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REVIEW ARTICLE

The Role of Artificial Intelligence in Combating Zoonotic and Public Health Infectious Diseases: A One Health Perspective on Challenges and Future Directions

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ABSTRACT

Zoonotic diseases cause 60% of total infectious diseases and 75% of emerging infections, and are a core danger to global health security. Climate change, globalization, and urbanization are also responsible for accelerating the convergence of determinants between people, animals, and the environment, thus driving the probability of spillover events. A One Health interdisciplinary approach is essential for building sustainable disease prevention and control against such multifactorial threats. To achieve that, artificial intelligence has been a key technology that is revolutionizing zoonotic and public health early disease detection, surveillance, diagnosis, and prediction modeling. AI enables faster epidemic forecasting, better resource allocation, and gene tracking using technologies such as computer vision, machine learning, deep learning, and natural language processing. AI is also employing predictive statistics and bioinformatics to support drug and vaccine discovery. AI in human, animal, and environmental health systems holds exceptional promise for enhancing health equity and epidemic readiness to counter threats such as data privacy, algorithmic bias, and infrastructure inequality. The objective of this review is to critically evaluate the growing contribution of AI in the fight against zoonotic and public health diseases, examine the ways in which it can be incorporated into the One Health model, and outline directions for developing morally acceptable, transparent, and sustainable AI-based healthcare systems.

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INTRODUCTION

One of the most potentially dangerous risks to global health security, zoonosis, accounts for about 60% of all infectious human illnesses and 75% of newly emerging diseases (Naithani *et al*., 2024). By expanding the interfaces between people, animals, and the environment, amplifying factors such as climate change, urbanization, and globalization increase the risk of spillover events (Sievers *et al*., 2024). Neglected zoonoses alone are responsible for an estimated 10 million Disability-Adjusted Life Years (DALYs) each year and are a source of substantial economic loss, particularly in low- and middle-income countries that depend on livestock. This long-standing problem is costly (Noguera Zayas *et al*., 2021). To drive research, improve surveillance, and allow the development of life-saving vaccines for people and animals, effective management is greatly dependent on the "One Health" model—a long-overdue multidisciplinary partnership bringing together the human, animal, and environmental health disciplines (Stephen, 2024). This present shortage of authoritative staff, in particular for commonly overlooked conditions like brucellosis and salmonellosis, reflects the serious necessity for high-level surveillance mechanisms and strategic planning of global public health activity, where AI can play a pivotal role in real-time monitoring, early detection, and predictive analytics (di Bari *et al*., 2022).

Because zoonosis are the origin of the vast majority of emergent infectious threats, early warning mechanisms and surveillance must be developed to minimize the effect and prevent mass epidemic outbreaks (Al Mutairi *et al*., 2024). It is also possible for public health workers to react quickly when infectious behavior is detected, and thus preventive measures in the form of targeted immunization drives and higher hygiene standards can be adopted (Ouamba *et al*., 2023). Epidemiological trends and also alleged spillover incidents are promoted by extreme environmental modification, such as urbanization and global warming. They are under surveillance, only under close observation (Meadows *et al*., 2023). Though this colossal requirement, resource disparity, and nature of zoonotic transmission chains continue to render good international vigilance challenging, a sign of the imperative need for a One Health functioning plan driven internationally (Erkyihun and Alemayehu, 2022).

Above all, Artificial intelligence (AI) today is a game-changer that makes the sophisticated analytical capability required to perform this One Health mandate possible by taking epidemiology and health care decision-making to unprecedented levels (Coiera and Liu, 2022). This powerful synergy engages the potential of AI to speed response and improve patient results, ranging from clinical decision support for improved patient sorting and predictive analytics for disease trend forecasting to high-speed automated synthesis of evidence (Malik and Singh, 2024). AI enhances monitoring and assists in addressing challenging issues such as antibiotic resistance by uniting complete, large, multisectoral information in the animal, human, and environmental realms. This enhances system resilience as well as equity (Irrgang *et al*., 2023). The One Health spirit has to guide future use of AI; however, if it is to anticipate and counteract legitimate concerns regarding its impact on the environment and ability to exacerbate social injustices so that its benefits bring real, lasting health justice (Ernawati *et al*., 2025; Fiaz *et al*., 2025; Kumar and Sanjaya, 2025).

Since zoonotic diseases account for the bulk of the emerging infectious threats, this review seeks to critically assess emerging global health security risks produced by them and illustrate the necessity of a globally coordinated 'One Health' operational strategy to stem them. Its main thesis would be in evaluating AI as a game-changer technology and its possibilities. It will focus especially on how the One Health imperative of early warning and swift response can be more suitably met by unleashing the potential of AI in predictive analysis, high-level surveillance, and multisectoral fusion of information. Moreover, the evaluation will also recommend prescriptions for sustainability and ethical needs required in an attempt to make equal access to AI, leading to prolonged health justice and immunity to future zoonotic crises.

Artificial intelligence in health sciences: In health science, AI is a pioneering, revolutionary force that applies high-end computational models and algorithms to simulate human intelligence and significantly improve care provision (Rekha, 2021). The general term covers a range of specific technologies, which together amount to enhanced administrative efficiency, tailored treatment, and diagnostics (Bansal and Sindhi, 2025). The essence of disease path and patient outcome predictive analytics is machine learning (ML) capable of allowing systems to learn through experience (Dixon *et al*., 2024). The subcategory Advanced utilizes multi-layered networks with the ability to process intricate data. These are the foundations in designing complex detection algorithms and diagnosis interpretation of medical images (Greenfield *et al*., 2021). Expert systems simulate human medical decision-making using enormous knowledge bases to assist in diagnosis and proposing treatment (Vhatkar *et al*., 2025). Computer vision enables the ability of machines to examine visual information to identify abnormalities in medical images and aid in surgery, and natural language processing (NLP) transforms the review of unstructured patient data and clinical notes to enable meaningful findings from massive volumes of text data (Pindi, 2018). Although these coupled AI technologies are exciting, their successful implementation in the health sector depends on addressing urgent concerns about data privacy, ethics, and proper testing needed to achieve reliable AI systems (Chukwurah *et al*., 2025). These major and general technologies are given in Table 1.

Meanwhile, mass global health crises have driven the application of AI in life sciences from an abstract tool to a needed, multi-dimensional engine (Glicksberg and Klang, 2024). This innovation has made AI a pillar in a number of preeminent disciplines: most self-evidently, the creation of telemedicine and improved diagnostics have significantly enhanced clinical application; the efficiency by which therapeutic leads can now be found has maximized medication development; and the capability of AI to subtyping disease and stratifying patients according to complex omics information has improved personalized medicine (Kaur, 2025). AI's potential for creativity is seen in the outstanding growth in development and implementation being driven globally by nations like the USA and China (Undie *et al*., 2024). However, to ensure that this technology continues to develop further, legal boundaries and issues of ethics have to be strictly controlled so that development is harmonized along with the correct ethics handling (Begishev and Shutova, 2025).

Table 1: Cross-Sectoral Uses of Human, Animal, and Environmental Disease Management.

AI Technology	Primary Function	One Health Domain	Studies	Applications	References
Machine learning (ML)	Predictive analytics and outbreak modeling	Human, animal	BlueDot, HealthMap	Early zoonotic outbreak detection (COVID-19, Ebola, Nipah); spillover hotspot identification	(Efthymiou, 2026)
Deep learning (DL)	Image and pattern recognition	Human	CNN-based diagnostic systems	Improved pathogen identification and medical imaging interpretation (97% accuracy)	(Guo *et al*., 2023)
Natural language processing (NLP)	Real-time epidemic intelligence from unstructured data	Human	EpiScan, ProMED, social media analytics	Early warning of outbreaks from analysis of news and social media streams	(Srivastava *et al*., 2025)
Computer vision	Automated visual data interpretation	Animal, environmental	Google wildlife insights, SpeciesNet	Monitoring of wildlife, species identification, spillover risk mapping	(Layman *et al*., 2023)
Expert systems	Decision support through rule-based inference	Human, veterinary	Diagnostic expert systems	Assist clinicians in zoonotic disease diagnosis and triage	(Guo *et al*., 2023)
Federated learning	Privacy-preserving collaborative model training	Human, animal	Global genomic surveillance initiatives	Combines genomic and epidemiological data across regions without breach of privacy	(Zhang *et al*., 2024)
Explainable AI (XAI)	Model transparency and trust building	Cross-sectoral	LIME, SHAP integrated DSS	Maintains interpretability in AI-informed policy	(Mirchandani, 2025)
AI-driven genomics and drug discovery	Vaccine and therapeutic candidate identification	Human, animal	AlphaFold, DeepMind models	Every vaccine and drug target for zoonoses is emerging rapidly	(Imam *et al*., 2024)

Its use in predictive and preventive medicine, where its process is changing health care from a reactive to a proactive effort, is the most significant use of this capability (Assadi and Nabipour, 2014). With accurate examination of medical images and electronic health records (EHRs), AI algorithms, namely Convolutional Neural Networks (CNNs), significantly improve early detection of disease and frequently detect disease at stages not feasible with conventional approaches (Adedamola *et al*., 2025). Besides, by using people's genetic and lifestyle data to build prediction models, technology facilitates the implementation of personalized treatment programs and preventives. This makes intervention a matter of early stages, particularly when treating chronic diseases (Suura, 2025). The evolution of AI in this field, nonetheless, requires strict adherence to data privacy and ethical regulation since algorithmic discrimination needs to be appropriately contained to ensure fair provision of health services and access, especially to marginalized groups (Voola *et al*., 2024). Various features of AI are given in Fig. 1.

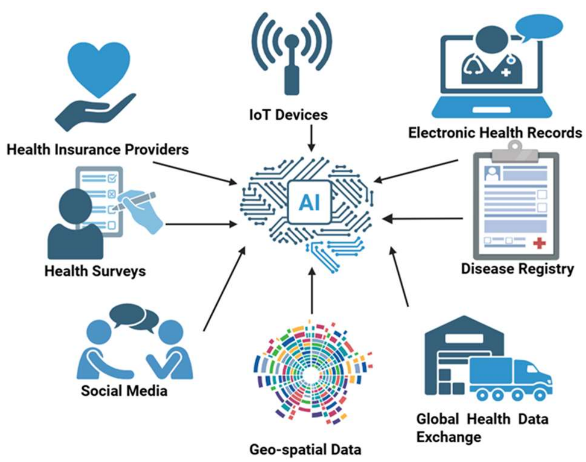

Fig.1: Versatile role of AI in different fields. Created in https://BioRender.com

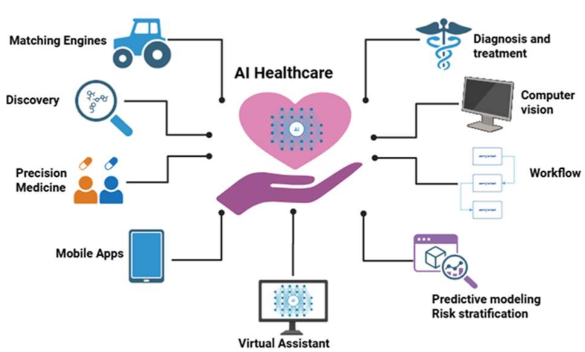

Fig. 2: AI powered innovations for better health outcomes. Created in https://BioRender.com

Role of AI in combating zoonotic diseases: The use of AI in the fight against zoonotic disease is a significant force multiplier that significantly expands early warning and surveillance systems (Zhang *et al*., 2024). Public health response is made possible due to AI-driven systems like BlueDot and HealthMap that demonstrate the value in using large, real-time data sets in attempting to issue timely warnings regarding potential disease danger (MacIntyre *et al*., 2023). Through repeated inputs such as environmental information (e.g., ecological and climatic conditions) for spillover hotspot detection and veterinary information for surveillance of potential reservoir animals, these sophisticated AI models are capable of outbreak prediction as well as identification of intricate patterns of transmission (Ghosh and Dasgupta, 2022). By implementing this complete integration of information, there is a guarantee of enhanced, all-around disease control system and precision of projections (Liu and Wang, 2020). But just as with nearly every application of AI to medicine, the realization of such titanic advantages would only be achieved by industriously overcoming genuine practical difficulties of resource allocation, informational privacy, and continuing challenges of ethics.

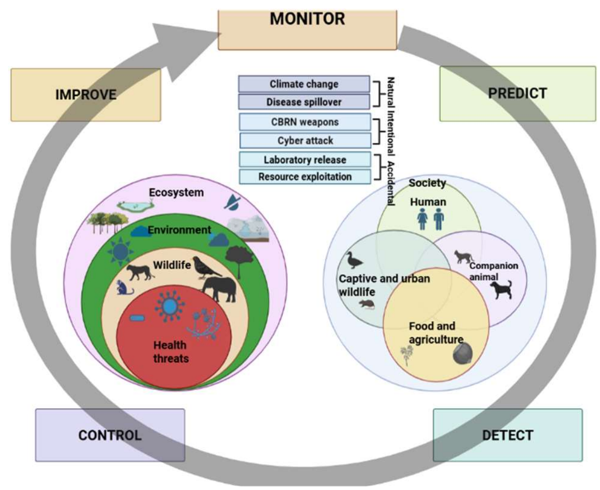

Fig. 3: One Health Artificial Intelligence System Flow. From data acquisition to predictive insights.

AI's multi-functional role in early warning of threats and predictive modeling, via cutting-edge ML and Deep Learning techniques to model and forecast zoonotic threats, is leading this cutting-edge surveillance (Pillai *et al*., 2022). These models, more accurate and sensitive than conventional methods, are critical to forecast spillover threats for such pathogens as COVID-19, Nipah, Ebola, and Avian Influenza with accuracy (Reddy *et al*., 2022). For instance, algorithms such as Naive Bayes have proved extremely consistent in predicting patterns in vectors to inform broad public health policy. AI works best when used to track vector-borne diseases such as malaria and dengue by transforming numerous streams of data into risk factors and association patterns (Kaur *et al*., 2023). AI enables anticipatory surveillance through systematic and routine monitoring of animal populations and disease transmission, such that targeted intervention can be implemented once detected (Ilmaskal and Daswito, 2025). However, success in implementation also involves solving basic problems of data standardization, differential technology access, and continuous ethics problems.

Deep learning-based models used for pathogen detection from images are one of the ways in which AI significantly enhances the diagnosis capability against zoonotic diseases (Sande and Rajguru, 2025). AI models can process complicated biological data with fearfulness through sophisticated models such as CNNs (Naskar *et al*., 2025). This leads to almost 97% detection through a stunning diminishment in false alarms. This technology innovation surpasses accuracy; AI-driven applications have also been seen reducing working time by 35% as compared to normal practice (Oduri, 2021). While successful integration into current bio-surveillance public health infrastructure continues to depend upon the addressing of some of the data standardization issues and ongoing ethical regulation, such potential for quick detection of pathogens—along with using large datasets in outbreak prediction and the identification of risk factors—is critical to increasing early diagnosis and facilitating rapid containment (Wajid Fazil, 2025).

Besides, AI is spearheading the proactive zoonotic disease medicine and vaccine discovery field by revolutionizing candidate identification using machine learning and deep learning (Bergquist *et al*., 2024). AI is further driving the forward-thinking discipline of zoonotic disease medicine and vaccine discovery by revolutionizing candidate identification via machine and deep learning (Malpani and Telrandhe). By facilitating rapid and accurate screening of chemical libraries in a bid to identify interesting compounds, such technologies are central to the acceleration of molecular docking, a simulation method critical to drug-target interaction understanding. Together with this, AI is a very good antigen predictor by browsing through the pathogen genomes for potential targets that would provoke a strong immune response, facilitating vaccine development. AI candidate screening allows one to achieve a faster and more effective public health response to emerging zoonotic threats by reducing significantly the time and expense of medicine development (Posinasetty *et al*., 2024). But to preserve human skills and collaborate in order to overcome obstacles such as data privacy and transparency of models is needed in order to achieve maximum efficiency of this process (Joseph and Pandey, 2025).

AI in public health disease management: Emerging from such technical advancements, AI at the same time simplifies epidemiologic data analysis and is a focal and disruptive function in disease control of public health (Kashyap, 2021). ML algorithms can possibly untangle concealed, nuanced patterns in large data sets, i.e., electronic health records (EHRs), patient co-morbidities, and population health patterns (Fatunmbi, 2024). Such patterns would then be applied to inform high-priority public health interventions and resource allocation. Also, by incorporating mobility patterns, AI models can predict disease transmission dynamics accurately and identify probable hotspots and early warning signals of an epidemic (Ogundipe, 2023). The decision-makers can thereby adequately address the inherent uncertainties of health emergencies through pre-emptive public health interventions tailored to subpopulations with particular risks. However, persistent concerns over data accuracy, privacy, and algorithmic bias must be addressed in a proper way such that ethical and effective use of instruments is guaranteed (Aliyuda, 2022).

Such analytical power has brought the use of AI for epidemic forecasting to transform public health interventions and become very effective in addressing TB, COVID-19, and flu (Lim *et al*., 2025). To forecast disease transmission with greater accuracy than ever before, multiple machine learning models like deep learning and ensemble models closely analyze massive amounts of data (Rahman *et al*., 2023). Particularly valuable, NLP also assists by monitoring and analyzing social media and news unstructured content and serving as a speed early warning system for newly emerging outbreaks (Munro *et al*., 2012). The proper application of such AI models will have to overcome centuries-long issues of data quality, model interpretability, and the built-in ethical issues of mass-scale public health AI systems, even though unavoidable in simulating the real-time actual spread of pandemics and seasonality trend predictions (Towfek and Elkanzi, 2024). Various applications of AI are given in Table 2.

Secondly, AI can be employed to directly provide healthcare and public health services, revolutionizing disease management using operating and communication platforms (Shah, 2024). AI-driven communication technologies like chatbots and virtual assistants during health emergencies are real-time triage and information-dissemination technologies that ensure prompt supply of the right public health message and rapid response to queries (Branda *et al*., 2025). In addition, telemedicine technology based on AI ensures effective remote consultation, which significantly enhances access to care among the underserved populations (Ledford *et al*., 2024). While at the same time, usage of predictive analytics optimizes usage of resources in emergency situations so that the health systems are able to run smoothly with new threats arising However, addressing algorithmic prejudice, overcoming issues of data privacy, and introducing strict ethical regulation are central to enabling such patient-facing systems to scale effectively (Shafik, 2025).

AI total effect is indeed a greater appreciation of the interdependency under the One Health concept—the large interfaces between people, animals, and the environment involved in causation of disease (Stephen, 2024). AI systems have significantly improved real-time surveillance for disease through continuous monitoring of animal populations and environmental data. It enables notification of zoonotic origin and response time quicker than through conventional means (Guitian *et al*., 2023). AI provides data-driven vision needed to guide and augment holistic interventions like strategic vaccination programs and improved animal husbandry, through big-data predictive modeling (Goud *et al*., 2025). Given that the underlying ethical considerations of model bias and data privacy are being taken seriously, such an ability necessarily breaks cycles of knowledge among human, animal, and environmental worlds, and thus a genuine holistic approach to disease therapy can be assured (Boudi *et al*., 2024). Besides these general AI technologies, modern technologies, including programming languages, are also playing an important role in public health and zoonotic diseases.

Programming languages for public health and zoonosis: Python is the most widely used programming language, accounting for more than 90 percent of contemporary implementations. The popularity of Python in modern AI-driven health research is due to extensive libraries for machine learning, epidemiological modeling, and genomic

Table 2: Applications of AI in One Health for zoonotic and public health disease management

Disease	Primary Host / Reservoir	AI Application	Core Technology Used	Objective	One Health Domain	Key Achievements	References
COVID-19 (SARS-CoV-2)	Humans, Bats	BlueDot, DeepCOVID, HealthMap	Machine learning, NLP, predictive analytics	Predicting outbreaks and epidemiological forecasting	Human	Identified global outbreak patterns days ahead of the WHO alert; informed travel warnings	(Nadhira Nazirun *et al*., 2022)
Avian Influenza (H5N1, H7N9)	Poultry, wild birds	Random forest predictive models, GIS-based ML	Deep learning, geospatial modeling	Outbreak zones prediction and risks of spillover	Animal, environmental	Reached AUC 0.95 for outbreak prediction; shortened detection lag by ~2 weeks	(Li *et al*., 2024)
Nipah Virus	Fruit bats	AI-enabled genomic analysis	Deep learning, ML genomic sequencing	Viral mutation identification, tracking reservoir	Animal, human	Identified early spillover patterns and high-risk areas	(Adiga, 2019)
Ebola Virus	Bats, non-human primates	ProMED, HealthMap NLP analytics	Natural language processing	Early outbreak signal detection	Human, animals	Identified outbreak 9 days before official reporting	(Pigott *et al*., 2014)
Malaria	Mosquito (*Anopheles* spp.)	Climate-AI, VectorAI	Machine learning, remote sensing	Modeling of vector populations. Forecasting transmission	Environmental, human	Enhanced regional vector control measures; improved predictive accuracy by 30%	(Wajid Fazil, 2025)
Dengue Fever	Mosquito (*Aedes* spp.)	Predictive vector modeling systems	ML, spatiotemporal data fusion	High-transmission zones identification and seasonal forecasting	Environmental, human	Facilitated pre-emptive vector control in 6 high-risk cities	(Nalini *et al*., 2025)
Brucellosis	Cattle, goats, sheep	Veterinary surveillance AI	Expert systems, ML	Automated case reporting, disease detection	Animal, human	Shortened reporting delay by 60%; enhanced detection in LMICs	(Millar and Stack, 2012)
Rabies	Dogs, wildlife	AI-guided vaccination DSS	Decision support systems, ML	Optimization of vaccine distribution strategies	Animals, human	Cut human cases by 18% in pilot areas	(Cabilla *et al*., 2025)
Tuberculosis (Human and Bovine)	Humans, cattle	CAD4TB, DL radiograph analysis	Deep learning (CNNs)	Automated chest X-ray screening and diagnosis	Human, animals	Attained 96% diagnostic accuracy; assisted TB programs in low-resource settings	(Guo *et al*., 2023)
Leptospirosis	Rodents, livestock	AI-based predictive ecosystem models	ML, GIS, hydrological modeling	Outbreak-prone flood zones prediction	Environmental, animal	Increased readiness in tropical flood prone areas	(Govan *et al*., 2025)
Antimicrobial Resistance (AMR)	Humans, animals	AI genomic predictors	Bioinformatics, ML	Detection of AMR genes and forecasting of resistance pattern	Cross-sectoral	Improved AMR monitoring and antibiotic stewardship networks	(Jancloes *et al*., 2014)
African Swine Fever (ASF)	Pigs, wild boars	Smart pig health AI, IoT sensors	ML, computer vision	Continuous herd monitoring and outbreak prediction	Animals	Identified stress signals prior to clinical symptoms; loss reduction by 22%	(Nadeem *et al*., 2024)
Zoonotic Influenza (H1N1, H3N2)	Swine, poultry	Genomic AI analytics	Deep learning, NLP	Vaccine strain prediction, Viral evolution tracking	Human, animal	Speeded up vaccine update cycles through predictive modeling	(Lou *et al*., 2024)
Lyme Disease	Deer, rodents, Ticks	EcoAI predictive mapping	Machine learning, remote sensing	Mapping vector ecology and risk modeling	Environmental, animal	Improved identification of new endemic areas	(Bingham-Byrne, 2025)
MERS-CoV	Camels	ML-enabled genomic pattern recognition	Machine learning, bioinformatics	Genomic correlation analysis and surveillance	Animal, human	Improve detection and response time; cross-border cooperation improvement	(Guo *et al*., 2023)

NLP: Natural language processing; ML: Machine learning; AI: Artificial intelligence; GIS: Geographic information system.

analysis (Padhi *et al*., 2023). Key Python frameworks include PyTorch and TensorFlow for deep learning models, which include convolutional neural networks (CNNs), recurrent neural networks (RNNs), transformers, and graph neural networks (Novac *et al*., 2022). CNNs are frequently applied in medical imaging for automated diagnosis of infectious diseases such as pneumonia and tuberculosis, while RNNs and transformers are used for predicting disease outbreaks and patient disease progression (Banapuram *et al*., 2024). Similarly, scikit-learn is related to classical machine learning algorithms, which are used in infectious disease risk prediction. Random forest and support vector machine models are commonly engaged to identify epidemiological risk factors, classify disease outcomes, and estimate zoonotic transmission probability by using clinical, demographic, and environmental databases (Rahman *et al*., 2023). Pandas and NumPy are used as core tools for data processing and cleaning in public health and zoonotic studies. They also handle large epidemiological datasets, such as case counts, surveillance records, laboratory results, and environmental variables (Harouni, 2024). GeoPandas and NetworkX are important for spatial and network-based epidemiological modeling. GeoPandas supports geographic mapping of disease incidence and vector distribution, which helps in the identification of spatial hotspots. On the other hand, NetworkX enables the analysis of contact networks among humans, livestock, wildlife, and vectors, which is more critical for understanding zoonotic transmission dynamics (Yap and Biljecki, 2023). In general python is commonly used in outbreak prediction systems, zoonotic spillover modeling, clinical risk prediction, and real-time disease surveillance platforms.

R programming language: R is an important tool in epidemiology and public health and is widely used for statistical analysis, Bayesian inference, and infectious and zoonotic disease modeling (Wang *et al*., 2024). For example, *tidverse* enables the cleaning and visualization of surveillance data, allowing for the identification of outbreak trends and hotspots in diseases such as avian influenza and brucellosis (Musa *et al*., 2024). *Rstan* and *brms* estimate production numbers and forecast outbreaks, while *Survival* supports time-to-event analysis (Shrestha *et al*., 2019). Similarly, *deSolve* simulates disease spread under interventions such as vaccination, immunization, and quarantine. *Shiny* enables interactive dashboards integrating epidemic curves, spatial maps, and predictions for real-time decision making (Ahmad *et al*., 2024). Overall, R facilitates rigorous analysis and predictive modeling for controlling zoonotic and infectious diseases.

High-performance languages: High-performance languages such as C++, Java, Julia, and Scala are essential for AI-based epidemiological models that demand computational efficiency and scalability (He, 2025). C++ is widely used at a larger scale for simulations, including the formation of models of the spread of COVID-19 or avian influenza in livestock, poultry, and for ultra-fast phylogenetic placement of pathogen sequences due to its speed and memory efficiency (Lehtimäki and Martikainen, 2025). Java and Scala are applied in big data public health pipelines and distributed systems to process large surveillance datasets from hospitals, laboratories, and wildlife monitoring programmes (Folasole, 2023). Similarly, Julia is emerging as a high-performance language for scientific computing, which offers simpler syntax for complex mathematical modeling of infectious disease dynamics (Pal *et al*., 2024). These languages have a strong linkage with Python and R through APIs to combine efficiency with the flexibility in data analysis, machine learning, and visualization. Their combination enables real-time outbreak simulations, risk assessment, and predictive modeling for zoonotic and public health applications.

Overview of AI models and platforms for disease outbreak prediction, zoonotic spillover, and public health surveillance: The rapid advancement of AI and computational modeling has significantly increased the scientists' ability to predict, monitor, and respond to infectious disease outbreaks, including zoonotic spillovers (Rocha *et al*., 2025). A wide range of I-driven tools and platforms now exist, targeting different aspects of public and animal health, from real-time surveillance and outbreak forecasting to clinical risk prediction and genomic monitoring (He, 2025). The integration of these tools in public and zoonotic disease strategies enables early warning, risk assessment, and informed intervention planning, particularly in the context of emerging pathogens and global pandemic threats. The following Table 3 provides a comprehensive overview of these AI models and platform highlighting the primary purposes of these models, computation frameworks, and key features.

AI within the One Health framework: This observation is the central tenet of the 'One Health' concept, which in effect requires mutual dependency between environmental, animal, and human health and, as a result, a definite, harmonized response to complicated world issues (O'Grady, 2025). This unified approach is crucial with respect to the more frequent occurrence of pandemics and issues such as antibiotic resistance, since problems within one area will always have ramifications in others (Boban *et al*., 2022). In order to build sustainable, evidence-based health solutions, the design's underlying principles need genuine collaboration from a variety of disciplines, from environmental science to veterinary medicine (Heim and Stärk, 2021). In order to promote disease surveillance, optimize resource utilization, and enable good policy decision-making, the value of the method is solely dependent on possessing full human, animal, and environmental information incorporated (Matus, 2025). But issues such as health systems that have broken down and constant need for long-term political and financial investment in all sectors are currently hindering the full potential of One Health (Brown *et al*., 2024).

Artificial Intelligence is the technology that enables the application of the One Health approach in this important context, mainly through enhanced decision support systems and inter-sectoral connections of data (Irrgang *et al*., 2023). To handle the cases of complicated challenges like Antimicrobial Resistance (AMR), the heterogeneous large-scale human, animal, and environmental streams of data should be linked together (Thakur *et al*., 2025). Pattern recognition capability and predictive modeling of AI are required for this. Most importantly, machine learning uses whole-genome sequencing to predict trends in AMR and combines imaging, electronic health records, and real-time monitor information to provide end-to-end intelligence (Pennisi *et al*., 2025). It is augmented by AI-decision support, which provides predictive information to public health managers and clinicians to facilitate anticipatory provision of care, epidemic forecasting, and resource planning (Zare and Shafaei Bajestani, 2024). Yet, beyond primary issues of data quality, interoperability, and ongoing requirement for close ethical control to limit algorithmic bias and secure professional acceptability, it is essential for the successful scaling of One Health AI (Galiana *et al*., 2024).

Finally, AI technologies in the field are transforming cattle and wildlife zoonotic reservoir surveillance so that it can pre-emptively warn of impending spillover events (Galiana *et al*., 2024). Technologies like Google's Wildlife Insights, for instance, deploy models trained on millions of camera-trap photos (e.g., SpeciesNet) to automatically identify species and quantitatively track changes in density and behavior in wildlife surveys (Thau *et al*., 2019). Virus onset prediction maps can be built by gathering data at nearby field sites of geographic "hotspots" and merging with environmental and land use data (Chakravarti *et al*., 2024). Artificial intelligence animal wellness programs (such as Connecterra's "Ida") on the other hand utilize animal sensors to track habits and notify in the event of any deviation that could constitute a zoonotic risk factor, such as mastitis or tuberculosis (Abdul Ghafoor and Sitkowska, 2021). Despite continued hurdles required by data imbalance and resource limitation in low-resource settings, such predictive modeling as Random Forests achieving high accuracy (AUC of 0.95) in problem detection like avian influenza in poultry and reduced detection times by nearly two weeks underscores the capability of AI to bring clinical, genomic, and environmental data together on One Health platform to inform both veterinary medicine and global health security (Nikoukar *et al*., 2025).

Table 3: Overview of AI models, tools, and integrated platforms used in disease outbreak prediction, zoonotic spillover analysis, public health modeling, clinical risk prediction, environmental health monitoring, and genomic surveillance.

Category	Model/Tool	Purpose	Primary Language/ Framework	Implementation Complexity & Scalability	Key Features	Target Species	Use in Veterinary Research	References
Outbreak Prediction	HealthMap	Global disease surveillance	Python, R, Java	Moderate: High web-scraping dependency	Real-time intelligence, NLP news aggregation	Livestock, wildlife, humans	Monitoring transboundary outbreaks	(Ilmaskal and Daswito, 2025)
	ProMED-mail	Emerging disease alerts	Python, NLP	Low: Human-curated, highly accessible	ML-assisted classification of reports	Livestock, wildlife, humans	Early detection of emerging animal diseases	(Rocha *et al.*, 2025)
	EpiForecast	Infectious disease forecasting	PyTorch, Stan	High: Requires Bayesian statistical expertise	Bayesian hierarchical outbreak models	Livestock, humans	Forecasting disease spread in specific regions	(Wang *et al.*, 2022)
Zoonotic Spillover	SpillOver (UC Davis)	Viral spillover risk scoring	R, Python	Moderate: Relies on wildlife viral data	Risk ranking of wildlife viruses	Wildlife, livestock	Assessing risk of pathogens moving to livestock	(Budeski and Lipsitch, 2025)
	Viral Forecasting (Meta)	Pandemic potential prediction	PyTorch	High: Uses complex Graph Neural Networks	GNNs for host-virus interactions	Wildlife, livestock	Predicting zoonotic emergence from animal hosts	(Johnson *et al.*, 2020)
	Zoonotic Risk (DeepMind)	Protein structure prediction	JAX	Extreme: Requires significant GPU resources	AlphaFold adaptation for host binding	Wildlife, livestock	Predicting viral protein binding to animal receptors	(Milton *et al.*, 2020)
Epidemiological Models	PyRoss	Compartmental modeling	SciPy, NumPy	Moderate: Flexible but requires math tuning	Models with specific interventions	Livestock, humans	Simulation of livestock disease control measures	(Adhikari *et al.*, 2020)
	Epigrass	Spatial epidemic modeling	Python (NetworkX)	Moderate: Requires GIS/Mapping data	GIS-enabled epidemic simulations	Livestock	Mapping regional animal disease outbreaks	(Halasa & Dürr, 2017)
Clinical & Phenotype	DeepPatient	Phenotype prediction	TensorFlow	High: Requires large Electronic Health Records	Deep learning for clinical risk	Livestock	Predicting disease susceptibility in farm animals	(Cui *et al.*, 2023)
	CheXNet (Stanford)	Pneumonia detection	PyTorch	Moderate: Requires high-quality X-ray sets	121-layer CNN for image analysis	Livestock (cattle, poultry)	Detection of lung infections in herd health	(Haque *et al.*, 2023)
	Random Survival Forests	Clinical risk scores	R, Python	Low: Established ML library support	Survival analysis & time-to-event	Livestock	Predicting survival or disease onset in herds	(Pölsterl, 2020)
Environmental Factors	MODIS/NEXUS	Climate-disease links	X-ray, scikit-learn	High: Massive satellite data processing	Satellite data + ML integration	Livestock, wildlife	Predicting vector-borne diseases via climate	(Fossen)
	VectorNet	Mosquito-borne modeling	PyTorch Geometric	High: Advanced geometric deep learning	GNNs for vector population dynamics	Livestock, wildlife	Forecasting mosquito-transmitted diseases	(Peters *et al.*, 2020)
Genomic Surveillance	Nextstrain	Pathogen evolution	Python, JS	Moderate: Standardized bioinformatic pipeline	Real-time phylogenetic analysis	Livestock, wildlife	Monitoring viral evolution in animal pathogens	(Hadfield *et al.*, 2018)
	GenSLMs (Argonne)	Viral genome understanding	PyTorch	Extreme: Large-scale language Models	Genome-scale language models	Livestock, wildlife	Predicting mutations in animal viruses	(Scotch *et al.*, 2019)
Integrated Platforms	BlueDot	Global outbreak intelligence	Python (NLP, ML)	Moderate: Proprietary data integration	Commercial-grade early warning	Livestock, wildlife	Detecting emerging global animal threats	(MacIntyre *et al.*, 2023)
	Epiverse-TRACE	Open-source epidemic tools	R, Python	Low: Designed for collaborative use	Open-source modeling suite	Livestock, wildlife	Tools for shared veterinary epidemiology	(VanderWaal *et al.*, 2017)

Challenges and limitations: Since technological and infrastructural constraints often overlap, deploying artificial intelligence in strategic sectors is to have a perverse set of problems, most critically for the developing world (Czyżewska-Misztal *et al*., 2025). Data quality and privacy are two of the largest challenges; the AI models need huge quantities of high-quality heterogeneous data, but in most resource-scarce areas, there is not enough data, not enough documentation, and no digital infrastructure, and this can lead to undermining model accuracy and embedding inefficiencies (Samuel-Okon and Abejide, 2024). This is also further exacerbated by algorithmic bias where, if not controlled, it provides biased results, especially in areas that are sensitive in nature such as healthcare and education, hence deepening already entrenched social injustices (Shin, 2024). Left unable to act across domains are interoperability and standardization across AI systems as well. Effective interoperating and system scalability are dependent on standardized technical foundations and standards of regulation (Joshi, 2025). This is a pressing issue in technologically differentiated economies with different technological capability. Some ethics issues are also still present, i.e., accountability and explainability of AI-based decision-making mechanisms (Varma, 2024). Human agency loss and transparency challenges and concerns around algorithmic decision-making are increasing as AI becomes more autonomous in the provision of fundamental services, making it important to have solid ethics that are based on human rights and society norms (Kulaklıoğlu, 2024). On top of these, the historically entrenched skill deficiencies remain predominant in the majority of underdeveloped countries, where adoption of AI is drastically impeded by the lacking AI skills with a weaker digital infrastructure (Abulibdeh *et al*., 2023). An overarching strategy through investment in digital infrastructure, capacity building initiatives, and intersectoral coordination—largely through public-private partnerships—is needed to overcome such limitation. Challenging as they are, limitation does provide space for novelty and fresh policy imagination (Cupiadi and Siswanti, 2025). The global south not only manages to overcome the challenges of the era but also takes advantage of the revolution-raising power of AI in tracing out responsive and inclusive policies in building enduring socioeconomic developments (Sundaram and Wesselbaum, 2025).

Future perspectives: The intersection of artificial intelligence, genetic monitoring, and bioinformatics revolutionizes the life sciences. The intersection bridges the theoretically from the impossible to enabling possible predictions for promising zoonoses and facilitating secure collaborative research globally. AI is able to leverage genomic, environmental, and epidemiological big data to predict epidemics, detect transmission patterns, and facilitate rapid public health response. The protein folding prediction has also been revolutionized by the emerging technologies such as "AlphaFold", which has also enhanced understanding of disease pathways and zoonotic potential. Scientists can enhance outbreak readiness with improved early warning signs detection of environmental trends and animal disease signs and evidence-based interventions such as targeted vaccination. Federated learning also emerged as a robust platform for decentralized analysis of data to enable institutions to cooperate and train AI models without compromising the privacy of the data, which is an imperative requirement for global genomics collaboration. The approach maximizes predictive precision and interpretability of AI solutions for precision medicine and public health and makes it easy to aggregate shattered datasets. But all these advantages would need to be achieved to the fullest if problems of data quality, regulatory ethics, and harmonization of regulations were well addressed in an orderly fashion. Ethical and responsible use of AI in genomic surveillance and global health innovation will still entirely depend on strong mechanisms of accountability and transparency.

Policy-makers are discovering AI-facilitated decision support systems (DSS) as frontline tools, particularly with increasing demands for AI transparency and accountability. The systems enhance decision-making in the healthcare and finance industries through predictive analytics and actionable insights. The use of Explainable AI (XAI) in DSS systems legitimates them by clearly delineating the reasonableness of AI-suggested policy, which is a requirement for effective policy-making. Future growth is predicated on increasing interdisciplinarity, i.e., by One Health AI platforms mapping across environment, animal, and human health systems to address increasingly interdependent global health issues. Shared platforms such as these could also facilitate explainability by including XAI techniques such as LIME and SHAP in a format that all, including stakeholders, will be able to understand and trust AI-delivered findings. But balance explainability and model accuracy is also hard to achieve since even that is tainted with ethics and computational concerns. For the further improvement of trustworthy AI into evidence-based policy-making, future studies must aim to create adaptive, open, and ethical designs that allow analytical resilience at the same time create user trust.

Conclusions: Artificial intelligence is now the strongest mechanism for remoulding the world's response to zoonotic disease and public health due to its unparalleled ability to forecast, detect, and connect data in the human, animal, and environment sectors. With support for evidence-informed policy making, anticipatory surveillance, rapid diagnosis, and One Health, AI civilizes intersectoral inequities. Its uses, from pandemic forecasting and gene research to vaccine and therapeutic invention, underscore the need to augment resilience and epidemic preparedness. Its full potential can only be achieved only, particularly in low-resource settings, if certain root issues relative to algorithmic bias, data privacy, and technological inequity are addressed. Solid healthy ethical standards, open government, and fair access must provide a framework to ensure health security-enhancing without amplifying disparities that already exist. Hence, to what extent AI is integrated into global healthcare systems in terms of responsibility, partnership, and solidarity will characterize to what extent it will contribute to the defense of humans against zoonotic and public health threats in the days to come.

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