

[2] Parums D.V. (2023). Infectious Disease Surveillance Using Artificial Intelligence (AI) and its Role in Epidemic and Pandemic Preparedness. Editorial Med Sci Monit.29:e941209. https://doi.org/10.12659/MSM.941209.

[3] Rahman, M.S., Safa, N.T., Sultana, S., Salam, S., Karamehic-Muratovic, A. & Overgaard, H.J. (2022). Role of artificial intelligence-internet of things (AI-IoT) based emerging technologies in the public health response to infectious diseases in Bangladesh. Parasite Epidemiology and Control, 18(e00266). https://doi.org/10.1016/j.parepi.2022.e00266.

[4] Otaigbe I (2022). Scaling up artificial intelligence to curb infectious diseases in Africa. *Front. Digit. Health* 4:1030427. https://doi.org/10.3389/fdgth.2022.1030427.

[5] Kibibi Muthoni L. (2024). The Role of AI in Enhancing Public Health Surveillance. Eurasian Experiment Journal of Biological Sciences, 5(2):37-40. https://kiu.ac.ug/assets/publications/2686_the-role-of-ai-in-enhancing-public-health-surveillance.pdf.

[6] Zengtao Jiao, Hanran Ji, Jun Yan, Xiaopeng Qi. (2022). Application of big data and artificial intelligence in epidemic surveillance and containment. Intelligent Medicine, 3(1): 36-43. https://doi.org/10.1016/j.imed.2022.10.003.

[7] Anjaria, P., Asediya, V., Bhavsar, P., Pathak, A., Desai, D., & Patil, V. (2023). Artificial Intelligence in Public Health: Revolutionizing Epidemiological Surveillance for Pandemic Preparedness and Equitable Vaccine Access. *Vaccines*, *11*(7), 1154. https://doi.org/10.3390/vaccines11071154.

[8] Isiaka, Amarachukwu., Anakwenze, Vivian., Ilodinso, Chiamaka., Anaukwu, Chikodili., Ezeokoli, Chukwuebuka., Noi, Samuel Mensah., Agboola, Gazali & Adonu, Richard Mensah. (2024). Harnessing Artificial Intelligence for Early Detection and Management of Infectious Disease Outbreaks. International Journal of Innovative Research and Development. 13. 52-65. https://doi.org/10.24940/ijird/2024/v13/i2/FEB24016.

[9] Tshimula, J. M. et al. (2024). Artificial Intelligence for Public Health Surveillance in Africa: Applications and Opportunities. https://arxiv.org/html/2408.02575v1.

[10] Pillai, S.V. & Kumar, R.S. (2021). The role of data-driven artificial intelligence on COVID-19 disease management in public sphere: a review. *Decision* **48**, 375–389. https://doi.org/10.1007/s40622-021-00289-3.

[11] Zeng, Daniel Dajun., Cao, Zhidong & Neill, Daniel. (2021). Artificial intelligence–enabled public health surveillance—from local detection to global epidemic monitoring and control. https://doi.org/10.1016/B978-0-12-821259-2.00022-3.

[12] Popescu, S.V. (2023). Using AI as a Tool for Infectious Disease Surveillance. https://www.contagionlive.com/view/using-ai-as-a-tool-for-infectious-disease-surveillance.

[13] Farhat F, Sohail SS, Alam MT, Ubaid S, Shakil, Ashhad M & Madsen DØ (2023). COVID-19 and beyond: leveraging artificial intelligence for enhanced outbreak control. *Front. Artif. Intell.* 6:1266560. https://doi.org/10.3389/frai.2023.1266560.

[14] Achieng, M. S., & Ogundaini, O. O. (2024). Big Data Analytics for Integrated Infectious Disease Surveillance in sub-Saharan Africa. South African Journal of Information Management, 26(1), 1668. https://doi.org/10.4102/sajim.v26i1.1668.

[15] Mensah, G. B. (2024). Artificial Intelligence and Ethics: A Comprehensive Review of Bias Mitigation, Transparency, and Accountability in AI Systems. Preprint. https://doi.org/10.13140/RG.2.2.23381.19685/1.

[16] Piccialli, F., di Cola, V., Giampaolo, F. *et al.* The Role of Artificial Intelligence in Fighting the COVID-19 Pandemic. *Inf Syst Front* **23**, 1467–1497 (2021). https://doi.org/10.1007/s10796-021-10131-x

[17] Pley, C., Evans, M., Lowe, R., Montgomery, H. & Yacoub, S. (2021). Digital and technological innovation in vector-borne disease surveillance to predict, detect, and control climate-driven outbreaks. The Lancet Planetary Health e739. https://doi.org/10.1016/S2542-5196(21)00141-8.

https://doi.org/10.69600/gjnmid.2024.v01.i04.16-29 https://gjnmid.com ISSN: 3057-3602 (Online)
Article history: Received date: 11th September 2024; Revision received: 1st October 2024; Accepted for publication: 30th October 2024

[18] Mensah, G. B. (2023). AI-Augmented Public Health Administration in sub-Saharan Africa: Addressing Challenges in Ghana's Cyberlaws Regimes for Smooth and Effective Use. International Journal of Legal Science and Innovation 5(6), 26 - 54.

[19] Syrowatka, A., Kuznetsova, M., Alsubai, A. *et al.* (2021). Leveraging artificial intelligence for pandemic preparedness and response: a scoping review to identify key use cases. *npj Digit. Med.* **4**, 96. https://doi.org/10.1038/s41746-021-00459-8.

[20] Zuhair, V., Babar, A., Ali, R., Oduoye, M. O., Noor, Z., Chris, K., Okon, I. I. & Rehman, L. U. (2024). Exploring the Impact of Artificial Intelligence on Global Health and Enhancing Healthcare in Developing Nations. Journal of Primary Care & Community Health 15 (21501319241245847). https://doi.org/10.1177/21501319241245847.

[21] Reinoso, G. P. G et al. (2024). Epidemiological Surveillance Innovative Applications for Community and Public Health: A Systematic Review. International Journal of Medical Science and Clinical Research Studies 04(03): 546-555. https://doi.org/10.47191/ijmscrs/v4-i03-32.

[22] Althagafi, H.M.S et al. (2022). Epidemiological Surveillance Systems in the Digital Age: A Review of Innovations and Applications. Migration Letters 19(S2): 1037-1047.

[23] Olaboye, J.A., Maha, C.C., Kolawole, T.O. & Samira Abdul. (2024). Innovations in real-time infectious disease surveillance using AI and mobile data. International Medical Science Research Journal 4(6): 647-667. https://doi.org/10.51594/imsrj.v4i6.1190.

[24] Mhlanga, D. (2022). The Role of Artificial Intelligence and Machine Learning amid the COVID-19 Pandemic: What Lessons Are We Learning on 4IR and the Sustainable Development Goals. *Int. J. Environ. Res. Public Health*, *19*, 1879. https://doi.org/10.3390/ijerph19031879.

[25] Mensah, G. B. (2024). AI Ethics. Africa Journal For Regulatory Affairs (AJFRA), 2024(1), 32-45. https://doi.org/10.62839/AJFRA/2024.v1.I1.32-45.

[26] Aldubikhi, A.I.S. (2022). The Role of Artificial Intelligence in the Control and Prevention of Infectious Diseases. Journal of Health Informatics in Developing Countries 1(7). https://www.jhidc.org/index.php/jhidc/article/view/387/358.

[27] Mokhtari, A. Artificial Intelligence for Public Health Surveillance: Harnessing new advances in predictive modeling. https://www.boozallen.com/insights/ai-research/artificial-intelligence-for-public-health-surveillance.html.

[28] Wong, Z. S.Y., Zhou, J. & Zhang, Q. (2019). Artificial Intelligence for infectious disease Big Data Analytics. Infection, Disease & Health 24(1). https://doi.org/10.1016/j.idh.2018.10.002.