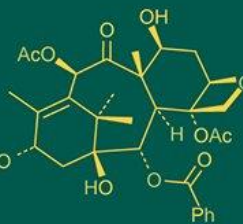
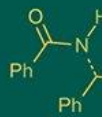


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Shrilla Elangbam

Livestock Production and Management Section, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India

Hari Om Pandey

Livestock Production and Management Section, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India

Baishali Deb

Livestock Production and Management Section, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India

V Apanai Celina

Livestock Production and Management Section, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India

Ashmita Debnath

Division of Animal Biochemistry, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India

Peyi Mosing

Division of Medicine, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India

Bed Singh

Livestock Production and Management Section, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India

Shraddha Pandey

Department of Agribusiness, MJP Rohilkhand University, Bareilly, Uttar Pradesh, India

Angella Elangbam

School of Molecular Sciences, The University of Western Australia, Perth WA, 6009, Australia

Corresponding Author:

Shrilla Elangbam

Livestock Production and Management Section, ICAR-Indian Veterinary Research Institute, Izatnagar, Bareilly, Uttar Pradesh, India

Artificial intelligence in animal and human health: Opportunities and challenges

Shrilla Elangbam, Hari Om Pandey, Baishali Deb, V Apanai Celina, Ashmita Debnath, Peyi Mosing, Bed Singh, Shraddha Pandey and Angella Elangbam

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Abstract

Artificial intelligence (AI), including machine learning and deep learning, is transforming both animal and human health by improving diagnosis, disease monitoring, and clinical decision-making. In veterinary medicine, AI supports real-time monitoring, disease prediction, early detection, and better animal welfare, while also advancing research, drug development, imaging, and parasite control. In human healthcare, AI aids medical imaging, drug discovery, robotic surgery, endoscopy, and personalized treatment, improving accuracy, efficiency, and patient outcomes. By analysing large and complex datasets, AI helps understand disease mechanisms and supports evidence-based decisions in public health. Despite its promise, challenges such as data privacy, bias, high costs, technical expertise, and unequal access need to be addressed. Overall, AI complements professional expertise and enhances healthcare delivery, driving innovation in both animal and human health.

Keywords: Radiology, animal disease, livestock, modelling, artificial intelligence, public health

Introduction

AI is increasingly shaping both animal and human health by transforming approaches to disease prevention, diagnosis, epidemiology, surveillance and public health. Across multiple fields, AI has automated traditionally manual healthcare processes, allowing professionals to focus on more complex responsibilities while AI handles data analysis and decision-support functions. A similar shift is occurring in both human and veterinary sciences, where AI contributes to improved healthcare through enhanced predictive analytics and greater diagnostic precision (Bouchemla *et al.*, 2023) [5]. AI is anticipated not only to expand access to care and elevate treatment quality but also to optimize resource utilization, thereby increasing the overall efficiency of healthcare systems. AI-driven approaches provide advanced tools for analysing disease dynamics, forecasting outbreaks and designing mitigation strategies, while also enhancing learning. By using real-time data, predictive models and simulations, these systems help identify outbreak patterns, support early detection techniques and strengthen evidence-based decision-making, thereby reinforcing public health response. This review explores the applications of AI in animal and human health, organizing them into clinical practice, biomedical research, public health and administration. It emphasizes the transformative potential of AI in improving diagnostics, optimizing resource use and strengthening overall healthcare systems, while also considering the associated opportunities and challenges.

Artificial intelligence as a revolutionising tool in animal health management

Leveraging AI approaches in animal health makes it possible to address areas in diagnosis and disease case detection, as well as animal disease prediction and real-time monitoring, by analysing extensive datasets to identify patterns, forecast outbreaks, enable early detection, facilitate timely intervention and support improved disease management and animal welfare.

Animal disease prediction and monitoring

AI technology has brought about a revolution in the field of animal disease prediction and monitoring.

AI systems can analyse extensive datasets to identify patterns and accurately forecast disease outbreaks, enabling early disease detection, facilitating timely intervention, and preventing the spread of infections. Singh *et al.* (2020) ^[8] proposed an intelligent framework for real time monitoring of animal diseases, using swine flu as an example. Chatterjee *et al.* (2021) ^[6] proposed an IoT based framework, LiveCare, for automated monitoring of cow health in large scale dairy farms. This system tracks daily behavioural changes and uses the Cow Disease Prediction (CDP) algorithm to analyse these changes and predict various cow diseases. Moreover, AI algorithms continuously monitor animal health parameters in real time, providing valuable insights for farmers and veterinarians to optimise disease prevention strategies and improve animal welfare. Overall, AI technology plays a crucial role in safeguarding animal health, enhancing disease management practices, and supporting sustainable agriculture.

Enhancing animal health and welfare

AI is revolutionising our comprehension of animal welfare and plays a crucial role in the monitoring and maintenance of animal health. Non-invasive AI based detection techniques reduce human intervention while accurately collecting data, thereby establishing a new benchmark for improving animal welfare. Fuentes *et al.* (2022) ^[22] pioneered a non-invasive computer vision approach and employed machine learning models to predict eye temperature, milk yield, and milk quality in 102 dairy cows ($R = 0.96$), demonstrating potential applications in both animal welfare and the modelling of biological and non-biological pressures. Feuser *et al.* (2022) ^[23] developed a diagnostic software tool that promptly identifies lameness in horses and reduces its impact on animal wellbeing. Figure 1 illustrates the integration of AI across key veterinary disciplines, highlighting its interconnected role in anatomy and imaging, parasitology, food science and public health.

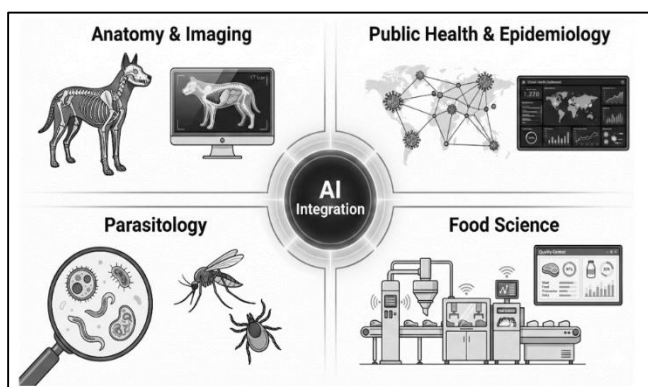


Fig 1: AI integration across core veterinary disciplines, including anatomy and imaging, parasitology, food science and public health (Pérez-García *et al.*, 2026) ^[15]

Diagnosis of animal diseases and pattern recognition

By identifying patterns, AI algorithms can accurately diagnose diseases, leading to a reduction in diagnostic errors and improved efficiency in veterinary practices. AI technologies, including machine learning and deep learning, have demonstrated strong capability in processing large datasets and detecting complex patterns, which are essential for improving diagnostic precision and advancing the understanding of disease mechanisms (Akinsulie 2024) ^[1]. Blömke *et al.* (2020) ^[4] designed an automated system to

assess pig welfare indicators and diagnose ear and tail lesions in pigs at slaughterhouses. The system showed high sensitivity above 77%, specificity above 96%, and accuracy above 95% in detecting lesions in both ears and tails. This finding is significant for diagnosing pig ear and tail diseases and ensuring animal welfare. AI based diagnosis enables early disease detection, allowing prompt treatment and improved outcomes for animals.

Biomedical Research

Biomedical research in veterinary science plays a vital role in improving animal health, welfare, and productivity, with significant implications for public health, food safety, and human well-being (Min 2024) ^[14]. It supports the development of innovative therapies, vaccines, and diagnostic technologies, strengthening disease prevention and management in both domesticated and wild animal populations. The integration of AI into veterinary biomedical research is transforming the field by enhancing data analysis, enabling more personalized treatments, and optimizing animal care through advanced monitoring systems (Yerlikaya 2024) ^[20]. AI tools, particularly machine learning, facilitate the examination of large datasets and the identification of complex patterns, contributing to a deeper understanding of disease mechanisms and greater diagnostic accuracy. Together, biomedical research and AI create a synergistic framework that advances knowledge of animal health and supports improved outcomes for both animals and humans (Basran 2024) ^[3].

Pharmacology

Another important area is pharmacology, where veterinary research contributes to the development of new drugs and therapies for animals, some of which may later be adapted for human medicine. This cross-species relevance is especially apparent in the study of zoonotic diseases, which can be transmitted from animals to humans. For instance, Amiroch *et al.* (2022) ^[2] applied machine learning (ML) techniques in virtual screening to identify antiviral candidates for avian influenza subtype A/H9N2. The successful identification of effective antivirals not only safeguards animal health but also reduces the risk of potential outbreaks in human populations.

Anatomy and medical imaging

Anatomy forms the foundation of veterinary education, requiring a thorough understanding of structural relationships and the ability to accurately interpret clinical images. Machine learning and deep learning techniques, particularly convolutional neural networks (CNNs), have been extensively used for the automated analysis of radiographic, CT and MRI images. In both educational and clinical settings, these models can assist in detecting fractures, tumors and structural abnormalities, supporting the development of diagnostic reasoning while increasing exposure to a wide range of clinical cases. In orthopaedic practice, CNNs have also been applied to predict hip and elbow dysplasia in young dogs using pelvic radiographs (Hauback *et al.*, 2025) ^[10]. The effectiveness of AI in veterinary medical imaging is supported by numerous studies. Recent research, including Joslyn and Alexander (2022) ^[11], emphasizes the feasibility of AI-assisted detection of specific radiographic abnormalities in veterinary radiology, particularly in research settings.

Parasite detection and risk prediction

Parasitology education seeks to equip future veterinarians with the knowledge and skills needed to prevent, diagnose and manage parasitic infections. In this field, AI has been introduced as a supportive tool for microscopic identification, understanding parasite life cycles and facilitating scenario-based problem-solving exercises.

AI models have demonstrated promising performance in detecting parasites and vectors, including mosquito species and *Echinococcus multilocularis* lesions, thereby enhancing diagnostic accuracy (Sulyok *et al.*, 2023) [19]. In addition, predictive algorithms have been used to model parasite protein structures and to forecast infection risks, contributing to improved prevention and control strategies.

Zoonotic disease surveillance

Health surveillance is another critical area, involving the monitoring of animal populations for signs of emerging diseases. Early detection and timely intervention are essential to prevent widespread outbreaks and protect food safety, as many pathogens can be transmitted from animals to humans through the food chain and other routes. Influenza, as previously noted, poses substantial risks to both animal and human health, making the surveillance of animal herds crucial for limiting interspecies transmission. Research indicates that as long as influenza viruses circulate in animals, individuals working on livestock farms or those indirectly exposed remain at risk of infection (X. Zhang *et al.* 2018) [21]. Moreover, the recognition of zoonotic diseases and their outbreak potential reinforces the importance of continuous monitoring and effective surveillance systems to reduce risks associated with animal-to-human transmission (Rist *et al.* 2014) [17].

Veterinary public health and emergency readiness

AI tools have been described as facilitating scenario-based learning within public health emergencies, including outbreak control, surveillance integration and the assessment of non-pharmaceutical interventions. Public health and veterinary healthcare play a fundamental role in

safeguarding both human and animal populations from disease, thereby promoting the well-being of communities and ecosystems. The incorporation of AI into public health systems substantially improves the efficiency and effectiveness of disease surveillance, outbreak forecasting, and response strategies. AI demonstrates considerable potential in strengthening public health initiatives, including surveillance systems, early outbreak detection, and clinical decision-making processes. In addition, AI supports research and evidence-based decision-making by facilitating the identification, tracking, and monitoring of emerging health threats (Jungwirth and Haluza 2023) [12]. Overall, the application of AI technologies enhances the capacity of both public health and veterinary sectors to anticipate, manage, and reduce health risks more effectively.

Timeline of artificial integration in medicine

In recent years, AI has become an essential component of healthcare education and has been implemented by numerous medical institutions globally. Its application in medical education is far more widespread in Western nations than in developing countries. From 2000 to 2020, significant developments occurred in AI, marking a period of major advancement and transformation in the field. In 2007, IBM developed an open-domain question-answering system called IBM Watson. In 2017, Bakkar and coworkers used IBM Watson to successfully identify novel RNA-binding proteins that were altered in amyotrophic lateral sclerosis. Pharmabot, introduced in 2015, was designed to support medication education for paediatric patients and their parents, while Mandy, developed in 2017 functioned as an automated patient intake system for a primary care practice. A convolutional neural network (CNN) is a DL algorithm used in image processing that mimics the function of interconnected neurons in the human brain. Several CNN architectures are currently available, including LeNet, AlexNet, VGG, GoogLeNet, and ResNet.

The steady growth and development of AI in medicine are described below, divided into key time periods of major change, as illustrated in Figure 2.

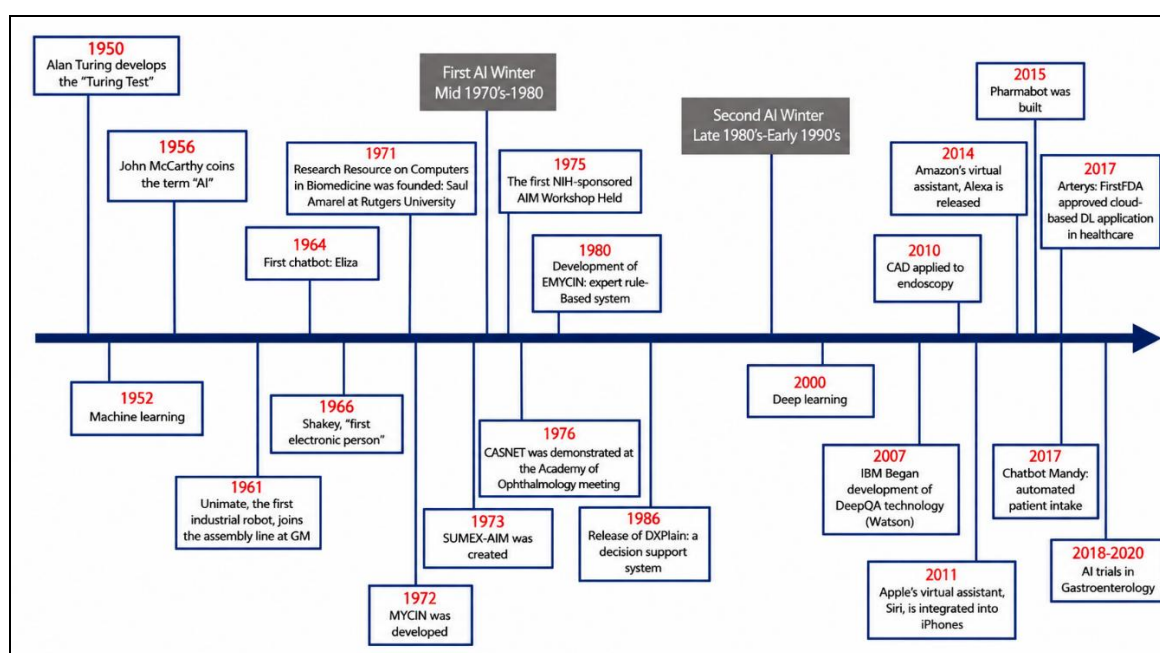


Fig 2: Timeline of the development and use of artificial intelligence in medicine. AI, Artificial intelligence; DL, deep learning; FDA, U.S. Food and Drug Administration; CAD, computer-aided diagnosis.

AI-driven innovations in human healthcare

AI in medicine (AIM) has progressed significantly over the past five decades. Since the introduction of machine learning (ML) and deep learning (DL), the applications of AI in medicine have expanded, creating opportunities for personalized medicine rather than solely algorithm-based approaches. Predictive models can be applied to diagnose diseases, predict therapeutic responses, and potentially support preventive medicine in the future. AI may enhance diagnostic accuracy, increase efficiency in provider workflows and clinical operations, enable improved disease and treatment monitoring, and improve procedural precision and overall patient outcomes.

Drug discovery and development

Drug discovery can be divided into four parts: drug design, polypharmacology, drug repurposing, and drug screening. The primary use of AI is in predicting drug properties (Fig. 3), which may reduce the need for clinical trials and live study participants, which would be beneficial from both

financial and ethical perspectives. The primary use of AI is in predicting drug properties, which may lessen the need for clinical trials and live study participants, offering benefits from both financial and ethical perspectives. Polykovskiy *et al.* (2020) ^[16] explored the ability of AI to predict the activity of various synthesized molecules. Daynac *et al.* (2015) ^[7] sought to assess the effectiveness of an artificial neural network in predicting the antimicrobial properties of different molecules, thereby making the process faster, more cost-efficient, and more reliable. Machine learning and deep learning algorithms have been applied in various drug discovery processes, including peptide synthesis, structure based virtual screening, ligand based virtual screening, toxicity prediction, drug monitoring and release, pharmacophore modelling, quantitative structure activity relationship, drug repositioning, polypharmacology, and physicochemical activity. Drug design and development is a significant area of research for pharmaceutical companies and chemical scientists.

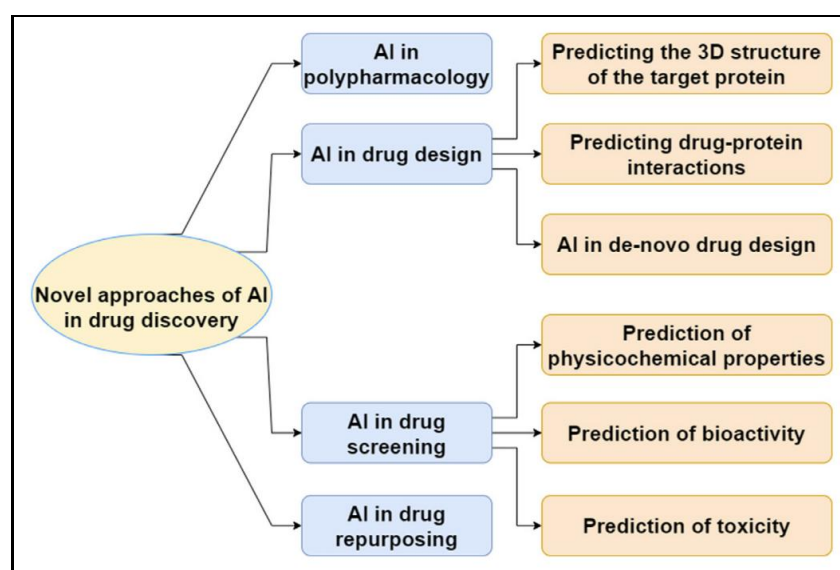


Fig 3: Use of Artificial Intelligence in drug discovery (Kalyane *et al.*, 2020)

AI in gastroenterology

AI use in gastroenterology has grown significantly in the past decade. Computer-assisted diagnosis during colonoscopy improves detection and differentiation of benign versus malignant colon polyps. AI applied to endoscopic ultrasound (EUS) also helps distinguish chronic pancreatitis from pancreatic cancer, a frequent diagnostic challenge.

Deep learning supports prediction of prognosis and treatment response. Artificial neural networks (ANNs) have been developed for diagnostic and predictive modelling. In a retrospective study of 150 patients, an ANN analysed 45 clinical variables and diagnosed GERD with 100% accuracy.

AI-assisted endoscopy

AI has also been applied to predict survival in esophageal adenocarcinoma, relapse and severity in inflammatory bowel disease, and the likelihood of distant metastases in esophageal squamous cell carcinoma. These early findings highlight AI's strong potential in future clinical practice. AI-assisted endoscopy is advancing quickly. Early CAD systems improved detection and classification of colon

polyps. In a trial of 1,058 patients, CAD increased adenoma detection (29% vs 20%), especially for small lesions. Optical biopsy models achieved 84.5%-98.5% accuracy, and a CNN predicted colorectal cancer invasiveness with 81.2% accuracy.

In Barrett's esophagus, de Groof *et al.* (2020) ^[8] developed a CAD system with 90% sensitivity and 88% specificity, outperforming nonexpert endoscopists. Another real-time CAD model detected early esophageal squamous cell carcinoma with 98% sensitivity and 95% specificity. Cazacu *et al.* also used ANNs with EUS to distinguish chronic pancreatitis from pancreatic cancer (95% sensitivity, 94% specificity).

Two approved systems include ENDOANGEL, which improved adenoma detection (17% vs 8%), and GI Genius by Medtronic, which achieved 99.7% lesion-level sensitivity. Repici *et al.* reported a 14% increase in adenoma detection using GI Genius.

Chatbots for virtual health assistance

Chatbots are AI systems designed to understand, process, and respond to human queries based on specific input data by retrieving information from internet databases and

producing human language through advanced natural language processing (NLP) models. They have attracted significant attention because of their capacity to generate human-like text and engage users in interactive conversations. They are mainly used as virtual teaching assistants, addressing learners' questions and recommending relevant resource materials. The primary advantages of chatbots include content integration, rapid access to information, support for multiple users, and immediate assistance. Case studies highlight the effectiveness of chatbots in mental health support, chronic disease management, and medication adherence, demonstrating their potential to provide 24/7 availability, cost efficiency, and scalability. However, challenges such as limitations in emotional intelligence, concerns regarding data security, and the need for appropriate regulatory frameworks must be addressed to optimize their implementation.

AI in radiology

With the growing access to radiological examinations, the increased workload for radiologists, and the shortage of experienced specialists, AI has moved to the forefront of medicine. Deep learning-based diagnosis has shown performance equal to or even surpassing humans in areas such as lymph node metastasis detection and mammography malignancy identification.

The detection of meningiomas on MRI demonstrates significant potential for AI application. Laukamp *et al.*, (2019)^[13] applied a multiparametric deep learning model to MRIs for detecting and segmenting meningiomas, comparing the results with manual segmentation. Using a training set of 249 preoperative MRI glioma cases and tumour classes defined by the BRATS benchmark, the system accurately identified 55 of 56 gliomas, comparable to assessments by two radiologists.

Algorithms developed by Zebra Medical Vision Ltd. (Shefayim, Israel) are currently integrated into PACS systems in over 50 hospitals worldwide and have analysed more than one million patient scans. These systems can automatically detect liver, lung, cardiovascular, and bone diseases. For instance, vertebral fractures are identified using algorithms applied to chest and abdominal CT scans: the spine is segmented, sagittal patches are extracted using convolutional neural networks (CNN), and the presence of fractures is predicted. Similar algorithms detect coronary artery calcium on non-contrast chest CT scans, helping predict cardiovascular events and mortality.

Robotic surgery

Robotic surgery, recognized for its minimally invasive approach and computer-controlled robotic arms, has transformed modern medicine by offering enhanced dexterity, improved visualization, and reduced tremor compared with conventional techniques. The incorporation of AI into robotic surgery has further enhanced surgical precision, efficiency, and accessibility. AI-assisted robotic coronary artery bypass grafting (CABG) is showing strong potential to improve outcomes in minimally invasive cardiac surgery. AI-assisted robotic minimally invasive CABG was associated with shorter operative times, reduced blood loss, and fewer complications compared with conventional techniques. AI is also advancing delicate neurological procedures, including brain tumour removal. A recent report in *Nature Medicine* described a case in which AI-powered

image guidance enabled surgeons to achieve a more complete tumour resection during complex brain surgery.

In addition, AI algorithms are being investigated for preoperative planning and intraoperative navigation in neurosurgery. These applications include generating patient-specific 3D brain models from imaging data and providing real-time visualization of critical anatomical structures during surgery, thereby enhancing precision and safety.

A major limitation to the widespread adoption of robotic assistance in surgery is its high cost. However, strong evidence consistently highlights the significant advantages of robotic surgery, especially in left colectomies and various rectal procedures, where it often outperforms advanced 3D laparoscopic systems.

Barriers and Potential of AI in Animal and Human Health

In livestock production, high costs and limited financial resources remain major barriers to the adoption of AI worldwide. Many farmers also lack the technical expertise required to choose appropriate hardware and software, install AI tools, and use them effectively. AI applications in animal farming rely on large and diverse datasets, which require substantial storage and computing power that standard computers cannot manage over long periods. In addition, unequal access to digital technologies, often linked to differences in education and technical skills, limits adoption in certain regions. The large volume of data generated by AI systems in animal farming must be handled daily throughout the year, often exceeding the storage and processing capacity of conventional computing systems.

Similarly, despite its potential in the medical field, AI continues to face several obstacles to widespread adoption. Large datasets are essential for effective machine learning and deep learning, yet data sharing between institutions remains limited due to privacy, security, and organizational concerns. Strengthening trust, ensuring data protection, and promoting the ethical use of AI can help address these issues. Another challenge is preventing biased outcomes in AI models. Validating results with external datasets and encouraging institutional or national collaboration can help reduce bias.

Despite these challenges, AI holds considerable promise for improving efficiency, accuracy, and decision-making in both animal and human health systems. Addressing these barriers will be key to realising its full potential.

Conclusion

Artificial intelligence has made significant contributions to human health while also advancing animal health. Real-time monitoring of human and animal populations, along with environmental conditions, enables timely interventions that help prevent outbreaks, disasters and large-scale crises. AI has been integrated into various aspects of assisted medical care, enabling broad applications such as disease screening, clinical decision support, drug research and development, and mobile health management. These advancements provide patients with more convenient and efficient healthcare services while improving operational efficiency and economic performance within medical institutions. Overall, AI continues to reshape both livestock management and medical practice, serving as a powerful supportive tool that enhances professional capabilities rather than replacing human expertise. However, the challenges associated with

AI, including concerns related to data privacy, bias, fairness and regulatory frameworks, must be carefully addressed to ensure its responsible and equitable use.

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