Health for Animals
global animal health association

DIGITAL REVOLUTION IN ANIMAL HEALTH

How Predictive, Monitoring and Diagnostics Technologies are Enabling Tailored Care and Better Welfare for Animals

Contents

Introduction

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.[1]

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.[2,3] 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.
- 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.

1 https://www.sciencedirect.com/science/article/pii/S1751731120001391?via%3Dihub
2 US Dog population, 1996: 52.9M; 2017: 76.8M, American Veterinary Medical Association, 1996 – http://concordanimals.com/Links/PDF/DogCatDemographics.pdf 2017 – https://www.avma.org/resources-tools/reports-statistics/us-pet-ownership-statistics
3 EU Dog population, 2010 : 60.2M ; 2020 : 70.5M, FEDIAF 2010 – http://www.stray-afp.org/nl/wp-content/uploads/sites/2/2012/08/facts_and_figures_2010.pdf FEDIAF 2020 – https://fediaf.org/who-we-are/european-statistics.html

The Basics

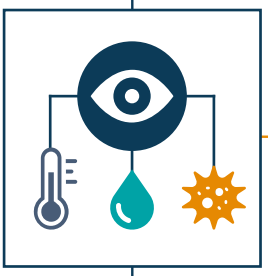
The Technologies

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.

Predictive technologies leverage the wealth of data and insights generated by monitoring and diagnostics to identify behaviour changes, risk factors, genetic predisposition and more, allowing veterinarians, farmers and pet owners to reliably predict changes in an animal's health before they become a problem.

Example: *Predictive technologies bring to bear the latest in artificial intelligence and machine learning to provide customized care plans that anticipate issues and implement the right prevention strategy.*



Monitoring technologies enable real-time monitoring of health in an animal or group of animals by tracking vital signs such as temperature, activity levels, feeding rates, water consumption, disease indicators, reproduction, etc., providing continuous access to actionable data and insights that can help improve health outcomes.

Example: *Sound monitoring systems can pinpoint a single cough in a barn containing hundreds of animals, while smart collars mean pet owners can identify early warning signs of illness like lethargy and reduced appetite.*

Veterinary diagnostics can reliably detect the presence of animal disease or parasites by assessing samples of blood, oral fluid, urine, etc, enabling swift treatment for sick animals or acting as a powerful prevention tool when performed regularly across animal populations.

Example: *'Point of care' diagnostics provide rapid results without needing an external lab, offering immediate answers to concerned animal owners.*

Evolution

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.

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.[4] 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.

Value of Big Data

Big data systems such as 'patient-like-mine' use aggregated diagnostic and insight data to help small animal veterinarians model different scenarios for a patient.

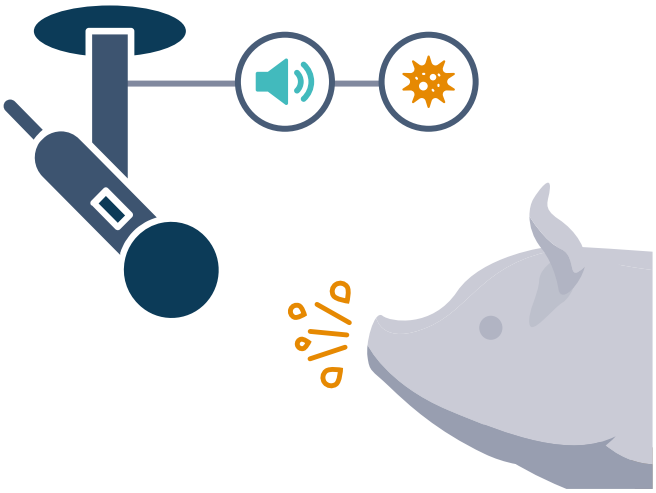
4 https://mayoclinic.pure.elsevier.com/en/publications/patient-like-mine-a-real-time-visual-analytics-tool-for-clinical-

Interconnectivity

The development of digital animal health tools has been expedited by increasing levels of interconnectivity, which have streamlined links between monitoring and diagnosis, and laid the foundations for breakthroughs that predict an illness before it manifests.[5]

For example, genomic sequencing can allow veterinarians to build a more comprehensive health profile for an individual animal to allow them to identify not only disease but genetic predispositions to disease, before they even occur.

Similarly, smart ear tag devices can track four key indicators in cows – eating, movement, heat detection and fertility – and transmit this information every 20 minutes, providing an accurate and up-to-date picture of each animal's health. This data then feeds into a system that alerts a farmer or veterinarian as soon as there is a change that could be an early sign of illness or a change in health status. The next generation of this technology, which is currently only available for cattle, is expected to be able to point to the possible cause of the change in behaviour with increasing levels of accuracy and specificity, and eventually recommend an effective treatment or response.



Sound detection technologies use microphones and sound analysis to monitor and identify audible signs of illness, such as coughs or respiratory changes.

Thermal imaging uses heat sensors and cameras to monitor changes in temperature within groups of animals down to specific body parts such as hoofs and udders.

Ear tag sensors can track the feeding, temperature, behaviour and movement of livestock and monitor vital signs for early indications of illness.

5 Graphic from: https://www.researchgate.net/publication/280489567_Internet_of_Animal_Health_Things_IoAHT_Opportunities_and_Challenges

Application

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.[6]

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.[7]

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.

47% of poultry farmers in Switzerland reported used smartphones to monitor chicken barns

Life-giving, as well as life-saving, technology

Illness is not the only health status that can be better anticipated and managed through new digital tools.

Monitoring technologies can also be used to determine with greater accuracy when an animal is in heat and most likely to conceive, a stage that has typically been challenging for livestock farmers to identify, leading to an unnecessarily high rate of unsuccessful inseminations.

Monitoring for a drop in eating or rumination levels can indicate with greater accuracy the likelihood of a cow being in oestrus, and improve the efficiency of cattle breeding, with benefits for both animals and farmers.

The same tools also provide a lifeline for new calves, which face the most precarious period within their first eight to 10 weeks, and can quickly become dehydrated before a health issue is apparent. Smart collars can track suckling behaviour, which falls at the first sign of ill-health, and allow farmers to seek veterinary help quickly.

6 https://www.cambridge.org/core/journals/animal/article/digital-technology-adoption-in-livestock-production-with-a-special-focus-on-ruminant-farming/17A7BAA5FEE95C7BC09DA4DC96CC21372

7 https://www.frontiersin.org/articles/10.3389/fvets.2019.00410/full

The Benefits

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.

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.

> ***"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."***

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.[8]

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.

8 https://www.sciencedirect.com/science/article/pii/S2214180421000131?via%3Dihub

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.

Gene analysis is an emerging area that could allow practitioners to predict possible health challenges in an animal's lifetime through a genetic "risk profile."

One Health

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.

Prediction software can anticipate changes in health, fertility and other attributes, based on patterns and data gathered by monitoring and diagnostic technologies.

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.[9] 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.

One US study found 20% of dogs visiting a dog park suffered from an intestinal parasite

This early intervention supports a longer, more fulfilling life for the animal, which extends and deepens the valuable bond between owner and pet.

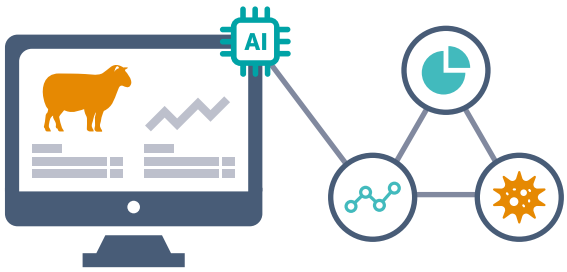
Resilience

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.

A.I. or machine learning-based diagnostics



Algorithms analyse patterns in data and determine the likelihood of illness by matching the data to recognized symptoms and disease profiles.

9 https://www.researchgate.net/publication/341834444_Detection_of_gastrointestinal_parasitism_at_recreational_canine_sites_in_the_USA_The_DOGPARCS_study

Productivity

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.

Just five animal diseases made up two-thirds of outbreaks between 2000 and 2016, impacting global food production and trade.[10] 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.

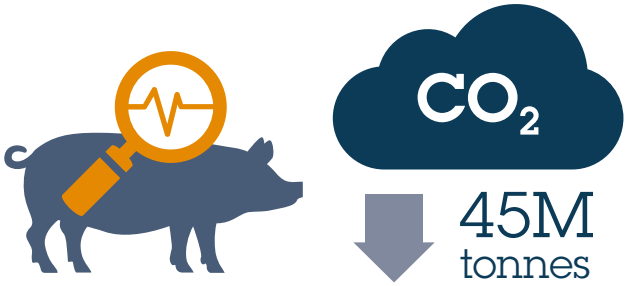
Five animal diseases
made up over two thirds
of global outbreaks between
2006 and 2016

Sustainability

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.[11]

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.[12]

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.



Predicting and preventing
a recent outbreak of African
Swine Fever could have saved
up to 45 million tonnes of greenhouse gases

10 https://www.oie.int/fileadmin/Home/eng/Publications_%26_Documentation/docs/pdf/TT/2016_A_84SG_9.pdf
11 http://www.fao.org/news/story/en/item/1157729/icode/
12 https://www.researchgate.net/publication/348621436_Advancing_environmental_sustainability_through_better_livestock_health_welfare

Patient Care

Veterinary care is inherently challenging as an animal cannot communicate how it is feeling or whether it is feeling symptoms. However, monitoring and diagnostics technologies can bridge this communications gap to help owners and veterinarians better understand what an animal is experiencing.

For instance, monitoring devices like smart collars help owners understand their animals' typical behaviour patterns such as exercise or feeding levels, which allows them to take action when unexpected changes occur that indicate a problem.

Regularly performed diagnostics provide veterinarians with insights into an animal's baseline health and the success of prevention or treatment programs. This allows a veterinarian and owner to create care plans tailored to the animal.

Furthermore, point-of-care diagnostics allow veterinarians to offer immediate answers to concerned animal owners, relieving their worry and allowing the veterinarian to provide a more thorough service to their client.

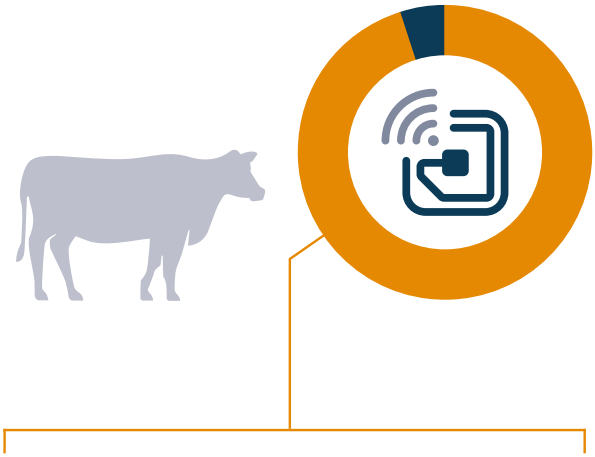
Smart collars use GPS to identify and track the location of a pet or farm animal

Traceability

Understanding every step of the 'farm to fork' journey, from how an animal is raised to the last mile to the grocery store shelf, can reveal opportunities to increase safety, efficiency and sustainability of food production.

Digital technologies allow collection of insights and intelligence throughout the lifecycle of the animal, helping ensure optimal health, feeding, and harvest times, which reduces the overall environmental footprint.

Digital ID systems can then track this protein as it moves through distribution systems and reaches store shelves, which allows retailers to better ensure safety protocols that avoid potential food-borne illness. Consumers then ultimately gain a better insight into their food, which enables more informed decision-making.



Accuracy levels of 95% have been found in the classification of animal behaviour by RFID tags and accelerometers

The Barriers

For the full benefits of digital technologies to be realised, several barriers must be overcome.

Regulatory

Inconsistencies across national and regional regulations, and across different types of technologies mean different markets are benefiting at different rates, putting some at a disadvantage. These variations also impact the level of investment directed towards innovations in developing monitoring, prediction and diagnostic technologies.

For example, point of care testing regulations in the European Union (EU) only defines medical devices intended for human use, while in Japan veterinary point-of-care regulations are comparable to those for in vitro medical devices for human medicine.[13] Regulations may also not be coherent across the constituent parts of diagnostic kits, for example, the equipment itself may not be subject to regulation but the reagent or testing substance will be.

An emerging regulatory area for digital animal health technologies lies in the new levels of data generated and stored through monitoring tools and platforms. While animals may not themselves be subject to privacy or data protection legislation, animal health data has a human dimension. For example, a pedometer or tracking device for a dog could be used to determine where the owner lives and distinguishing habits or behaviours.[14] Conversely, regulations that do not distinguish between human and animal health when it comes to data gathering and storage can create unnecessary challenges for pet owners, particularly when it comes to avoiding punitive insurance premiums.

Infrastructure

A crucial barrier to the adoption of digital tools is the available digital infrastructure. Reliable connectivity over a range of 1.5km is required for the health data of livestock to be regularly transmitted from smart tags or collars the field or the shed to a system that can record and analyse it. This kind of technology is currently limited to cattle, which roam less than sheep and are more likely to stay within range.

Digital infrastructure also varies enormously around the world, and so, while new animal health technology may exist in principle, it often cannot be effectively deployed without broadband, risking a global "digital divide" in animal health.

As well as digital infrastructure, animal owners also need the requisite training to be able to understand and interpret the large volumes of data they can now access about the health of their livestock and pets. Some products have made use of universal indicators such as colour-coded LED lights to indicate a change in health status, but more sophisticated platforms that aggregate data points also require ongoing training and support.

13 https://www.oie.int/en/document/regulation-of-veterinary-point-of-care-testing-in-the-european-union-the-united-states-of-america-and-japan/
14 https://www.researchgate.net/publication/280489567_Internet_of_Animal_Health_Things_IoAHT_Opportunities_and_Challenges

Public Support

Digital technologies can often provide significant 'positive externalities' to livestock operations that may provide outsized value to the public, but not always a direct benefit to the producer. For instance, conservation of certain natural resources or tracking the emissions footprint of production.

Therefore, it is important to consider whether the public sector can create greater incentives to adopt digital technologies that benefit wider society and reduce the barrier to adoption for producers.

Perception

New developments in digital technologies also raise new ethical and social questions, particularly when it comes to probability-based diagnosis.

Pet owners or farmers may be less inclined to accept a diagnosis based on likelihood as determined by an algorithm, even when based in clinical evidence, which may discourage veterinarians from adopting the technology.

The expansion of genomic sequencing for animal health also presents ethical questions and the potential for confusion around the related fields of genome editing and modification.

And to maximise the full preventative benefits of digital tools, pet owners must be prepared to take their animals for regular check-ups to allow veterinarians to build a health profile and identify emerging patterns or health issues.

Data

The ability to generate large volumes of animal health data brings with it questions around data ownership and protection, as well as concepts such as "the right to be forgotten" and market-specific legislation such as the General Data Protection Regulation (GDPR) in the EU. Lack of harmonized or clear data regulations creates significant, sometimes insurmountable, barriers to delivering digital technologies in certain markets.

Recommendations

The following recommendations would contribute towards minimising the barriers to digital technologies:

- Greater recognition among governments, policymakers and public authorities of the value of animal health technologies and the importance of public support, resources and investment into technologies that not only diagnose disease, but also address broader public health challenges including antibiotic resistance, zoonotic disease, and food and nutrition security.
- More responsive regulation where regulation is appropriate to address the idiosyncrasies of animal health technologies as distinct from human medical devices and technologies. Devices should have their own set, or sets, of product regulations, rather than be grouped with the same requirements applied to administered vaccines and biologicals or medical device definitions.
- Allowing for regulatory frameworks to consider whether a product is intended for companion or livestock animals and treating them appropriately. For instance, horses may face limited access to technologies in some markets where they are considered as 'for human consumption' even when they are owned as a companion animal.
- Greater consistency in the application of regulations across markets to inspire consistency of access and benefit.
- Public engagement and awareness around the innovations in animal health technologies and potential benefits for pet owners and livestock farmers.

Conclusion

For centuries, animal health tools have equipped veterinarians to defend livestock and pets against disease threats. Vaccines have been the primary method of prevention while traditional diagnostics have guided disease treatment and management.

But as prevention is better than cure, the best form of defence is a good offense. With the added power of digital technology, artificial intelligence and machine learning, animal health strategies can become proactive rather than reactive, offering the potential to identify, manage and treat health issues before they emerge.

Digital technologies have the potential to increase veterinary intelligence and capacity by an order of magnitude, increasing both the number of animals that can be monitored and the specificity with which they can be managed.

With more and better data, customised and lifelong healthcare plans can be developed for individual animals based on risk profiles that guide interventions to pre-empt and prevent health issues from undermining their wellbeing.

And given animal health is so intrinsically linked to human and environmental health, such developments hold the promise to transform not only the animal health landscape but broader public health under the One Health banner, from zoonotic outbreaks and antibiotic resistance to more sustainable livestock production.

However, at present, the field continues to develop inconsistently, constrained from delivering the full social, economic and environmental benefits by several core barriers.

While animal health technologies are continually evolving and emerging, the infrastructure needed to deliver them – including the regulatory environment – typically develops at a slower pace.

Governments and policymakers can support the digital revolution in animal health by prioritising the architecture needed for these new technologies, from prioritising rural connectivity and digital infrastructure to fostering more agile, responsive regulation where needed that accommodates the changing profile of animal health technologies.

By working with the animal health sector, public authorities can also support greater acceptance of new technologies among veterinarians, farmers and pet owners by raising awareness of the potential benefits and communicating clearly how and in which circumstances they can be used.

Finally, continued innovation needs incentivisation, which comes through a recognition of the value that such technological advances offer and providing the corresponding support.

Early interventions to stop or treat a disease reduces the burden of ill-health – on animals, their keepers and society at large, with animal diseases directly impacting the income, employment, disease risk and food security of billions of people worldwide. A digital revolution in animal health stands to herald a new era for One Health.

www.healthforanimals.org