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Technological Strategies to Improve Animal Health

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ABSTRACT

As animal health and production are crucial factors in the agricultural industry, the health of livestock directly affects their productivity and, consequently, the income of farmers. Technological advances have contributed to animal health and production practices in recent years. This Research Topic focused on using promising technological techniques to reduce animal illness incidence and significance to improve animal health and output. This was achieved through the collection of 25 original research articles, 5 review articles, 3 systematic review articles and one method article, it brings together 212 leading authors in cutting-edge research issues on technology for diagnosing, preventing, controlling, and treating animal diseases important to public health and animal production. The livestock sector expansion and change offer significant prospects for agricultural development, poverty reduction, food security, and human nutrition. Large-scale livestock production and food chains meet the expanding demand for animal products in many nations. Food safety and public health depend on efficient, healthy, and safe livestock production. It is therefore that several techniques to improve and increase the current agricultural production of the different animal species are being developed and evaluated, including drug delivery systems such as micro/nano systems; disease management through the use of vaccines, alternatives to antibiotics, or nutraceuticals; improvement of animal nutrition with prebiotics, probiotics, biosorbents, or bioactive substances; reproductive technologies; precision livestock farming and even employing genetic improvements.

KEYWORDS: animal, health, technological, strategies, disease, management

1. INTRODUCTION

Power quality is a major cause of concern in the industry and it is important to maintain good power quality on the grid. Therefore, there is The speed of both the development and application of digital technologies in animal health is increasing exponentially. While it took 150 years for dairy farming to shift from hand milking to mechanised milking, the last three decades alone have seen the introduction of milking robots, wearable sensors and heat detectors to identify the optimum window for cattle breeding.

During these same decades, the global pet population has exploded in countries across the world. Across the United States and European Union, households in each region have added nearly 1 million dogs annually in recent years., This growth has spurred the introduction of tools for more affordable, rapid, species-specific care

that can help veterinarians keep up with the ever-increasing stream of small animals entering the clinic.

New digital tools, services and insights are continually uncovering new potential to enhance the key pillars of defending and maintaining good animal health: prediction, prevention, monitoring, diagnosis and treatment.

Modern data infrastructure and analytics is allowing knowledge to be aggregated globally and across animals in every region so that:

Veterinarians facing a rare circumstance or illness can tap into insights gleaned from the experiences of others to better understand treatment options.[1,2,3]

Researchers seeking subtle signs of health changes can use machine learning to analyse endless animal profiles and diagnostics results to find the subtle 'signal in the noise' that enables new protocols for prevention.

Retailers can lean upon digital traceability systems that allow them to see how animals are raised and their produce reaches store shelves, helping them inform consumers of the safety and sustainability of production.

Furthermore, digital technologies are allowing for a level of individualized care never before achieved in animal health. Farmers can pinpoint the first animal to fall ill amongst a herd of thousands based off a cough, elevated temperature or change in activity level. Small animal veterinarians can create tailored, life-long health plans, built off the accumulated experiences of countless similar pets, that anticipate issues and provide pet owners with better peace of mind.

Digital technologies hold immense promise to strengthen prevention, productivity, One Health, and overall animal care. It begins with the three primary areas of innovation – predictive, monitoring and diagnostics technologies.

The digitalisation of diagnostics has provided more, better and earlier data about the signs and symptoms of ill-health, contributing to a greater understanding about how health conditions develop in animals and how to predict, prevent and treat them.

Digital monitoring provides a stronger defence against the spread of diseases within a group of animals, and between animals and people. From microphone systems that identify fluctuations in poultry vocalization to computerised patient records and activity trackers for pets that help owners care for their pets in new ways – technology has relieved the burden of observation and filled the communications gap between animal and human.

This data is increasingly being aggregated to build veterinary intelligence systems that can predict changes in an animal's health state before it even occurs, allowing for preventative measures and custom health plans. Tools already exist that can amass and cross-reference animal health data and alert a farmer or veterinarian to an emerging issue based on signs in an animal's behaviour, biological markers or diagnostics results.

As a new class of veterinary technologies, prediction, monitoring and diagnostics have the potential to transform animal health so that animals and their keepers can enjoy all the benefits of a long, productive and healthy life.

The digital revolution in animal health – and its potential to dramatically reduce health threats – is here.

Predictive, monitoring and diagnostics technologies are distinct categories of technology that also interact as a tripartite ecosystem to uphold not only the health of individual animals but herd health, household health, pet health and, ultimately, public health.

Modern data insights and analytics provide these technologies with the unique ability to generate cumulative knowledge to enable better health outcomes.

Livestock disease and ill-health comes with multiple costs to farmers, from veterinary fees for examinations and treatments to the additional feed, water and care needed by sick animals, which in turn produce lower levels of meat, milk and eggs.[4,5,6]

Just five animal diseases made up two-thirds of outbreaks between 2000 and 2016, impacting global food production and trade. Digital tools that expedite the prevention and early diagnosis of these diseases can

allow livestock farmer to reduce these costs while increasing their production.

Moreover, the increased capability of digital tools to monitor individual animals can also save on farm labour costs. Industry best practice, such as the Common Swine Industry Audit (CSIA), for example, includes 27 criteria to demonstrate wellbeing and food safety. Direct animal observation is always preferred but this can be expensive and difficult to resource without technology.

However, with audio and camera monitoring systems, and animal intelligence software, farmers can support the health of every animal without the need for additional staff. It ensures the welfare needs of the animals are achieved to a level not possible with traditional manual oversight alone.

2. DISCUSSION

Products like predictive 'animal intelligence' software that aggregates veterinary records and results as well as digital first monitoring tools like smart collars, activity trackers and ear or neck tag sensors that use GPS to track animal movement are native to the digital revolution.

Diagnostics, on the other hand, have been widely available in animal care for decades. Developers are blending this 'traditional' technology with digital infrastructure to offer a tool that can now not only diagnose illness but prevent it.

Traditional diagnostic technologies typically include screening equipment, such as ultrasounds and x-rays, as well as testing kits, including reagents, or substances applied to biological samples to diagnose the presence of a virus or bacteria depending on the reaction.

The process of diagnosing illness based on a physical specimen has been refined to become more streamlined, mobile and efficient thanks to the emergence of technologies like microfluidic devices, or tiny chips, which can analyse extremely small volumes of fluid without needing to be processed in a lab.

Researchers are now exploring ways to bring molecular diagnostics, a high-precision method of analysing biological markers in the genetic code and proteins of an organism, to the point of care, which can improve the accuracy of diagnostics.

The methods have helped the field of diagnostics evolve over recent decades to become increasingly digitalised. New tools are making use of artificial intelligence to flag potential health threats to a veterinarian, where previously this work would have relied upon manual analysis.

For example, diagnostic platforms are already available that use image recognition technology, algorithms and artificial intelligence to identify common worms in cats and dogs in less than 10 minutes by recognizing parasitic eggs in stool samples.[7,8,9]

Big Data systems such as "patient-like-mine" use aggregated diagnostic and insight data from millions of animals to provide real-time support for small animal veterinarians by referring to previous treatments and clinical decisions made in similar cases and modelling different scenarios. This facilitates better informed decision-making that enables more effective, targeted treatments for pets.

The ability to easily aggregate huge volumes of diagnostic data and health information has created the opportunity to identify patterns and risk factors not only for individual animals but across herds, regions and species. These insights have transformed the field of diagnostics into a tool of prevention, allowing veterinarians to act sooner and with greater confidence on the farm and in small animal practices.

The adoption of digital animal health technologies is inconsistent around the world and across different species. In Switzerland, for example, which is considered a well-developed but small-scale agricultural producer, one survey found five to seven per cent of farmers raising suckler cows used cameras, electronic ear tags and electronic weighing systems, while 10 per cent of sheep farmers used camera monitoring. Among poultry farmers, as many as 47 per cent used smartphones to monitor chicken barns.v

In Scotland, around 30 per cent of farmers reported using electronic identification (EID) for farm management, with 13 per cent using cattle surveillance and less than 10 per cent using webcams, smart phones or tablets for animal husbandry.

Livestock farmers and veterinarians are increasingly using connected devices and systems that aggregate data on a dashboard, and similar tools can now also be used for small animal veterinarians, who typically rely on electronic medical records for individual animals.

3. RESULTS

The development and uptake of digital animal health technologies has already had a transformative impact on

small and large farms, contributing to fewer losses, higher standards of animal health and welfare, more precise animal husbandry, and an increase in meat, milk and eggs.

For small animals, digital technology means millions of veterinary patient records and diagnostic data can be analysed to identify new, subtle indicators of health issues. This enables veterinarians to take preventative action earlier in a pet's life and develop tailored plans to maintain health well into their senior years.

As the class of technology evolves and becomes better integrated, it has the potential to revolutionise the animal health landscape with untold benefits for sustainable livestock production, food security, and even conservation through solutions like virtual fencing to manage grazing and poaching.

In households, the digital revolution means the life of a pet can be longer and more fulfilling, bringing greater benefits to the family around them.

Innovations in the pipeline and the platforms that harness digital's collective potential can underpin the ultimate goal of veterinary medicine that is predictive, preventive, personalized and participatory.

Addressing an illness before a disease or an outbreak occurs and spreads helps to reduce emissions associated with raising animals, and new technologies, including digital tools and diagnostics, have the potential to contribute to emission reductions of almost a third.

For example, predicting and preventing a recent outbreak of African Swine Fever could have saved up to 45 million tonnes of greenhouse gases invested in pig production that was ultimately wasted because it was not converted into food.[10]

New diagnostic products and techniques such as microfluidics, imaging and molecular diagnostics can also help veterinarians analyse smaller samples more quickly, making diagnostics more efficient and allowing health issues to be addressed sooner at the point of care.

Disease control

At their most fundamental, veterinary technologies are intended to prevent and control disease as a cornerstone of protecting animal health and well-being.

Advances in digital diagnostics and monitoring, which increase the speed at which a health change is detected, are empowering farmers, pet owners and veterinarians to act sooner. This offers a greater likelihood of curtailing an illness and stopping it from spreading.

For example, AI-driven image recognition of parasites in stools can accelerate deworming treatment prescribed for a cat or dog, reducing the impact and the chance of worms spreading within the family. Meanwhile, Big Data can transform diagnostic records into a tool of prevention to help identify the onset of chronic illnesses before they take hold, which is increasingly important as pets live longer.

Such technology not only improves the speed of disease control but also capacity, which is also crucial for livestock farms with hundreds of animals all with different health profiles.

Smart tags and collars can track a change in basic animal behaviour down to individual livestock, indicating an illness as much as half a day before a farmhand would, which can make all the difference in terms of intervention, particularly for young livestock.

Accuracy levels of 95 per cent have been found in the correct classification of animal behaviour by radio-frequency identification (RFID) tags and accelerometers, which reduces the margin of human error and the improbability of identifying the earliest sign of ill-health through observation alone.

Furthermore, the digital backbone of these technologies often allows for monitoring to occur at a distance. This is crucial factor in countries and regions where the distance to the nearest veterinarian is considerable, and this data can help ensure accurate information reaches them before they travel to observe a potentially ill animal.

Animal welfare

Quicker and more accurate monitoring, predictive and diagnostic ability reduces not only the threat of disease to animals but also the severity and impact of disease, which brings with it improvements in animal welfare by minimising the pain, distress and suffering associated with ill-health.

Digital tools have enhanced capacity to provide detailed insights into the health state of a pet with diverse data points rapidly available to veterinarians. Greater volumes of data can expose the most minor change in behaviour or biomarker, which can be enough for an algorithm to detect an imminent condition or illness.

With more information, veterinarians are able to develop pet-specific, life-long healthcare plans, which also give pet owners peace of mind.

New and emerging monitoring technologies can also then be used to validate a treatment protocol, with real-time updates on whether or how a pet is responding to medication, and a greater opportunity to review and adjust a prescription.

4. CONCLUSION

The benefits of controlling diseases in livestock and pets extend beyond the wellbeing of the individual animal.

The increased ability to anticipate a change in health status and intervene before an illness or outbreak takes hold supports a One Health approach, which collectively defends the health of animals, people and planet.

The use of digital predictive, monitoring and diagnostic technologies can allow for earlier treatment or a change in regime that also means:

- Reduced need for antibiotics, which means less risk of drug resistance and environmental exposure, and effective responsible use programs that treat animals suffering from disease while helping preserve antimicrobial effectiveness.
- Proactive vaccination and control programs that lower risk of disease spreading to other animals and, in the case of zoonoses, to people.
- Potentially detecting zoonotic disease in its early stage, while it may be pre-symptomatic and has not spilled over to nearby people.
- Fewer losses in food production, meaning improved food and nutrition security.[11]

In households, the proximity of pets to people means monitoring for the first signs of illness and swiftly diagnosing any issues is paramount, otherwise the risk of zoonotic transfer rises. As pet monitoring tools evolve, a future where subtle, often overlooked issue are flagged before worsening is nearing reality.

Human-Animal Bond

Pets play a unique One Health role in households. These animals offer valuable companionship that lead to a host of benefits for the surrounding people, including lower levels of asthma, better heart health, improved mental health and more. Avoiding serious health issues mean a longer life for pets and continued companionship to the family around them.

Pets can often suffer from subtle and silent health challenges. One study found that 1 in 5 dogs visiting a dog park in the USA suffered from an intestinal parasite. For a parasite like heartworm, external symptoms often become apparent only once the issue is life-threatening.

Just as people receive regular, preventative medical screenings, regular diagnostic testing of pets can detect potential health issues before they grow and allow for earlier intervention. Monitoring technologies can help identify whether an animal is displaying subtle signs of a health problem like increased lethargy or reduced feeding.

Improvements in the prevention and control of diseases in animals have the potential to reduce the impact of disease outbreaks on society at large.

Diagnostics have themselves become a prevention tool thanks to emerging digital technologies that allow diagnoses and health characteristics across animals to be compiled, analysed and used to identify new risk factors for illness. For slow onset diseases, these subtle trends often precede clinician awareness, while machine learning has vastly expanded the opportunity to detect such patterns in growing volumes of clinical pathology data.

AI-powered predictive technologies have the ability to analyse health data across limitless numbers of animals, helping identify new, early indicators of disease, which can be a key tool in pandemic and outbreak preparedness, especially when this data is shared across borders and sectors.[12]

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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