Role of artificial intelligence in disease surveillance

Submission: 05 January 2026 | Acceptance: 20 May 2026 | Publication: 17 July 2026

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ABSTRACT:

Background: Artificial intelligence (AI) has revolutionized disease surveillance by enhancing early detection, real-time monitoring, and predictive modeling of infectious and non-infectious diseases. AIdriven systems have improved accuracy and efficiency in tracking disease patterns, enabling timely interventions and public health responses.

Aim: This study aimed to evaluate the effectiveness of AI-based disease surveillance systems in identifying disease outbreaks, predicting trends, and improving public health decision-making. **Methods:** A retrospective observational study was conducted at Services Hospital, Lahore, from February 2024 to January 2025. A total of 130 cases were analyzed to assess the impact of AI-driven surveillance tools on disease monitoring. Data were collected from hospital records, AI-integrated epidemiological tracking systems, and public health reports. The study compared AI-based predictions with traditional surveillance methods in terms of accuracy, response time, and outbreak detection efficiency. **Results:** AI-based surveillance significantly improved disease detection accuracy compared to conventional methods ($p < 0.05$). The average response time for identifying outbreaks was reduced by 35%, leading to faster public health interventions. Predictive modeling demonstrated high reliability, with a sensitivity of 92% and specificity of 89% in forecasting disease trends. AI tools effectively analyzed large datasets, identified emerging health threats, and optimized resource allocation for disease control. **Conclusion:** The study confirmed that AI played a crucial role in enhancing disease surveillance by improving detection accuracy, reducing response time, and enabling efficient outbreak management. Integrating AI with traditional surveillance strategies could strengthen public health preparedness and response capabilities. Further research is recommended to refine AI models for broader applications in epidemiology. **Keywords:** Artificial intelligence, disease surveillance, outbreak detection, predictive modeling, public health, epidemiology, AI-driven monitoring.

INTRODUCTION:

Artificial intelligence (AI) had played an increasingly significant role in disease surveillance, offering innovative solutions to monitor, predict, and control the spread of infectious and chronic diseases. Traditional methods of disease surveillance, which relied on manual data collection, laboratory testing, and epidemiological modeling, had several limitations, including delays in data processing and reporting. AI-based approaches, however, had the potential to enhance the speed, accuracy, and efficiency of disease monitoring by leveraging vast amounts of real-time data from multiple sources, including electronic health records, social media, and remote sensing technologies [1]. Machine learning algorithms had been widely used in disease surveillance to analyze large datasets and identify patterns that could signal outbreaks. These algorithms had been trained on historical data to detect anomalies and predict the likelihood of disease emergence [2]. For example, AI-driven models had been employed to forecast influenza outbreaks by analyzing trends in patient visits, pharmacy purchases, and online searches for flu-related symptoms. Similarly, AI had played a crucial role in tracking vectorborne diseases such as dengue and malaria by incorporating environmental and climatic data to predict high-risk regions [3].

The COVID-19 pandemic had underscored the importance of AI in disease surveillance. AI-powered systems had been used to detect early signals of the outbreak by monitoring global news reports, social media discussions, and health records. AI models had helped in predicting the spread of the virus, estimating case numbers, and guiding public health interventions. For instance, AI-driven platforms such as BlueDot and HealthMap had provided early warnings about the outbreak by analyzing global disease patterns [4]. Moreover, AI had assisted in contact tracing efforts, helping authorities track infected individuals and their potential contacts more efficiently.

Natural language processing (NLP) had been another critical component of AI-driven disease surveillance. NLP algorithms had been used to extract valuable insights from unstructured data sources, such as clinical notes, research articles, and online discussions. These insights had enabled health agencies to identify emerging health threats and respond proactively [5]. Additionally, AI-based sentiment analysis had been utilized to assess public perceptions of disease outbreaks and vaccination programs, allowing policymakers to tailor communication strategies accordingly.

Remote sensing and AI integration had further enhanced disease surveillance capabilities. AI-driven image analysis had been used to monitor environmental changes that contributed to disease outbreaks. For example, satellite imagery combined with AI algorithms had been applied to track deforestation, urbanization, and climate

change, which had influenced the spread of zoonotic diseases [6]. Drones equipped with AI-powered sensors had also been deployed to monitor mosquito breeding sites, facilitating targeted interventions to control vector-borne diseases.

Despite its numerous advantages, AI-driven disease surveillance had faced several challenges. Data privacy concerns, biases in AI algorithms, and the need for high-quality datasets had posed significant barriers to implementation. Moreover, AI models had required continuous updating and validation to maintain accuracy and reliability in diverse healthcare settings [7]. Ethical considerations regarding the use of AI in public health decision-making had also been a topic of debate.

Overall, AI had revolutionized disease surveillance by providing real-time monitoring, predictive analytics, and automated data processing. As AI technologies continued to evolve, their integration with public health infrastructure had been expected to improve disease detection and response strategies. Future advancements in AI, coupled with interdisciplinary collaborations, had the potential to further enhance global disease surveillance systems, ultimately contributing to improved health outcomes and epidemic preparedness [8].

MATERIALS AND METHODS:

Study Design and Setting:

This study was conducted as a descriptive, observational study at Services Hospital, Lahore to evaluate the role of artificial intelligence (AI) in disease surveillance. The study took place over a period of twelve months, from February 2024 to January 2025.

Study Population:

A total of 130 participants were included in the study. The study population comprised healthcare professionals, hospital administrators, and data scientists involved in AI-based disease surveillance. Additionally, epidemiological data from hospital records and AI-driven surveillance systems were analyzed.

Data Collection:

Data were collected using a combination of structured interviews, retrospective hospital records, and AIbased surveillance reports. The study incorporated:

Interviews with stakeholders to assess the perceived effectiveness and challenges of AI implementation.

Hospital surveillance data to compare AI-driven predictions with traditional disease monitoring systems. Real-time AI-based analytics reports to evaluate AI's accuracy, sensitivity, and specificity in detecting disease outbreaks.

AI-Based Surveillance System Evaluation:

The study analyzed AI models used at Services Hospital for disease surveillance. The AI tools included machine learning algorithms, natural language processing (NLP) for symptom pattern recognition, and automated alert systems. The effectiveness of these AI models was assessed using:

Predictive accuracy compared to historical hospital data.

Timeliness of disease detection relative to conventional methods.

User satisfaction and feasibility of integration into the hospital's workflow.

Data Analysis:

Quantitative data were analyzed using SPSS (version 26.0). Descriptive statistics (mean, standard deviation, and percentage distributions) were used to summarize the effectiveness of AI models.

Sensitivity, specificity, and positive predictive values of AI-based surveillance were calculated. Qualitative data from interviews were analyzed using thematic analysis to identify key challenges and advantages.

Ethical Considerations:

Ethical approval was obtained from the Institutional Review Board of Services Hospital, Lahore. Written informed consent was obtained from all participants before interviews. Patient data used in AI evaluations were anonymized to ensure privacy and confidentiality.

RESULTS:

This study was conducted at Services Hospital, Lahore, with a total study population of 130 participants from February 2024 to January 2025. The results demonstrated the effectiveness of artificial intelligence (AI) in disease surveillance by analyzing diagnostic accuracy, response time, and predictive capabilities in detecting infectious diseases.

Table 1: Comparison of AI-Based and Traditional Surveillance Methods:

Parameter	AI-Based Surveillance	Traditional Surveillance
Average Disease Detection Time (hours)	3.5	18
Sensitivity (%)	92	75
Specificity (%)	90	78
Accuracy (%)	91	76
False Positive Rate (%)	8	22
False Negative Rate (%)	7	18

Table 1 compared AI-based disease surveillance with traditional methods. AI-based surveillance significantly reduced the disease detection time (3.5 hours vs. 18 hours), thereby enhancing early intervention capabilities. The AI model exhibited higher sensitivity (92%) and specificity (90%) compared to traditional methods (75% and 78%, respectively), indicating superior detection and classification of cases. Additionally, AI-based surveillance demonstrated greater overall accuracy (91%) and a lower false positive rate (8%) compared to traditional methods (22%). The false negative rate was also lower (7% vs. 18%), emphasizing AI's effectiveness in minimizing missed cases.

Table 2: Predictive Performance of AI in Disease Surveillance:

Disease Type	Actual Cases	AI-Predicted Cases	Prediction Accuracy (%)
Influenza	40	38	95
Dengue	30	29	97
COVID-19	35	32	91
Tuberculosis	25	23	92
Overall	130	122	94

Table 2 presented the predictive performance of AI in identifying disease cases. The AI model accurately predicted cases of various infectious diseases with high accuracy. The prediction accuracy was highest for dengue (97%) and influenza (95%), while COVID-19 (91%) and tuberculosis (92%) also exhibited strong predictive performance. The overall prediction accuracy was 94%, showcasing the potential of AI in forecasting disease outbreaks and enabling timely public health responses.

These findings underscored the critical role of AI in disease surveillance by improving detection speed, accuracy, and predictive capability. AI-driven models demonstrated superior performance compared to traditional methods, offering a promising approach for enhancing public health surveillance systems.

DISCUSSION:

Artificial intelligence (AI) played a crucial role in disease surveillance by enhancing the ability to detect, track, and predict disease outbreaks with greater accuracy and efficiency. The integration of AI in public health systems significantly improved data analysis, enabling healthcare professionals to respond more rapidly to potential threats. Through machine learning algorithms, AI analyzed vast amounts of data from various sources, such as electronic health records, social media platforms, and online news articles, to identify early warning signs of disease outbreaks [9]. These predictive capabilities allowed for timely intervention, reducing the spread of infectious diseases and mitigating their impact on public health. One of the major contributions of AI in disease surveillance was its ability to process unstructured data from diverse sources. Traditional surveillance methods often relied on manual data entry and analysis, which were time-consuming and prone to human error [10]. AI-powered tools, such as natural language processing (NLP) algorithms, extracted valuable insights from epidemiological reports, clinical records, and public health databases, improving the accuracy and efficiency of disease monitoring. For example, AI-driven surveillance systems detected anomalies in patient symptoms and reported unusual disease

patterns, aiding in the early identification of potential outbreaks.

Furthermore, AI facilitated the automation of contact tracing during disease outbreaks. By analyzing mobility data from mobile phones and wearable devices, AI-assisted systems reconstructed transmission networks and identified individuals at risk of infection [11]. This approach significantly enhanced the effectiveness of containment strategies, particularly in highly transmissible diseases such as COVID-19. AI-driven models also optimized the allocation of healthcare resources by predicting the demand for medical supplies, hospital beds, and healthcare personnel based on real-time disease progression data. Another key aspect of AI in disease surveillance was its application in genomic sequencing and pathogen identification. AI-powered bioinformatics tools analyzed genomic data to detect mutations in viruses and bacteria, helping researchers understand the evolution of pathogens. This information proved valuable in designing targeted vaccines and treatments, contributing to more effective disease management strategies [12]. AI-based epidemiological models also predicted the likelihood of disease outbreaks by analyzing climatic, environmental, and demographic factors, allowing public health authorities to implement proactive measures.

Despite its numerous advantages, the implementation of AI in disease surveillance faced several challenges. Data privacy concerns emerged as a significant issue, as AI systems relied on vast amounts of personal health information. Ensuring the security and confidentiality of sensitive data remained a priority for policymakers and healthcare organizations. Additionally, biases in AI algorithms posed potential risks, as models trained on incomplete or skewed datasets could lead to inaccurate predictions and disparities in healthcare outcomes. Addressing these biases required continuous refinement of AI models and the inclusion of diverse datasets to improve their generalizability [3].

Moreover, the reliance on AI-driven surveillance required significant infrastructure and technical expertise, which posed challenges for low-resource settings. Many regions with limited access to advanced healthcare technologies struggled to integrate AI into their disease surveillance frameworks. Collaborative efforts between governments, research institutions, and technology companies were necessary to bridge this gap and ensure equitable access to AI-driven public health solutions. AI played a transformative role in disease surveillance by enhancing data analysis, improving early detection of outbreaks, and optimizing healthcare resource allocation [14]. While challenges such as data privacy, algorithmic biases, and infrastructure limitations persisted, ongoing advancements in AI technology continued to refine its applications in public health. Future research

and policy initiatives aimed at addressing these challenges would further strengthen AI-driven disease surveillance systems, ultimately contributing to more effective disease prevention and control measures worldwide [15].

CONCLUSION:

Artificial intelligence played a crucial role in disease surveillance by enhancing early detection, monitoring outbreaks, and predicting disease trends. AI-driven algorithms analyzed vast datasets, identifying patterns those traditional methods often missed. Machine learning models improved diagnostic accuracy, while natural language processing facilitated real-time analysis of medical reports and social media trends. Additionally, AI-supported surveillance systems strengthened public health responses by enabling timely interventions. Despite challenges such as data privacy concerns and the need for robust validation, AI significantly improved disease tracking and outbreak management. Future advancements were expected to further refine AI's role in global health surveillance.

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[https://doi.org/10.7759/cureus.106690](https://doi.org/10.7759/cureus.106690?utm_source=chatgpt.com)