Artificial Intelligence in One Health: Integrating Human, Animal, and Environmental Health through Digital Innovation

AUTHORS DETAIL

Baseer Ahmad[1], Zubair Azhar Nomi[1], Rana Muhammad Shahbakht[1], and Kiran Khurshid[2*]

1. Faculty of Veterinary and Animal Sciences, Muhammad Nawaz Shareef University of Agriculture, Multan.
2. College of Animal Sciences and Technology, Yangzhou University, China.

*Corresponding author: kirankhurshid78@gmail.com

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Abstract

One Health approach acknowledges the interdependence that exists between the health of humans and animals and the environmental health. These are the higher practices of zoonotic diseases or diseases that animals can transmit to humans and this is why the integrated proactive health surveillance strategy is valuable. Specifically, an emerging technology with revolutionary devices is the Artificial Intelligence (AI), which can be used to improve disease predictions and diagnoses and environmental health surveillance. There are also AI applications, such as machine learning-based predictive models of outbreaks, AI veterinary diagnostics and antimicrobial resistance (AMR) surveillance that can be used to shift the approach to addressing the global health challenges. In this chapter, the researcher explains that AI can be utilized to enhance the incorporation of human, animal and environmental health in the one health model. It also discusses how AI has contributed to zoonotic disease control, AMR surveillance, modeling of diseases spread by vectors, measurement of health risks created by climate change and creation of food safety. The concerns that come along with the implementation of AI in One Health are also critically considered in this chapter and they include information management, privacy, and ethical issues in low-resource and high-resource contexts.

Keywords: Artificial Intelligence, One Health, Human, Animal, Environment.

Introduction

One Health model is developed on the basis of the fact that human health, animal health and ecosystem health are attached. Over 60 percent of the recently identified infectious diseases in humans are of animal origin, with the brightest examples of the influence of the zoonotic threats on the planet being the COVID-19, avian influenza, and Ebola (Ezanno et al., 2021). These diseases not only prove the closeness of man and animals to one another, but also the essence of the combined strategy in order to avoid diseases keeping the surrounding environment in mind (Neethirajan, 2024).

The past ten or so years have seen a surge in the application of the Artificial Intelligence (AI) in the social field of public health, which provides the powerful tool of big data and multifaceted data analysis that traverses the entire domain of human, animal, and environmental health (Benis et al., 2021). AI now acts as the impetus behind the progress of One Health initiatives, in which machine learning (ML) epidemic predictor models are being trained, and where AI is deployed in veterinary diagnostics and antimicrobial resistance (AMR) monitoring (Mac Loughlin, 2025).

Within the framework of AI, predictive models might be created which will consider a diverse collection of diverse information providers, including epidemiology indicators, environmental sensors, even genome sequencing, preempting the disease outbreaks before they become difficult to control (Singh et al., 2024). The world needs such tools to address the health crises, such as zoonotic diseases and other issues, such as AMR and vectors-borne diseases. Moreover, AI can tell the health outcomes of climate change, environmental degradation, and automate food safety and the food supply chain, as well (Bök and Micucci, 2024).

On one hand, AI has massive opportunities in One Health and problems on the other hand. These include data privacy, bias of algorithms, and the need to provide concise governance frameworks in line with which AI tools may be utilized in an ethical and responsible manner (Scarpa and Casu, 2024). The application of AI to One Health will require cross-sector and interdisciplinary collaboration, investment in the information infrastructure and privacy protection in a manner that the entire population will be positioned to experience fair access and fair outcome, particularly in low-resource settings (Zhang et al., 2024).

AI Applications in One Health

1. AI for Zoonotic Disease Surveillance and Prediction

The AI systems can store large amounts of human, animal and environmental data to identify tell-tale signs of zoonotic diseases. Normal surveillance systems are rather reliant on human intelligence and epidemiological warnings; they are likely to be slow in the actual disease outbreak (Ho, 2022). Nevertheless, AI allows conducting real-time surveillance through combining data associated with a variety of sources, including satellite images, weather patterns, and movement data of migratory animals with standard veterinary health records (Ezanno et al., 2021).

Indicatively, machine learning systems have been able to forecast the propagation of avian flu with the use of variables like density of poultry, migration paths, and the climate conditions at a given area (Benis et al., 2021). Likewise, the AI-based tools were applied to predict the number of cases and the regions with the greatest exposure to infection during the COVID-19 pandemic, which would enable the allocation of resources and early intervention (Mac Loughlin, 2025). Using satellite data together with veterinary health data, AI models can become more accurate and efficient in these predictions, becoming more effective in responding to new risks (Bergquist et al., 2025).

AI can be used not only to predict epidemics. Predictive models that consider environmental factors, including temperature, humidity, and urbanization, can also be used to reduce the potential threat of zoonotic disease outbreaks by locating the hotspots and the vulnerable groups (Congdon et al., 2022). As an example, regions that are vulnerable to deforestation can be highlighted with the help of AI systems, which will make it possible to intervene in human and animal health areas. With the development of AI technology, the ability to identify new diseases and new pathogens that spill into human populations will be increasingly functional. In the majority of the world, artificial intelligence-based early warning mechanisms will be instrumental in ensuring the spread of zoonotic infections is kept at a minimum and the population's health preparedness is enhanced (Jutel et al., 2023).

As shown in Figure 2, AI can significantly improve zoonotic disease surveillance by enabling real-time monitoring, predicting epidemics, and targeting early interventions.

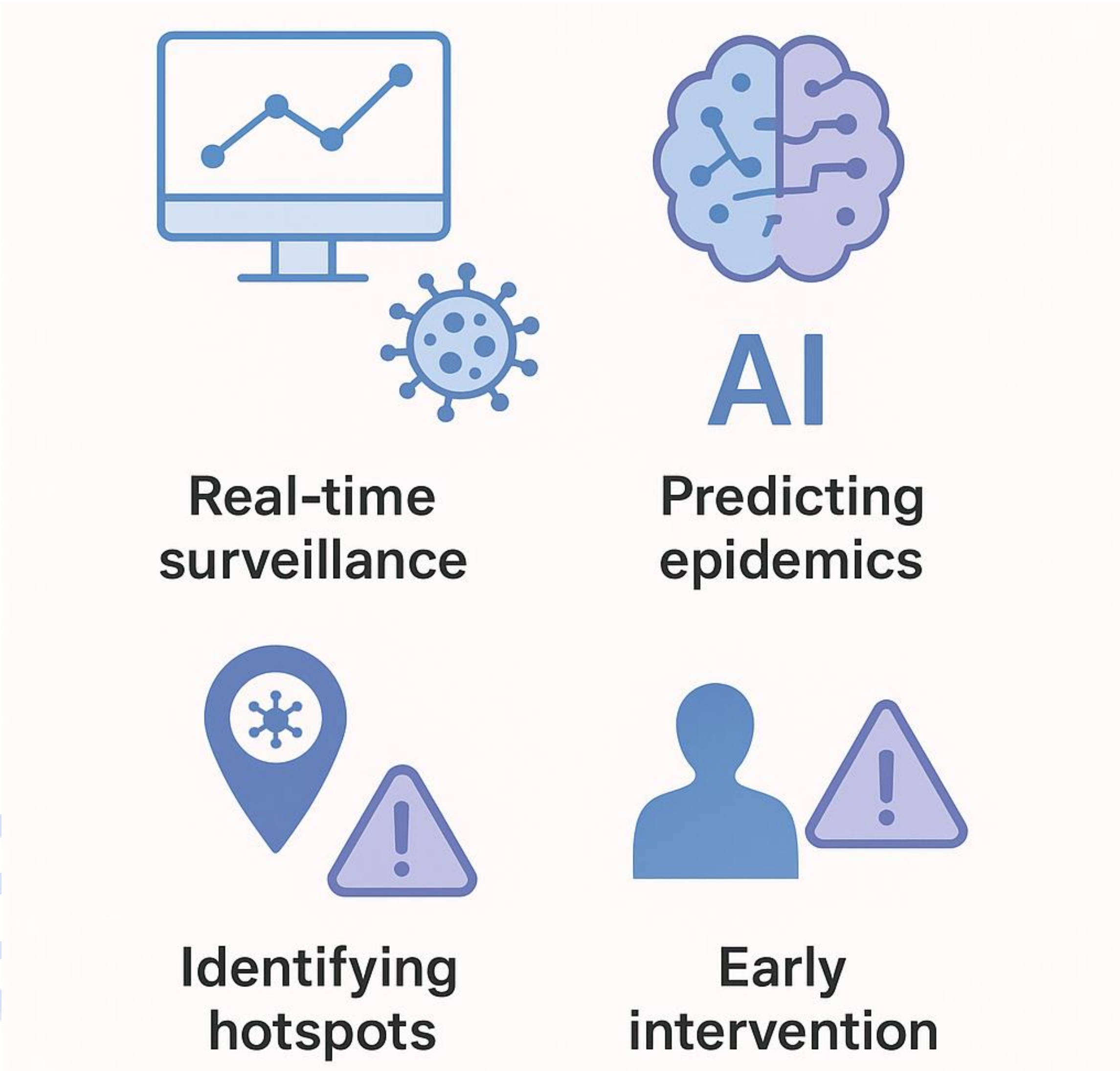

Fig. 1: AI-driven systems enable real-time surveillance, epidemic prediction, hotspot identification, and early intervention for zoonotic disease control.

2. AI in Antimicrobial Resistance (AMR) Monitoring

Antimicrobial resistance is a developing epidemic that is threatening the health of humans and veterinary care. Antibiotics have found their way into the human and animal care industry, resulting in the development of AMR pathogens that have been resistant to traditional treatments (Pandit and Vanak, 2020). AI could be significant in the AMR fight because it can be used to conduct more effective surveillance but also to detect resistance genes in microbial genomes. A particularly interesting example is genomic analysis, based on AI and used to detect and monitor resistance genes in bacterial populations (Singh et al., 2024). The AI models can be used to foresee the development of resistant strains based on deep learning algorithms and take proactive measures to reduce the spread of resistance (Gao, 2021). Furthermore, it is possible to run text-mining research articles, clinical reports, and laboratory findings using natural language processing (NLP), which would allow AI systems to detect new AMR trends in real-time (Roy et al., 2025).

AI models can also be used to blend the data of multiple sources including hospital databases, livestock health reports, and international surveillance networks to identify patterns and relationships in the development of AMR in different areas (Djordjevic, et al., 2024). This international data consolidation aids in the realization of the spread of AMR pathogens across countries and continents and areas where AMR surveillance and control activities are emphasized (Wang et al., 2024).

The emergence of novel patterns of resistance can be early detected through AI, which translates the political effect of the decrease in antibiotics use and the necessity to adopt antimicrobial stewardship measures (Pitt and Gunn, 2024). Moreover, AI-based decision support systems could be used to assist clinicians and veterinarians in making decisions regarding the most suitable therapies to be employed in case of infection to minimize the application of broad-spectrum antibiotics. The fight against AMR in the human and veterinary fields will be unable to do without these decision support tools (Shaheen, 2022).

3. AI-Enabled Veterinary Diagnostics

Veterinary diagnostics is one of the emerging fields where AI-based technologies of image recognition are turning the sphere upside down, and, its immense potential can be used to identify the presence of diseases in animals and other pets with the help of AI (Kour et al., 2022). Medical images like X-rays, CT scans, and ultrasound images can be analyzed by AI and identify signs of disease, including tumors, fractures, and infections with a level of accuracy comparable to that of human experts (Yang et al., 2023).

Mobile AI solutions are especially helpful to the rural or resource-starved veterinarians of the rural areas. The tools will enable the veterinarians to take diagnostic images using their smart phone and this can be analyzed using the help of an AI model that is capable of detecting a disease in addition to providing them with a treatment option in a terribly short period of time (Pérez Sant et al., 2021) . The thing is that it is a stunning technology, which can make a significant contribution to the diagnosis rate, the rate of errors in diagnosis and the convenience of locating veterinary care even in underserved areas. Animal health is also improving using AIs in veterinary diagnostics, which is preventing the transmission of zoonotic diseases in the One Health system (Appleby and Basran, 2022). Immediate disease identification in animals and predictive algorithms of the disease effect will lead to focused treatment and the outcome is the preservation of animal and human health. Moreover, AI technology can be incorporated into telemedicine systems that allow veterinarians to give remote consultations and diagnoses to customers without having to travel (Owe and Baum, 2021).

4. AI in Vector-Borne Disease Modeling

Examples of such diseases that are spread through vectors and are highly problematic in regions with a fluctuating climate and increased urbanization are malaria, dengue, and Zika (Jeong and Choi, 2022). Distribution and dispersion of the population of vectors like mosquitoes can be predicted using AI models and they are affected by the environmental factors like temperature, humidity and rainfall (Kleinstreuer and Hartung, 2024).

Climatic, entomological and geospatial Deep learning models combining climatic, entomological and geospatial data have been demonstrated to be useful in models predicting shifts in vectors distribution across differing climate conditions. As an illustration, AI may be applied to predict the output of climate change on the geographic distribution of mosquitoes that may be utilized to prevent vectors and reduce the risk of transmission (Zador et al., 2023). The integration of AI into the currently used epidemiological approaches will also help the relevant bodies of the state establish a more effective and customized intervention to control the proliferation of vector-borne diseases. The models also contribute to the identification of the potential hotspots of the future outbreak that can be responded to on time to the emerging health risks (Victoire et al., 2023). The possibility to visualize and project the disease spread in relation to the position of vectors is also due to the integration of AI and geographic information systems (GIS) (Shivadekar, 2025). Through AI-based geospatial mapping, we shall be capable of marking regions where the likelihood of the breeding of mosquitoes is high, which will subsequently affect more efficient and focused vector control operations (Lin and Chou, 2022).

5. AI for Environmental Health and Climate Change Impact Assessment

The extent of environmental degradation has far-reaching impacts on the health of both animals and human beings. All these processes, climate change, deforestation, water contamination, and loss of biodiversity influence the processes of diseases, they provide new conditions to the eruption of pathogens. AI can analyze the huge volumes of satellite and sensor information and follow such environmental shifts and assess their impact on human well-being (McLaughlin, 2025). An example is that AI algorithms could be used to match remote sensing data with publicly accessible health datasets to determine how deforestation is linked to the emergence of a zoonotic disease, e.g. Ebola or malaria. In the context of monitoring the alterations in land use and environmental factors, the AI models can predict the consequences of the disruption of the ecosystem on the spread of infectious diseases (AlZubi and Galyna, 2023). In addition, AI may help identify areas that are environmentally hotspots, that is, many factors are combined such as high biodiversity, deforestation, and urbanization, which predispose the areas to the transmission of diseases (Cella et al., 2023). Another instance of AI use is in monitoring water quality and pollution, which has a direct impact on human and animal health. By means of AI-powered sensors and satellite data, authorities may trace the pollutants in real-time and determine the impact of the variation in environmental factors on the spread of waterborne diseases (Bravo Quezada et al., 2025).

6. AI in Food Safety and Supply Chain Monitoring

Food safety is also a vital component of the One Health since it has a direct influence on the health of both animals and people. AI may be used to play a central role in food safety monitoring, whereby risks of food contamination of various foods are identified before food products are accessible to consumers (Sharan et al., 2023). In practice, the computer vision system can be implemented on the food processing lines to detect anomalies (e.g. contamination, spoilage, etc.) in real time. It is also possible to combine AI with blockchain technology to improve the traceability of food in intricate companies (Kim and Cha, 2021). Using the combination of AI data analysis with multiple resources and blockchain keeping records that are safe and transparent, stakeholders can guarantee the safety of food products between the farm and the table (Krishnamoorthy and Manojkumar, 2024). These AI-based systems will enhance food safety by providing real-time information on the threats, minimize the likelihood of contamination, and increase the overall resiliency of a supply chain (Zhang et al., 2021). Furthermore, AI can be used to minimize the transmission of food-borne diseases, thereby benefiting humans and animals through the optimization of food safety protocols. Furthermore, AI will be able to perform tracing of the contamination origin which enhances quicker response and removal of affected products from the market (Jadav et al., 2023). AI applications in One Health are broad, ranging from zoonotic disease surveillance to food safety monitoring, as indicated in Table 1.

Table 1: AI Applications in One Health

Application Area	AI Tool/Technique	Description	Example/Use Case
Zoonotic Disease Surveillance	Machine Learning, Data Integration	Analyzing human, animal, and environmental data for early detection of diseases.	Predicting avian influenza spread using poultry density, migratory bird routes, and climate variables.
Antimicrobial Resistance (AMR)	Genomic Analysis, Natural Language Processing (NLP)	Identifying resistance genes in microbial genomes and mining literature for trends.	Identifying AMR genes in bacterial populations and forecasting resistance patterns.
Veterinary Diagnostics	Image Recognition, Mobile AI	AI tools to assist in analyzing veterinary diagnostic images (X-rays, ultrasounds).	AI-powered diagnostic tools for rapid analysis of veterinary images, particularly in rural areas.
Vector-Borne Disease Modeling	Deep Learning, Geospatial Analysis	Predicting shifts in vector populations based on climate change.	Predicting mosquito population changes with AI models and supporting vector control programs.
Environmental Health Monitoring	Satellite Imagery, Sensor Data	AI models that analyze environmental data (e.g., deforestation, water contamination) to predict disease outbreaks.	AI-driven analysis of deforestation and zoonotic spillover risks.
Food Safety Monitoring	Computer Vision, Blockchain AI Integration	Detecting contamination in food products and improving supply chain transparency.	AI in poultry processing lines to detect contamination or spoilage, integrated with blockchain for traceability.
Pandemic Preparedness	Predictive Models, Genomic Data Analysis	Forecasting outbreaks and preparing for zoonotic spillover.	AI-based pandemic models using One Health data to predict COVID-19 case surges.
Climate Change Impact Assessment	AI and Environmental Modeling	Assessing the effects of climate change on public health by processing climate, health, and environmental data.	Identifying regions where climate change is likely to increase the transmission of vector-borne diseases.
AMR Surveillance Across Sectors	Integrated Data Systems	Using AI to monitor AMR trends across both veterinary and human healthcare sectors.	Global data integration for AMR tracking, detecting patterns across human and animal populations.
One Health Data Integration	Machine Learning, Big Data Analytics	Combining data from human, animal, and environmental health sectors to improve decision-making.	Building One Health platforms that aggregate data from multiple sectors for real-time surveillance.

7. Ethical and Governance Considerations in AI for One Health

The incorporation of AI technologies into One Health programs is becoming more common; therefore, it is necessary to tackle the issues of AI ethics and governance. Some of these concerns include the privacy of data, bias of algorithms, and fair access of AI to various groups of people and places. Because health data is sensitive data, particularly in low-resource settings, AI systems should be secure, transparent, and accountable so that AI can be utilized in a responsible manner (Mishra and Sharma, 2023). To make AI an ethically deployed form, the One Health, the person needs to introduce open governance frameworks that would define the process of data sharing, the openness of the aspects of the algorithm, and supervision (Fisher and Rosella, 2022). Healthcare, agricultural, environmental science, and technology are some of the multi-sectoral partnerships to establish a potent regulatory framework that is regulation-flexible and can adapt innovation that is supported by AI to help people feel at home. Equality should be the enlightener of such form of governance, where AI technology should be distributed to the underprivileged people, especially the low- and middle-income countries (Mustapha et al., 2021). The AI must never widen the already existing inequities in health but should be viewed as having the capacity to mitigate the inequities and develop world health equity. Transparent policies, such as data sharing, algorithmic responsibility, and technological access, will be needed to address the responsible use of AI in One Health (Plowright et al., 2021). There are numerous obstacles, such as problems with data privacy and algorithmic bias, as illustrated in Table 2, that will need to be addressed before AI can be integrated into One Health appropriately.

Table 2: Challenges in Implementing AI for One Health

Challenge	Description	Impact on One Health	Potential Solutions
Data Privacy and Security	The need to safeguard sensitive health data, especially when integrating data from multiple sectors.	Sensitive health data from humans, animals, and the environment must be protected.	Developing secure data-sharing protocols and encryption methods.
Algorithmic Bias	AI models can inherit biases from training data, leading to inaccurate predictions or discrimination.	May result in biased health interventions or resource allocation.	Regular audits of AI systems to ensure fairness and accuracy.
Data Availability and Quality	Inconsistent, fragmented, or incomplete data can limit the effectiveness of AI models.	Incomplete or low-quality data can result in poor predictions or missed early warning signs.	Improving data infrastructure and investing in data quality assurance programs.
Regulatory Challenges	Lack of clear regulatory frameworks for the use of AI in health contexts, particularly in low-resource settings.	Delays or inefficiencies in AI adoption and use in public health.	Establishing global regulatory standards for AI applications in One Health.
Interdisciplinary Collaboration	One Health requires collaboration across multiple sectors, including healthcare, agriculture, and the environment.	Lack of coordination between sectors can delay AI-based interventions.	Building cross-sector partnerships and fostering open data sharing.
Ethical Concerns	Ensuring that AI use does not exacerbate inequalities or create unintended consequences.	AI could disproportionately benefit certain populations while neglecting others.	Implementing ethical guidelines and frameworks for equitable access.
Data Standardization	Inconsistent data formats and measurement methods across sectors hinder effective integration.	Fragmented data prevents holistic analysis and slows down interventions.	Creating standardized data collection and reporting methods across sectors.
Cost and Accessibility	High costs associated with developing and implementing AI tools, particularly in low-resource settings.	AI tools may not be accessible to all regions, particularly in lower-income countries.	Providing funding for AI adoption in resource-limited regions and promoting open-source AI solutions.
Technological Literacy	Low levels of AI understanding among professionals in human, veterinary, and environmental health.	Lack of technical expertise can slow AI adoption in One Health.	Offering training programs and workshops to improve AI literacy in the health and environmental sectors.
Public Trust	Concerns about the transparency and accountability of AI systems can hinder adoption.	AI systems may face resistance if the public does not trust the technology.	Engaging in public outreach and providing transparency about AI decision-making processes.

Conclusion

Artificial intelligence has the capacity to revolutionize the One Health model, as it will allow interventions to occur sooner, surveillance to be more efficient, and predict and manage zoonotic diseases, AMR, and environmental-related health threats more effectively. However, the opportunities of AI in One Health need to be realized by addressing the severe challenges, including the limitations of data infrastructure, ethical concerns, and the need to form cross-sector collaboration. As the number of global health issues caused by climate change, urbanization and biodiversity loss increases.

Artificial intelligence will definitely remain an invaluable asset to the health of the human species, animals and nature as a whole. The AI-based approaches of One Health are likely to enable the health system to become stronger and more active, able to cope with the complexity of health threats observed in the world. As AI is investing in it, optimizing data governance processes, and ensuring that implementing AI is ethically acceptable, it can be the main source of improved health outcomes of all living systems, whether human or non-human and environmental.

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