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EMPOWERING FUTURE VETS INNOVATING ANIMAL HEALTH BUILDING A ONE HEALTH WORLD

From the

Editor's Desk

Dear Readers,

Welcome to the inaugural edition of **NEXTVETS MAGAZINE (Volume 1, Issue 1)**. It is a privilege to introduce a platform dedicated to advancing veterinary science, promoting professional collaboration, and embracing the **One Health** vision.

Veterinary medicine today plays a crucial role in animal health, public health, food security, and environmental sustainability. **NEXTVETS MAGAZINE** aims to connect researchers, academicians, clinicians, students, and veterinary professionals by sharing quality research, review articles, case studies, innovations, and success stories that inspire excellence.

This first issue is the result of the dedication of our editorial team, reviewers, authors, and the continued support of the **Veterinary Association of India (VAI)**. I sincerely thank everyone who has contributed to making this vision a reality.

I invite the veterinary fraternity to join us in this journey by sharing knowledge, research, and experiences that strengthen our profession and contribute to a healthier future for animals, humans, and the environment.

Thank you for your support, and I hope you enjoy the very first issue of **NEXTVETS MAGAZINE**.

With warm regards,
Col. (Dr.) A.S. Rathore
Editor in Chief
NEXTVETS MAGAZINE
Published by Veterinary Association of India (VAI)
www.nextvets.org

Editorial Board

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EMPOWERING FUTURE VETS INNOVATING ANIMAL HEALTH BUILDING A ONE HEALTH WORLD

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Identification of Healthy Animals (Cattle, Buffalo, Sheep, Goat, & Pig) and Birds (Poultry & Duck) for Vaccination: An Overview

Dr. Alok Kumar Yadav

Assistant Commissioner
C.C.S. National Institute of Animal Health
Baghpat-250609, Uttar Pradesh
Email address: alokvet1000@gmail.com

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Abstract:

Vaccination is one of the most effective preventive measures for controlling infectious diseases in livestock and poultry. However, vaccines should be administered only to healthy animals and birds to ensure optimal immune response and minimize the risk of adverse reactions. Identification of healthy animals involves careful clinical examination and observation of general health status before vaccination. Healthy cattle, buffaloes, sheep, goats, and pigs typically exhibit normal body temperature, alertness, active movement, bright eyes, moist muzzle (where applicable), good appetite, normal rumination in ruminants, smooth hair coat, and absence of nasal discharge, coughing, diarrhea, lameness, or wounds. Similarly, healthy poultry and ducks are active, alert, have bright eyes, clean feathers, normal feed and water intake, regular droppings, and show no signs of respiratory distress or weakness. Animals or birds that are sick, stressed, severely malnourished, or recovering from illness should not be vaccinated until they regain normal health. Proper identification of healthy individuals before vaccination enhances vaccine efficacy, promotes animal welfare, reduces disease outbreaks, and contributes to improved livestock productivity and sustainable animal health management. Regular health assessment, good husbandry practices, and adherence to recommended vaccination schedules are essential components of successful disease prevention programs.

Keywords: Healthy animal identification, Vaccination, Livestock health, Poultry health, pre-vaccination examination, Clinical health assessment, Disease prevention

Introduction:

Animal behaviour is a significant factor in determining an animal's health. Normal animal behaviour includes staying with the herd, having bright eyes, a moist nose without discharge, no wounds, and a normal appetite. Normal behaviours are actions we expect to see from animals in good welfare, such as playing or grooming. Normal behaviours tell us that an animal is happy, healthy, and relaxed in its environment. When animals become stressed, bored, or sick, they may perform abnormal behaviours such as biting, hiding, or pacing. A healthy animal has a shining, smooth and even coat as well as shiny horns and hoofs. Eyes should be clear, without discharge or excessive tearing, and the muzzle should be moist. In short-haired animals, e.g. goat and cattle, the hair or coat of the healthy animal will be smooth and shiny. Healthy cattle, buffaloes and their calves lick their coats, and the lick marks will show. Horses should not sweat when resting.

Observing Basic Health Parameters:

1. **Breathing frequency** - (Breathing in + breathing out) is 10-30 times per minute in normal adults and 30-50 times per minute in calves. Observed best from the animal's right flank, seen from behind.
2. **Rumination** - Not less than 40 times per minute and 7-10 hours per day.
3. **Rumen movement** - Two to three per minute can be felt by pressing lightly on the upper part of the left flank.
4. **Appearance** - A healthy animal has a shining, smooth and even coat as well as shiny horns and hoofs. Eyes should also be normal without discharge or tears and muzzle moist.
5. **Fever** - Usually accompanied by rapid breathing, shivering and occasionally diarrhoea. Ears, horns and legs are usually cold to touch while body is too warm.

How can you identify a healthy animal?

1. Shows normal movement, has a normal body temperature, a good appetite, and no cough, nasal discharge, or ocular discharge.

2. Animal husbandry is the science of managing animal livestock. It involves feeding, breeding, and controlling diseases in farm animals. Animal husbandry involves rearing animals such as cattle, poultry, and fish to obtain desired products.

3. A healthy animal's posture is normal. It feeds regularly.

4. Animal Husbandry is the scientific management of animal livestock. It includes various aspects such as breeding, feeding and disease control. Animal-based farming includes cattle, goat, sheep, poultry and fish farming.

In order to take care of the animals properly, it is important that animal keepers should be aware of the animal diseases.

Diseases can be properly diagnosed only by a veterinarian, but if the farmer is personally careful about some activities, he can get the disease checked in time and can avoid any major damage. The difference between healthy and diseased cattle can be seen easily. Diseased animals look lazy and ears also seem to be loose.

A healthy animal is always alert, moves its ears again and again and also takes interest in nearby activities.

- Healthy animals' eyes are always bright.
- Animals chew the cud till 6-8 hours after eating.
- The animal's nose remains wet and cool.
- Animal's skin remains smooth and shiny.
- The animal defecates 8-10 times daily, producing approximately 15-20 kg of faeces.
- The animal's body temperature remains around 100-102.5 degrees Fahrenheit.
- The respiratory rate should be 10-30 breaths per minute.

Signs of Good Health and Illness in Farm Animals:

Farmers must observe their animals closely to make sure they are healthy. A sound management program to keep animals healthy is essential to the farming of all livestock. If the health of the herd is compromised, the farming operation will suffer reduced efficiency. To recognize clinical signs of diseases that are common to livestock, it is important to be familiar with what is normal or healthy. Farmers should assess the herd or flock's general health on a regular basis, including its vital signs, body condition and coat. As a farmer, you should be able to notice signs of ill health in your animal. You should be able to tell whether the animal is being fed well, and is being kept in an adequately clean and comfortable environment. You should also be able to identify when the animal is not getting enough nutrition from its diet, or when it has fallen prey to an illness or parasitic infection.

A healthy animal is alert and aware of its surroundings. It is active and holds its head up, watching what happens around it. It should stand on all of its feet. If an animal stands separate from the herd, it is often due to ill health. An animal which is not interested in its surroundings and does not want to move has health problems. Healthy animals exhibit normal posture. They are alert, have clear eyes and respond to touch. A running nose or dull eyes may indicate ill health.

A healthy animal will walk easily and steadily, balancing its weight on all of its feet. Steps should be regular. Irregular movements result from pain in the feet or limbs. If you go near an animal that is lying down, it should stand up quickly, if it doesn't, it may have health problems. Any animal that cannot walk or stand properly must be closely watched, since it may be suffering from ill health. When you notice that the animal is favouring one leg when it walks, it is important that you restrain it until you find out the cause and treat it effectively.

The eyes should be bright and alert with no discharge at the corners.

Most animals have erect ears which move in the direction of the sound. Ear movements are also meant to swat away flies. The body temperature of a pig can be checked by touching its ear.

The nose should be clean with no discharge. In cattle and buffaloes, the muzzle should be moist, not dry. Healthy animals frequently lick their noses with their tongues.

There should be no saliva dripping from the mouth. If chewing is slow or incomplete, there could be a problem with the teeth.

Healthy animals have a good appetite for food and generally like to feed to their satisfaction. Sick animals have no appetite for food. If you notice that your animal has suddenly lost its appetite for food, it could be because it has fallen ill.

The coat of healthy animals should be clean, smooth and shiny and show complete cover. Signs of ill health are the coat looks dull and hairs fall out. Cold, dry and scarred skin signifies diseases. When you see your animal suddenly show symptoms of a skin disorder, you must pay immediate attention. In short-haired animals, e.g. cattle, the hair or coat of the healthy animal will be smooth and shiny. Healthy cattle and their calves lick their coat and the lick marks will show.

If a cow or buffalo keeps looking at its flanks or kicks at its belly it has a pain in the stomach.

Every breed of farm animal has a specific range of body temperature, pulse rate and respiratory rate that is considered normal. Radical deviation from these values signifies ill health. You will have to check the vitals of your farm animal to ensure that it is physically, mentally and psychologically fit.

Breathing should be smooth and regular when the animal is at rest. Remember that movement and hot weather will increase the rate of breathing. If the animal is resting in the shade, it should be difficult to notice the chest moving as it breathes.

Taking the pulse is important when examining an animal. The pulse of cattle is taken at a point on the underside of the base of the tail. The normal rate is 40–80 beats per minute in an adult. In buffalo the pulse rate is 40-60 beats per minute. Remember that the pulse rate will be higher in young animals. To take the pulse you should feel for it with the first two fingers of your hand. In llamas, alpacas and pigs there is no point at which the pulse can be taken; the beat of the heart itself must be felt for.

Any deviation of the faeces i.e. too hard, too watery, contaminated with worm segments or stained with blood, indicates ill health. If your animal begins to defecate on its own body, it is an indication that it has a problem in its alimentary canal and needs immediate attention. The droppings of a healthy animal will be firm. Very soft droppings (diarrhea) are a sign of ill health. If the animal has difficulty in defecating (constipation) this is also a sign of poor health.

The normal colour of urine is pale yellow. Deep yellow, blood stained, or cloudy urine shows ill health. When your animal shows pain while urinating, there may be something wrong with its urinal system. The urine should be clear, and the animal should show no signs of pain or difficulty in urinating.

If feed is available, a healthy animal will have a full belly. Cattle chew the cud (ruminate) for 6 to 8 hours each day. It is a sign of ill health when these animals stop ruminating.

In the milking animal, a sudden change in the amount of milk produced could indicate a health problem. Any sign of blood or other matter in the milk indicates an infection in the udder. There should be no swelling of the udder and no sign of pain when it is touched. There should be no injury to the teat.

When an animal coughs continuously, it means that something is irritating its throat. Coughing is not necessarily a sign of ill health, if it isn't a persistent or chronic cough.

Healthy animals do not show any sign of pain. When animals begin to show signs of pain by grinding their teeth or groaning, it is an indication that something is wrong.

This is the lining of various systems and organs of the body, e.g. eyes, nose or anus. The mucous lining of healthy animals is moist. When these become dry, the animal experiences discomfort and requires immediate attention.

Healthy Livestock	**Unhealthy Livestock**
Alertness	Lethargic/Listless
Chewing cud	Ruminants not chewing their cud
Sleek coat	Rough hair coat
Bright eyes and pink	Eye membrane Dull eyes
Normal faeces and urine	Abnormal faeces and discoloured urine
Normal temperature	High temperature

Gait steady, No limping	Limping
Normal respiration	Laboured breathing / coughing
Stays in herd or flock	Separates self from herd or flock
Eats and drinks normally	Loss of appetite
Contentment	Runny nose
Normal pulse rate	Swelling on any body part

Appearance of the healthy animal:

Appearance of the animal:

- The healthy animal is alert and aware of its surroundings. It is active and holds its head up watching what is happening around it.
- It should stand on all of its feet. The separation of an animal from the others in its group is often a sign of a health problem.
- An animal which is not interested in its surroundings and does not want to move has health problems.

Movement (GAIT):

- The healthy animal will walk easily and steadily with all of its feet taking its weight.
- Steps should be regular. Irregular movement results from pain in the feet or limbs.
- Horses normally stand during the day.
- If you go near an animal that is lying down, it should stand up quickly otherwise it has health problems.

Eyes:

The eyes should be bright and alert with no discharge at the corners.

Ears:

- Most animals have erect ears which move in the direction of any sound.
- Ear movements will also be quick to get rid of flies, The body temperature of the pig can be checked by touching the ear when an unusually high temperature will be noticed.

Nose and muzzle:

- The nose should be clean with no discharge.
- In cattle and buffaloes, the muzzle should be moist, not dry.
- In sheep and goats, the nose should be cool and dry.
- Healthy animals frequently lick their noses with their tongues.

Mouth:

There should be no saliva dripping from the mouth. If chewing is slow or incomplete, there may be a problem with the teeth.

The coat:

- In short-haired animals, e.g. goats and cattle, the hair or coat of the healthy animal will be smooth and shiny.

- Healthy cattle, buffaloes, and their calves lick their coats, and the lick marks will show.

- Horses should not sweat when resting.
- In poultry, the feathers should be smooth and glossy and not ruffled.
- In pigs a curly tail is a sign of good health while a scaly skin points to health problems.

Behaviour:

If a horse, cow or buffalo keeps looking at its flanks or kicks at its belly it has a pain in the stomach.

Breathing:

- Breathing should be smooth and regular at rest. Remember that movement and hot weather will increase the rate of breathing.
- If the animal is resting in the shade it should be difficult to notice the chest moving as it breathes.

Pulse:

Taking the pulse is important when examining an animal. In man the pulse can be easily taken but in animals it is more difficult and requires practice.

1. In sheep and goats, you can feel the pulse on the inside of the top of the back leg. The rate of the pulse is 70 - 130 per minute in the adult.
2. The pulse of cattle is taken at a point on the underside of the base of the tail, the normal rate is 40 - 80 per minute in the adult. In buffalo the pulse rate is 40 - 60 per minute.
3. The pulse of the horse is taken on the inside of the cheek. The normal rate is 35 - 40 per minute.
4. The pulse of the camel is taken at a point on the underside of the root of the tail. The normal rate is 35 - 45 beats per minute.

Remember that the pulse will be higher in the young animal. To take the pulse you should feel for it with the first two fingers of the hand.

In the llama, alpaca and the pig there is no point at which the pulse can be taken. In these animals, the beat of the heart itself must be felt for.

Droppings or Dung:

- The droppings of the healthy animal will be firm. Very soft droppings (diarrhea) are a sign of ill health.
- If the animal has difficulty in defecating (constipation) this is also a bad health sign.

Urine:

- The urine should be clear, and the animal shows no signs of pain or difficulty in urinating.
- Horses, mules and donkeys can have thick yellow urine which is normal.

Appetite and Rumination:

- If feed is available, a healthy animal will have a full belly.
- Pigs naturally rush to their feed; if they do not, something is wrong.
- Sheep, goats, cattle, buffalo and camels chew the cud (ruminate) for 6 to 8 hours each day. It is a sign of ill health when these animals stop ruminating.

Milk:

- In the milking animal, a sudden change in the amount of milk produced can mean a health problem.
- Any sign of blood or other matter in the milk points to infection in the udder.
- There should be no swelling of the udder and no sign of pain when it is touched. There should be no injury to the teat.

Body temperature

If you suspect that an animal is sick you should take its temperature. Taking the temperature may reveal a higher-than-normal body temperature, which is a sign of infection.

Conclusion:

The identification of healthy animals and birds before vaccination is a fundamental step in ensuring the success of disease prevention programs. Healthy cattle, buffaloes, sheep, goats, pigs, poultry, and ducks respond more effectively to vaccines, resulting in stronger immunity and better protection against infectious diseases. A thorough pre-vaccination health assessment, including evaluation of body condition, behaviour, appetite, body temperature, and the absence of clinical signs of illness, helps ensure that only suitable animals and birds are vaccinated. Sick, stressed, severely malnourished, or debilitated individuals should be treated and allowed to recover before receiving vaccines. Combining accurate health screening with proper vaccine handling, correct administration techniques, bio-security measures, and adherence to recommended vaccination schedules improves herd and flock health, reduces disease transmission, enhances productivity, and minimizes economic losses. Therefore, identifying healthy animals and birds prior to vaccination is an essential practice for effective livestock and poultry health management and sustainable animal production.

References:

Please contact the corresponding author.

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Precautions for Vaccination

Dr. Sheetal Pant

Assistant Commissioner
C.C.S. National Institute of Animal Health
Baghpat-250609, Uttar Pradesh
Email address: pantshe@gmail.com

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Abstract:

Vaccination is one of the most effective and economical methods for preventing infectious diseases in livestock, poultry, and companion animals. However, the success of a vaccination program depends on careful adherence to recommended precautions before, during, and after vaccine administration. Prior to vaccination, animals should be clinically healthy, free from fever or severe stress, and maintained under good nutritional and hygienic conditions. Vaccines must be purchased from authorized sources, stored and transported according to the recommended cold chain (usually 2–8°C), and checked for expiry date, batch number, and physical integrity before use. During vaccination, sterile equipment, correct dosage, recommended route of administration, and proper animal restraint should be ensured to prevent contamination, injury, and vaccine failure. Vaccines should be prepared and administered according to the manufacturer's instructions, avoiding exposure to direct sunlight or excessive heat. Following vaccination, animals should be monitored for any adverse reactions, protected from unnecessary stress, and provided with adequate feed, water, and rest. Proper disposal of used needles, syringes, and vaccine containers, along with accurate vaccination records, contributes to biosafety and effective disease management. Adherence to these precautions enhances vaccine efficacy, minimizes adverse effects, improves animal welfare, and strengthens disease prevention and control programs in both livestock and poultry production systems.

Keywords: Vaccination precautions, Vaccine administration, pre-vaccination assessment, Livestock vaccination, Vaccine safety, Vaccine efficacy, Cold chain management, Vaccine storage, Vaccine

Introduction:

Vaccination has been an essential tool over the years for preventing, controlling and eradicating infectious diseases, for improving animal health and welfare and reducing the need for treatment, as well as contributing to food safety and public health. Animals have been both the receiver and the source of vaccines. Through laboratory testing, the first animal vaccine created was for chicken cholera in 1879 by Louis Pasteur.

The main issues in relation to the vaccination of animals are access and availability. The logistics of distributing vaccines to marginalized populations is still a challenge. Not all animal vaccines are identical. The veterinarian has the scientific background to advise the animal owner, and to prescribe the right product for each species, category of animals, risk or disease condition, based on the directions provided in the products' leaflet. The veterinarian will assess the health status of the animals or herd/flock before vaccination, by observation of clinical signs and/or use of diagnostic tools, ensuring a proper administration and advice on booster doses to reach a level of immunity that will successfully protect the animals.

Before Vaccination:

a. Become familiar with vaccine labels before scheduling vaccinations to avoid errors in timing and the number of packs required.

b. Maintain cold chain unless otherwise stated, livestock vaccines must be stored at 2-8°C. Vaccine components may degrade prematurely if stored inappropriately. Freezing can reduce efficacy due to separation of the adjuvant from the antigen, and it can cause adverse drug events due to release of endotoxin from Gram negative cell walls. In the case of live vaccines, deviation from the recommended temperature directly affects the viability of the organism.

The most common causes of cold chain failure are:

- Vaccines left outside the refrigerator on delivery.
- Power cuts.
- Refrigerator failure (especially in hot weather).
- Accidental alteration of the thermostat setting.
- Door seal failure (the refrigerator works harder and the resulting temperature gradient within the refrigerator creates warm vaccine

near the door and frozen vaccine at the back).

- Overloading the refrigerator with vaccine packs stored too close together (inadequate cool air circulation).
- Cooling large masses of warm objects in the same space (e.g. colostrum).

c. Protect vaccines from light, as ultraviolet light accelerates vaccine degradation.

d. Coordinate all life stages and livestock classes with a herd health program leaving some ages or classes unvaccinated may fail to achieve herd immunity and result in an apparent vaccine breakdown. Vaccination events should be planned to avoid administering several products simultaneously, e.g. vaccines, anthelmintics and mineral injections, especially to sick or stressed animals and during hot weather. Check equipment and vaccine sometimes as a label condition. Use of incorrect or poorly calibrated equipment may result in overdosing (resulting in not enough vaccine on hand and potential toxicity with mineralised vaccines) or underdosing (meaning the entire group should be re-vaccinated).

Dispose of needles in sharps containers:

- Veterinarians and farmers should dispose of needles in designated and appropriately labelled sharps containers. These containers should be collected by medical waste service providers.

Dispose of vaccine packs and unused vaccine responsibly

Some products are harmful to the environment.

- Dispose of empty containers by wrapping with paper and putting in garbage or in approved medical waste containers.
- Vaccine packs containing unused vaccine should be disposed of at veterinary clinics in approved medical waste containers.

Store part- used packs according to label instructions

Check the recommended in-use storage life of opened vaccine packs.

- Do not inject unused vaccine in the gun or draw-off tube back into the vaccine pack. This could contaminate the entire vaccine pack.
- Clearly record the date the pack was opened on the packaging. Many vaccines have a space provided on the carton.

- Unscrew the delivery tube from the vaccine pack.
- Disinfect the stopper with a suitable antiseptic, e.g. methylated spirits.
- Unless otherwise stated, place the vaccine pack in the original outer packaging and store upright in the refrigerator at 2-8°C, protected from sunlight.
- Use a new draw-off tube with each new vaccine pack. Some draw- off tubes can be boiled to sterilize them and then reused. Frequent attachment of the connecting tube may cause the stopper to leak. Therefore, the tube should not be attached more than twice.

Post-vaccination reactions

Ensure owners are aware of the possibility of post-vaccination reactions, such as local tissue lumps and abscesses. Local reactions are more likely with some vaccines. Adherence to aseptic technique will minimize the risk of post-vaccination reactions. Suspected adverse events should be reported.

Conclusion:

Vaccination is one of the most reliable and cost-effective measures for protecting animals against infectious diseases. However, administering a vaccine alone does not guarantee protection. Its success depends on careful planning, proper storage and handling, correct administration, and appropriate monitoring after vaccination. Even a high-quality vaccine may fail to provide adequate immunity if recommended guidelines are not followed.

Veterinarians play a central role in ensuring the success of vaccination programmes by selecting suitable vaccines, evaluating the health status of animals, following recommended vaccination schedules, and educating livestock owners about good vaccination practices. Maintaining the cold chain, using sterile equipment, handling vaccines correctly, and monitoring animals for any adverse reactions are all essential steps in achieving the desired immune response.

Ultimately, effective vaccination is a shared responsibility between veterinarians and animal owners. When vaccines are used correctly and responsibly, they not only protect individual animals but also strengthen herd immunity, reduce the spread of infectious diseases, improve livestock productivity and welfare, and contribute significantly to food security and public health.

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Please contact the corresponding author.

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Challenges and Future Directions in Wildlife Health Management in India: Integrating One Health for Sustainable Conservation

Dr. Arpan Chauhan

M.V.Sc. Scholar (Veterinary Medicine)
Email address: chauhan27051998gmail.com

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Abstract:

India's rich wildlife biodiversity plays a crucial role in maintaining ecological balance, yet it faces increasing threats from habitat fragmentation, climate change, emerging infectious diseases, and expanding human–wildlife interactions. These challenges have elevated wildlife health management as a critical component of biodiversity conservation and public health. The One Health approach, which integrates human, animal, and environmental health, provides an effective framework for addressing complex health issues at the wildlife–livestock–human interface. This article discusses the significance of wildlife health, the evolving role of veterinarians in disease surveillance, rescue, rehabilitation, and conservation, and the importance of interdisciplinary collaboration. It highlights key challenges, including inadequate surveillance systems, limited specialized infrastructure, shortage of trained wildlife veterinarians, illegal wildlife trade, and the influence of climate change on disease dynamics. The article further explores future directions involving advanced molecular diagnostics, genomic technologies, artificial intelligence, geographic information systems (GIS), remote sensing, and integrated disease surveillance to strengthen wildlife health management in India. Greater investment in research, capacity building, and institutional collaboration is essential for enhancing preparedness against emerging zoonotic diseases and supporting sustainable conservation. By adopting the One Health framework, India can improve wildlife health, safeguard biodiversity, and protect livestock and human populations from emerging health threats.

Keywords: One Health, Wildlife Health, Conservation Medicine, Zoonoses, Biodiversity

Introduction:

India possesses extraordinary biological diversity, supporting a wide variety of mammals, birds, reptiles, and other wildlife that are fundamental to healthy ecosystems. However, increasing urban expansion, habitat degradation, climate variability, and closer interactions among wildlife, domestic animals, and humans have created new challenges for disease prevention and biodiversity conservation. In this changing scenario, wildlife health has become a vital component of biodiversity conservation and public health. The One Health approach provides an integrated framework that recognizes the close relationship between animal health, human health, and environmental well-being.

Importance of Wildlife Health

Healthy wildlife populations contribute to ecological stability by maintaining food chains, pollination, seed dispersal, and natural population control. Disease outbreaks in wildlife can disrupt ecosystems and, in some cases, spill over into livestock and human populations. Events involving avian influenza, Nipah virus, rabies, and bovine tuberculosis demonstrate how diseases at the wildlife-livestock interface can have far-reaching consequences. Continuous health monitoring of free ranging and captive wildlife is therefore essential for early detection and effective disease management.

Expanding Role of Veterinarians

Modern wildlife veterinarians perform responsibilities that extend far beyond clinical treatment. Their work includes disease surveillance, rescue and rehabilitation of injured animals, preventive healthcare, quarantine management, diagnostic investigations, and participation in conservation programmes. They also collaborate with forest officials, ecologists, microbiologists, epidemiologists, and public health professionals to investigate disease outbreaks and develop preventive strategies.

With the advancement of veterinary science, wildlife health management now combines clinical expertise with laboratory diagnostics, epidemiology, pathology, and conservation biology.

One Health: A Collaborative Strategy

The One Health concept emphasizes that the health of people, animals, and ecosystems cannot be addressed independently. Wildlife often serves as an important indicator of environmental changes and Emerging disease threats. Effective implementation of One Health requires coordinated surveillance systems, information sharing among institutions, rapid diagnostic support, and multidisciplinary research. Important components of a successful One Health program include:

- Integrated disease surveillance across wildlife, livestock, and humans
- Advanced molecular diagnostic techniques
- Monitoring of antimicrobial resistance
- Environmental risk assessment
- Community awareness and education
- Collaboration between veterinary, medical, and environmental sectors

Major Challenges in Wildlife Health Management

Despite significant progress, several obstacles continue to affect wildlife healthcare in India. One of the most pressing challenges is the shortage of specialized wildlife veterinarians and dedicated diagnostic laboratories. Disease surveillance in free ranging wildlife remains difficult because of inaccessible habitats and limited field infrastructure. Habitat fragmentation and increasing human encroachment have intensified human–wildlife interactions, increasing opportunities for disease transmission.

Climate change further complicates disease ecology by influencing vector distribution, parasite survival, and host susceptibility. Illegal wildlife trade and transboundary movement of animals also facilitate the spread of infectious diseases. Limited financial resources and inadequate research funding continue to restrict long-term wildlife health monitoring programmes.

Future Directions

Strengthening wildlife health systems requires investment in both infrastructure and human resources. Modern technologies such as genomic sequencing, geographic information systems (GIS), artificial intelligence, and remote sensing are improving disease surveillance and outbreak prediction. Portable diagnostic tools and digital reporting systems can enhance field-based disease detection.

Greater emphasis should also be placed on training veterinarians in wildlife medicine, expanding interdisciplinary research, and establishing stronger collaborations between veterinary universities, zoological parks, forest departments, and public health agencies. These initiatives will improve preparedness for Emerging diseases while supporting biodiversity conservation.

Personal Perspective

As an M.V.Sc. scholar in Veterinary Medicine involved in wildlife-based research, I have observed that maintaining the health of captive and rescued wild animals requires an integrated scientific approach. Regular health surveillance, timely diagnosis, effective parasite control, and collaboration between veterinarians and wildlife managers are essential for improving animal welfare and conservation outcomes. These experiences reinforce the importance of applying One Health principles in routine wildlife healthcare.

Conclusion

Wildlife health is an indispensable component of environmental sustainability, livestock health, and human well-being. The growing risk of emerging infectious diseases highlights the need for stronger surveillance systems, scientific research, and interdisciplinary collaboration. By embracing the One Health approach and strengthening wildlife healthcare infrastructure, India can better conserve its rich biodiversity while protecting both animal and public health for future generations.

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Please contact the corresponding author.

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Beyond Antibiotics: Harnessing Genetics and Genomics for Sustainable Mastitis Management in Dairy Cattle

Dr. Saalom King J

Ph.D Scholar

Department of Animal Genetics and Breeding

Veterinary College and Research Institute, Namakkal- 637 002, Tamil Nadu, India

Email address: saalomking31@gmail.com

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Abstract:

Mastitis remains one of the costliest diseases affecting dairy production, reducing milk yield, compromising animal welfare and increasing antimicrobial use. Conventional control measures, although essential, cannot fully prevent this recurrent infection because disease susceptibility is influenced by genetics. Precision breeding integrates genomic technologies such as quantitative trait loci mapping, genome-wide association studies, genomic selection, transcriptomics and other multi-omics approaches to identify animals with superior genetic resistance. Selection based on genomic estimated breeding values enables earlier and more accurate breeding decisions which reduces disease incidence and antibiotic dependence. Combined with effective management and veterinary care, precision breeding offers a sustainable strategy for healthier, more productive, and resilient dairy herds.

Keywords: Mastitis, genomic selection, transcriptomic, breeding

Introduction:

Mastitis remains one of the most economically important diseases affecting the global dairy industry. Despite advances in dairy management, nutrition, housing and veterinary care, inflammation of the mammary gland continues to reduce milk production, compromise animal welfare and increase production costs. Dairy cattle contribute nearly 80% of the world's milk production. Mastitis affects mostly affects cattle, buffaloes than sheep and goats. As the world's largest milk producer, India depends on healthy dairy herds to sustain food security, rural livelihoods and the growing dairy economy (FAO, 2021). Unlike many infectious diseases, mastitis is a multifactorial disorder resulting from interactions among pathogens, host immunity, genetics, environmental conditions and farm management. Consequently, even well-managed herds also experience recurrent infections if animals are genetically susceptible.

Conventional mastitis control relies on good milking hygiene, housing sanitation, vaccination, dry cow therapy and antimicrobial treatment. While these measures remain essential, growing concerns over antimicrobial resistance (AMR), treatment costs and recurrent infections have highlighted the need for sustainable long-term solutions (Kupczyński *et al.,*2024). One such solution is precision breeding, which combines modern genomics with conventional breeding to identify and select animals carrying favourable genetic variants for disease resistance. Technologies such as quantitative trait loci (QTL) mapping, genome-wide association studies (GWAS), genomic selection, transcriptomics and other omics now enable breeders to improve herd health while maintaining productivity. Rather than replacing conventional control measures, precision breeding complements them by gradually developing dairy populations that are naturally more resilient to mastitis and less dependent on antibiotic therapy.

Understanding mastitis: More than an udder infection

Mastitis is an inflammation of the mammary gland, most caused by bacterial pathogens entering through the teat canal. It results in substantial economic losses through reduced milk yield, poor milk quality, increased veterinary costs, premature culling and compromised animal welfare. The disease occurs in two forms. Clinical mastitis is characterised by visible signs such as swelling, pain, heat, abnormal milk and reduced milk production. Infection may involve only one quarter or several, but lesions remain specific to particular quarter because each quarter functions independently and early diagnosis with appropriate treatment can often prevent permanent damage. Subclinical mastitis, however, is more difficult to detect because affected animals show no obvious clinical signs. Since these animals continue producing contaminated milk and act as reservoirs of infection, subclinical mastitis accounts for most economic losses in dairy herds.

A key indicator of udder health is the somatic cell count (SCC), which reflects the number of immune and epithelial cells present in milk. Healthy cows typically have SCC values below 100,000 cells/mL, whereas counts exceeding 200,000 cells/mL strongly indicate intramammary infection (Rupp and Boichard, 1999). Consequently, SCC has become an important tool for mastitis diagnosis, milk quality monitoring and genetic evaluation. Although antibiotics remain indispensable for treating bacterial mastitis, repeated antimicrobial use contributes to antimicrobial resistance and increases production costs. Moreover, chronic infections may cause irreversible fibrosis of mammary tissue, permanently reducing milk-producing capacity. These limitations emphasise that mastitis should not be viewed solely as a disease requiring treatment but as a multicausative disorder influenced by pathogen exposure, environmental conditions, management practices and the animal's genetic susceptibility. This understanding forms the basis for developing long-term preventive strategies such as precision breeding.

Why conventional control alone is not enough?

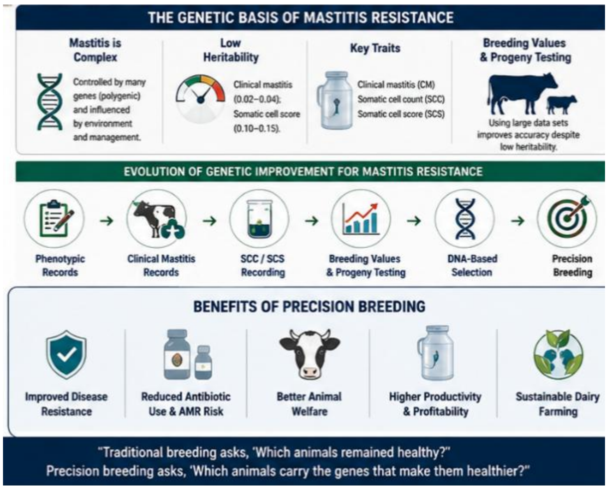
Conventional mastitis control has greatly improved udder health through hygienic milking practices, housing sanitation, balanced nutrition, vaccination, dry cow therapy and regular herd monitoring. These measures remain the cornerstone of mastitis prevention and have substantially reduced disease incidence in dairy herds. Despite these advances, mastitis continues to be one of the most prevalent and economically alarming diseases. The persistence of mastitis, even in well-managed farms, demonstrates that disease occurrence is influenced not only by pathogen exposure and management but also by the animal's inherent ability to resist infection.

Although antibiotics remain essential for treating bacterial mastitis, they are administered only after infection has developed, by the time tissue damage and production losses may already have occurred. Repeated antimicrobial use also increases treatment costs, milk withdrawal periods and the risk of antimicrobial resistance (AMR), a growing concern within the One Health framework (Kupczyński *et al.,*2024). Likewise, currently available vaccines reduce disease severity but cannot provide complete protection against the diverse pathogens responsible for mastitis. These limitations have shifted attention from treatment towards prevention. Rather than relying solely on therapeutic interventions, modern breeding programmes aim to enhance the animal's natural resistance to disease. Unlike antibiotics or vaccines, genetic improvement is a permanent and cumulative approach, allowing favourable alleles to be transmitted to future generations. Although breeding cannot replace good management, it offers a sustainable long-term strategy that complements conventional mastitis control (Shook, 1989). This paradigm shift-from treating mastitis to breeding animals that are naturally more resistant forms the basis of precision breeding.

Can we breed dairy animals that are naturally resistant to mastitis?

The answer is yes but it is not straightforward. Unlike simple inherited traits, mastitis resistance is a polygenic trait, controlled by numerous genes that collectively influence immune function, inflammatory responses and mammary gland health. In addition, environmental factors such as pathogen exposure, nutrition, housing and management strongly influence whether disease develops. One of the greatest challenges is the low heritability of mastitis. Clinical mastitis has a heritability of only 0.02-0.04, indicating that environmental factors contribute more to disease occurrence than genetics (Heringstad *et al.,*2000). Consequently, selecting animals solely based on disease history results in slow genetic progress.

To improve selection accuracy, breeders rely on measurable indicators of udder health. The most widely used are clinical mastitis (CM) records and somatic cell count (SCC). During intramammary infection, immune cells migrate into the mammary gland, increasing the number of somatic cells in milk. Because SCC is routinely measured during milk recording, it serves as a practical indicator of udder health. For genetic evaluation, SCC is converted into somatic cell score (SCS), which has a slightly higher heritability (0.10-0.15) and is therefore more effective for selection (Rupp and Boichard, 1999). Breeders further improve selection accuracy by estimating breeding values, which predict an animal's ability to transmit favourable genes to its offspring. Historically, progeny testing of bulls provided reliable estimates of mastitis resistance based on the performance of hundreds of daughters (Shook, 1989). Several countries, particularly the Scandinavian dairy breeding programmes, successfully incorporated SCC and clinical mastitis records into national selection indices, demonstrating that disease resistance can be improved without compromising milk production (Heringstad *et al.,*2000). Nevertheless, conventional selection remains relatively slow because it depends on phenotypic records collected after animals begin producing milk. This limitation has driven the adoption of molecular genetics and genomics, enabling breeders to identify genetically superior animals shortly after birth using DNA-based information. These advances have laid the foundation for precision breeding, where genomic information guides the selection of healthier, more resilient dairy animals.



Precision breeding in action: From DNA markers to genomic selection

The transition from conventional breeding to precision breeding marks a major milestone in livestock genetics. Traditional breeding relied on pedigree records and observable performance, whereas modern genomic technologies enable the identification of genetically superior animals at an early age, even before desirable traits are expressed. The first breakthrough came with the discovery of QTLs-genomic regions associated with economically important traits. Unlike single-gene disorders, mastitis resistance is a polygenic trait, controlled by numerous genes with small individual effects. QTL mapping demonstrated that resistance has a measurable genetic basis and can therefore be improved through selective breeding. The Animal QTL Database currently reports more than 1,800 QTLs for somatic cell score (SCS) and over 500 QTLs for clinical mastitis (CM), illustrating the complex genetic architecture of mastitis resistance (Hu *et al.,*2013).

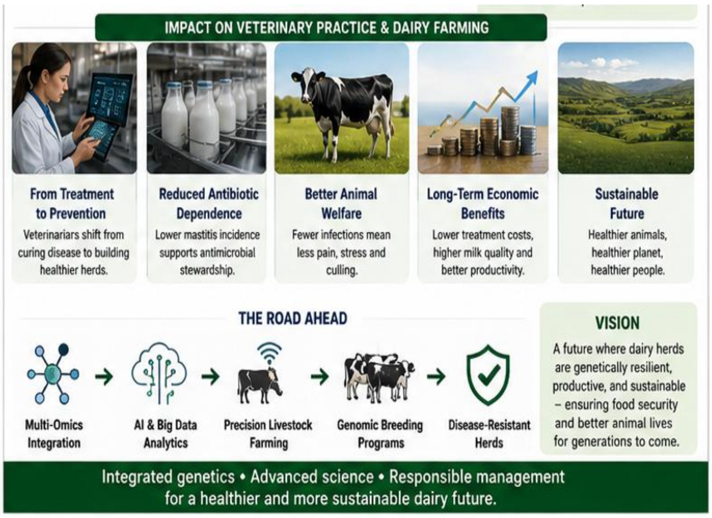
Although QTL mapping identified important genomic regions, these regions often contain many genes, making it difficult to identify the true causative variants. This limitation led to the adoption of genome-wide association studies (GWAS), which analyse hundreds of thousands of single nucleotide polymorphisms (SNPs) across the genome. Combined with high-density SNP chips and whole-genome sequencing, GWAS has enabled researchers to identify candidate genes involved in immune regulation, inflammation and mammary gland defence with much greater precision. These advances paved the way for marker-assisted selection (MAS) and, more importantly, genomic selection. While MAS relies on a limited number of DNA markers linked to favourable QTLs, genomic selection simultaneously evaluates thousands of SNPs across the genome to estimate an animal's genomic estimated breeding value (GEBV). Because of its ability to capture the combined effects of numerous genes, genomic selection is effective for complex, low-heritability traits such as mastitis resistance. Importantly, breeding values can now be predicted shortly after birth using a simple DNA sample, allowing faster and more accurate selection of superior animals. Recent advances extend precision breeding beyond DNA sequence alone. Whole-genome sequencing, transcriptomics and other multi-omics approaches help identify functional genes and biological pathways associated with host immunity and udder health. When integrated with GWAS and QTL information, these technologies improve the identification of candidate genes responsible for disease resistance (Mackay, 2004).

Precision Breeding: Transforming Veterinary Practice and Sustainable Dairy Farming

Precision breeding extends beyond identifying disease-associated genes-it aims to produce healthier animals, reduce disease incidence and promote sustainable dairy production. Unlike therapeutic interventions that act after infection, genetic improvement gradually increases the frequency of favourable alleles within a population, providing cumulative and permanent benefits across generations. Importantly, precision breeding complements rather than replaces conventional mastitis control. Good management practices, including hygiene, nutrition, biosecurity, vaccination and regular herd monitoring, remain essential. However, combining these measures with genetic improvement enhances the animal's natural ability to resist infection, resulting in more effective and sustainable disease control.

For veterinarians, this approach represents a shift from reactive disease treatment to proactive disease prevention. In addition to diagnosis and therapy, veterinarians are increasingly involved in interpreting genomic information, advising breeding decisions and collaborating with geneticists to improve herd health. As genomic technologies become more accessible, their role in precision breeding will continue to expand. Reducing mastitis through genetic selection also supports antimicrobial stewardship. Because mastitis is one of the leading causes of antibiotic use in dairy farming. Breeding animals with improved disease resistance can decrease antimicrobial use, lower treatment costs, reduce milk discard and contribute to global efforts to combat antimicrobial resistance within the One Health framework (Dhital *et al.,*2026).

Beyond disease control, precision breeding improves animal welfare by reducing pain, chronic infections and premature culling while enhancing longevity and lifetime productivity. These health improvements translate into significant economic benefits through lower veterinary expenses, fewer replacement animals and improved farm profitability. Although precision breeding is also being explored in species such as dairy goats, where copy number variations (CNVs) and epigenetic mechanisms like DNA methylation are being investigated for disease resistance, practical implementation still requires further research. Moreover, genetic improvement should not be viewed as a standalone solution. The greatest success will come from integrating genomics with accurate phenotypic recording, sound management practices and continuous veterinary oversight. Ultimately, precision breeding is reshaping veterinary medicine by shifting the focus from treating mastitis after it occurs to preventing disease through informed genetic selection. This integrated approach promises healthier animals, reduced antibiotic dependence, improved farm sustainability and a more resilient dairy industry.



Future perspectives: Towards precision livestock health

Advances in animal genomics have transformed disease resistance breeding from a theoretical concept into a practical tool for dairy improvement. However, the future of precision breeding lies in integrating genomics with multi-omics technologies, artificial intelligence (AI) and digital livestock management systems. While genomic studies identify DNA variants associated with mastitis resistance, approaches such as transcriptomics, epigenomics, proteomics and metabolomics provide deeper insights into gene regulation, biological pathways and immune mechanisms. Integrating these datasets with genome-wide association studies and QTL mapping can improve the identification of reliable biomarkers for disease resistance. Similarly, AI and machine learning can combine genomic information with production records, health data, environmental measurements and sensor-based monitoring to predict disease risk, optimise breeding decisions and develop herd-specific health strategies. As genotyping costs decline, national genomic breeding programmes and breed-specific reference populations will play an important role in expanding precision breeding, particularly in developing countries.

Emerging technologies such as gene editing, especially CRISPR-based approaches, offer potential opportunities for introducing favourable genetic variants; however, ethical, regulatory and economic challenges currently limit their application in food-producing animals. Therefore, genomic selection remains the most practical strategy for improving mastitis resistance in dairy populations. Nevertheless, genetics alone cannot eliminate disease, as mastitis results from complex interactions among host genetics, pathogens, environment, nutrition and management practices. Future mastitis control will depend on integrating precision breeding with effective veterinary care, biosecurity, vaccination, nutrition and early disease detection. Veterinarians will increasingly work alongside geneticists, bioinformaticians and data scientists to translate genomic discoveries into practical herd health solutions, ultimately improving animal welfare, reducing antimicrobial use and promoting sustainable dairy production.

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Please contact the corresponding author.

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Ethical dilemmas faced by veterinarians in translational research and clinical practice

Dr. Deepthi V
PhD Scholar
Division of Pharmacology & Toxicology,
ICAR- Indian Veterinary Research Institute,
Izatnagar, Bareilly, Uttar Pradesh.
Email id:
deepthi99v@gmail.com

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Abstract

Veterinary research stands at a crossroads where innovation meets responsibility, demanding that every step forward honors the life it touches. Veterinarians are duly qualified to minimize animal suffering through the application of scientific knowledge and to safeguard animal welfare. Yet, when contributing to healthcare through research, veterinarians must conduct studies in compliance with ethical frameworks that govern research planning and implementation. While discoveries from in vivo research have advanced medicine, they often come at the cost of animal lives. These lives, though not directly benefited, deserve humane treatment, reminding us that every creature is entitled to dignity in life and in death. Implementing the 3Rs principles of reduction, refinement and replacement, alongside the growing importance of translational research in companion animal oncology, provides a pathway to balance innovation with ethics. Furthermore, addressing ethical challenges in preclinical trials and clinical practice requires veterinarians to align practice with regulatory education, welfare and consent.

Keywords: Clinical practice, Companion animals, Ethics, In vivo trials, Veterinarian, 3Rs principle.

Introduction:

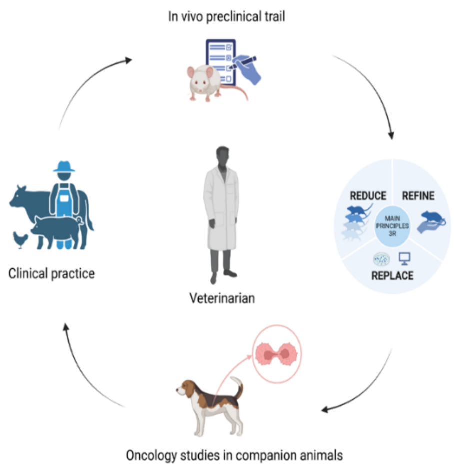
The primary role of a veterinarian is to safeguard the health of animals for the well-being of humans. For centuries, numerous pieces of evidence including the smallpox vaccine (Riedel, 2005), antibiotic effects of penicillin (Gaynes, 2017) from in vivo animal testing have made significant contributions towards the scientific advancement in the field of health care. Hence, the fact that every mankind is benefited from a greater to a lesser extent from such animal findings cannot be denied. Despite its numerous advantages, there is always a group of individuals or organisations protesting either to limit or stop such in vivo research. So, understanding the concept of ethics is needed to assess the ethical concerns of in vivo research.

Ethics deals with moral duty considered either as morally right or wrong. It can also be viewed as one's personal beliefs, whether an action is right or wrong, good or bad (Fischer, 2004). Hence, all animal experiments in preclinical trials require the knowledge and skills of a qualified veterinarian who is legally authorised to assess the health of research animals in accordance with ethical principles (Kiraga & Dzikowski, 2023). This article addresses the ethical challenges veterinarians face in balancing innovation with welfare, focusing on the 3R principle, translational research, clinical practice, informed consent, persistent dilemmas of preclinical and clinical trials.

The 3Rs principle (Refinement, Reduction, Replacement):

Every animal experiment planning undergoes the implementation of the 3Rs principle (Russell & Burch, 1959). The 3Rs principle includes "reduction", "replacement" and "refinement" while the concept of "rehabilitation" is included in the 4Rs principle. "Reduction" involves the minimal usage of animals that can produce appropriate statistical strength as per the regulatory requirements for the approval of the test compound. "Replacement" implements the use of alternatives to animals such as in vitro studies, in silico computer modelling, epidemiological, microbiological and clinical studies that can train machine learning deep network algorithms. "Refinement" is generally concerned with minimizing animal suffering during experimentation by administering anesthesia, analgesia, inhalation instead of injection (minimize pain due to needle injection), humane animal restrain that prevents repetition of experiment that might occur due to wound licking, restricting use of painful inflammatory substances such as Complete Freund's Adjuvant in immunological studies, alternatives to Draize tests such as Corrositex, EpiOcular tests (Ibrahim, 2006).

Instead of leaving suffering animals alive, it is morally correct to kill the animals under proper anaesthesia after the end of the experiment. But it is still controversial when certain research experiments that cannot avoid pain raise many ethical concerns. Besides providing insights into mechanisms, efficacy and safety, drug testing in animals faces significant constraints. It should be clearly justified for the harm caused to animals against the benefit of better innovations. But the high failure rate of anticancer therapies due to their poor clinical effectiveness, rather than the drug safety issues, questions the present in vivo efficacy studies (Regan et al., 2018). The use of standardized laboratory conditions, inbred strains and artificial disease models limits translational relevance. Moreover, such models cannot replicate the long-term dynamics of human tumor growth, the features of minimal residual disease or the complex heterogeneity of the macro and microenvironment characteristic of spontaneously arising human cancers (Paoloni & Khanna, 2008).



Role of veterinarian in clinical research and practice (Created in Biorender)

Though it is ethically concerning to use animals from the lower order species for animal research, some experiments necessitate the use of primates as they are the evolutionarily closest to humans. This is because the use of rodent models in many diseases with idiopathic pathogenesis and ineffective treatments, leads to poor clinical translation. Despite the ethical dilemma, such conditions mandate the use of sentient animals, the primates to arrive at effective prevention and treatment of diseases (Kiraga & Dzikowski, 2023).

Importance of translational research:

The concept of use of naturally occurring animal diseases as human disease models was first proposed by Nobel laureate August Krogh in 1929. He stated that “for a large number of problems there will be some animal of choice on which it can be most conveniently studied” (Krogh, 1929). Natural disease models overlap with human diseases in terms of the underlying pathophysiology, exposed environment and therapeutic responses. The American Veterinary Medical Association (AVMA) maintains an Animal Health Studies Database website https://ebusiness.avma.org/aahsd/study_search.aspx listing details of companion animal clinical trials about diseases of translational importance including mesenchymal stem cell therapy for cats with chronic kidney disease and dogs with osteoarthritis, to immunotherapy for equine skin tumors and gene therapy for canine degenerative myelopathy.

Pets as natural disease models make veterinary research a valuable contributor to human health outcomes (Quigley et al., 2024). In canine models, tumorigenesis occurs within a biologically relevant chronology under an intact immune system, enabling progressive emergence of immune escape mechanisms, therapeutic resistance and metastatic progression (Regan et al., 2018). Oncology trials are more frequently conducted in animals because veterinary drug approval can proceed on the strength of animal data alone, whereas human drug approval requires independent human clinical data and cannot rely solely on veterinary findings (Fürdös et al., 2015). Further, the shorter lifespan of dogs in comparison to humans enables faster efficacy data. Generally, the effectiveness of oncology therapies requires accurate identification of tumor biology and the patient cohorts most responsive for therapeutic benefit. Thus, a collaborative initiative for an Oncology-Pathology Working Group can enhance communication between oncologists and pathologists to ensure excellence in pathology reporting within veterinary oncology (Regan et al., 2018).

Ethical challenges in translational research:

Best-practice guidelines for veterinary oncology trials support rigorous evidence generation, while attention to patient welfare and owner advocacy ensure ethical integrity and trust in the research team (Page et al., 2016). Thus, effective strategies for veterinary clinical trial recruitment should adopt a holistic perspective, encompassing protocol development and coordination, inclusive recruitment, incentive structures, workforce allocation, promotional efforts and participant continuity. While human clinical trial evidence and frameworks provide valuable benchmarks, it is equally important to evaluate current veterinary methodologies and identify opportunities for refinement within this discipline (Quigley et al., 2024). Regulatory frameworks do not allow authorities to assess whether consumer product tests are unnecessary or ethically imbalanced against animal welfare.

In practice, this means that toxicity testing continues even when it imposes considerable suffering on animals yet produces only superficial human benefits, such as “new and improved” household cleaners (Ibrahim, 2006). Ethics committee submissions are also bound only by laboratory animal regulations, yet these do not fully apply to companion animals. Housing standards, for instance, cannot be standardized for pet dogs and essential elements such as predefined quality standards for owner consent forms are not addressed (Fürdös et al., 2015). Stem cell research, cloning technology and xenotransplantation viewed as an alternative to animal experimentation actually involves countless animals in experiments throughout its development.

Ethical challenges in clinical practice:

Early efforts to teach ethics in veterinary practice were centered on “professional etiquette” (Rollin, 2013), rather than addressing deeper ethical dilemmas such as those involved in euthanasia decisions. A key ethical challenge in veterinary practice is the divergence between safeguarding animal welfare and client expectations. Ethical dilemmas in veterinary practice are often settled in favour of the client rather than the animal. This is accomplished through legislation that treats animals as property, denying them comparable legal and moral recognition to humans. If such standing were equal, practices like using animals for food or fibre would be hard to defend. Thus, even in production-based industries, veterinarians often struggle to align ethical duties to animals with the expectations of the corporation. Hence, veterinarians emphasize the importance of ethical oversight in companion animal practice where the interests of animals, owners, practitioners and sponsors may conflict (Clutton et al., 2017). Veterinarians in clinical practice also face greater difficulty with ethics oversight than laboratory animal specialists, particularly when procedures fall outside the framework of randomized controlled trials (Quain et al., 2021).

To avoid blame or paternalism, some veterinarians present treatment options without guidance, a "vending machine medicine" approach (Hartnack et al., 2016) that prioritizes client autonomy but neglects responsibility for the animal's welfare. Though clients make the final decision, they often depend on veterinarians for counsel during difficult choices. However, poor food animal transportation decisions, veterinarian's contribution to ongoing animal negligence, economic decisions impacting animal welfare, failure of the client to follow up on timely veterinary care, owner's nonacceptance of their animal's poor quality of life and owner's denial of end-of-life realities are some of the reasons animal welfare needs often go unmet (Hernandez et al., 2018).

Veterinary consent in clinical trials:

Although clinical trials are an old concept, the FDA did not mandate them until the thalidomide crisis of 1962 revealed the dangers of unregulated prescribing, thereby prompting the FDA to strengthen trial requirements (Junod, 2008). In September 2023, FDA also issued draft guidance on informed client consent in companion animal clinical trials. By reshaping veterinary informed consent through defined procedures, timelines and formats, this guidance imposes compliance responsibilities yet simultaneously enhances owner engagement and clinical trial enrolment (Frederick, 2024). Veterinarians sometimes extend their work beyond the laboratory, studying rare conditions in donated pets or monitoring vaccination trials in dogs and cats. Such nontraditional uses of companion animals in research have driven the establishment of regulations to guarantee that these animals' benefit from clinical veterinary innovations and practices (Hampshire, 2003). Unlike medical informed consent, which protects the patient's rights, veterinary consent primarily secures the owner's property rights. As a result, a veterinarian acting without consent is liable for property damage, whereas a physician would face charges of assault (Flemming & Scott, 2004).

Conclusion: Navigating the ethical dilemmas at the intersection of translational

research and clinical practice is thus essential for the continued advancement of both human and clinical medicine. Translational research, particularly through comparative oncology in companion animals, provides a vital bridge for accelerating drug development that benefits multiple species including humans. However, this progress must be guided by a strong commitment to the 3Rs principles, ensuring that the experimental techniques remain as humane as possible. Furthermore, the ethical integrity of clinical trials depends on strong informed consent, protecting animal and owner interests while maintaining public trust in research process. Ultimately, veterinarians must balance science and advanced care, keeping medical innovation rooted in patient welfare.

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Please contact the corresponding author.

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Designing the Next-Generation Climate-Smart Animal Health System for Indian Conditions

Manisha Choudhary and *Ajay Kumar Dang

Animal Physiology Division
ICAR - National Dairy Research Institute
Karnal, Haryana, India
*Email id: *ajaydang@icar.gov.in*

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Introduction:

Climate change has emerged as one of the most significant global challenges influencing agriculture, livestock production, and food security, with rising ambient temperatures, erratic rainfall, prolonged droughts, floods, and more frequent extreme weather events disrupting livestock production systems worldwide; India, home to the world's largest livestock population, is particularly vulnerable because a substantial share of its dairy and livestock sector is managed by smallholder farmers who depend heavily on natural resources, and since livestock underpins rural livelihoods, nutritional security and the national economy, safeguarding animal health under changing climatic conditions has become a national priority. Climate change affects animal health through both direct and indirect pathways: direct effects include heat stress, dehydration, altered metabolic function, reproductive inefficiency and increase mortality during extreme weather events, while indirect effects stem from shifting distributions of vectors and pathogens, deteriorating feed and water quality, shrinking fodder availability, and rising antimicrobial resistance driven by disease pressure, and together these pressures erode productivity, profitability, animal welfare, and the overall resilience of livestock farming systems, making traditional animal healthcare approaches insufficient to address the rapidly evolving climate-related risks. The concept of a Climate-Smart Animal Health System (CSAHS) responds to this gap by integrating climate adaptation, disease prevention, precision livestock management, sustainable resource use, and digital technologies to strengthen livestock resilience while minimizing environmental impact, aligning with the broader goals of climate-smart agriculture by improving productivity, enhancing adaptation to climate variability, and reducing greenhouse gas emissions; for a country like India, where livestock production is diverse and largely smallholder-driven, the next-generation climate-smart animal health system must therefore combine advanced technologies with indigenous knowledge, policy support, and farmer-centred extension services.

Climate Change and Animal Health Challenges in Indian Conditions

Heat Stress and Declining Productivity:

Heat stress represents one of the most critical climate-induced challenges affecting Indian livestock, particularly dairy cattle and buffaloes. Elevated temperature-humidity index (THI) reduces feed intake, milk yield, reproductive efficiency, immune competence, and overall animal welfare. High-producing crossbred dairy cattle are especially susceptible because of their greater metabolic heat production than indigenous breeds. Heat stress also alters endocrine and metabolic pathways, increases oxidative stress, and suppresses immune responses, making animals more vulnerable to infectious diseases. With climate projections indicating more frequent and prolonged heat waves across India, effective heat stress mitigation will become increasingly important for sustaining dairy production.

Emerging and Re-emerging Infectious Diseases:

Climate change is altering the epidemiology of infectious diseases by modifying the survival, transmission, and geographical distribution of pathogens and vectors. Increasing temperatures and changing rainfall patterns facilitate the expansion of vector populations such as ticks, mosquitoes, and biting flies, leading to a higher incidence of diseases including babesiosis, theileriosis, anaplasmosis, bluetongue, Japanese encephalitis, and lumpy skin disease. Extreme weather events also disrupt biosecurity measures and animal movement patterns, increasing the risk of disease outbreaks. Strengthening surveillance systems and predictive disease forecasting has therefore become essential for early detection and rapid response.

Water Scarcity, Feed Shortages, and Nutritional Stress:

Erratic rainfall, droughts, and land degradation reduce the availability and quality of fodder resources, resulting in nutritional deficiencies and impaired animal health. Heat stress further increases water requirements while reducing voluntary feed intake, creating a negative energy balance that affects growth, milk production, and reproductive performance. Climate-induced fluctuations in crop production also influence feed prices and availability, disproportionately affecting resource-poor livestock keepers. Ensuring year-round access to climate-resilient fodder resources, efficient water management, and balanced nutrition is therefore fundamental to climate-smart livestock production.

Antimicrobial Resistance and Biosecurity Challenges:

Climate-related disease outbreaks often lead to indiscriminate use of antibiotics, accelerating the development of antimicrobial resistance (AMR). The emergence of resistant pathogens threatens both animal and public health and highlights the need for judicious antimicrobial use, improved vaccination strategies, strengthened biosecurity, and disease prevention programs. Climate-smart animal health systems should prioritize preventive healthcare rather than relying primarily on therapeutic interventions.

Constraints of Smallholder Livestock Farming:

More than two-thirds of India's livestock is reared by small and marginal farmers who have limited access to veterinary healthcare, climate information, quality breeding services, and modern technologies. Financial constraints, fragmented landholdings, poor infrastructure, and inadequate extension services further reduce their capacity to adapt to climate change. Consequently, climate-smart animal health interventions must be affordable, scalable, locally adaptable, and supported by strong institutional mechanisms to ensure widespread adoption across diverse agro-climatic regions.

Components of a Next-Generation Climate-Smart Animal Health System

Climate-Resilient Livestock Breeding:

Developing livestock populations that can withstand climatic stress while maintaining productivity is fundamental to a climate-smart animal health system. Indigenous Indian breeds such as Sahiwal, Gir, Tharparkar, Red Sindhi, and Murrah buffalo possess superior thermotolerance, disease resistance, and adaptability to harsh environments compared with many exotic breeds. Future breeding programs should integrate conventional selection with genomic tools to identify genetic markers associated with heat tolerance, disease resistance, feed efficiency, and reproductive performance. Marker-assisted selection, genomic selection, and gene-editing technologies can accelerate the development of climate-resilient animals without compromising productivity. Conservation of indigenous germplasm should remain a national priority because these breeds represent valuable genetic resources for climate adaptation.

Precision Livestock Farming and Smart Monitoring:

The rapid advancement of digital technologies has transformed livestock management through Precision Livestock Farming (PLF). Smart sensors, wearable devices, accelerometers, rumination monitors, GPS collars, and automated milk recording systems enable continuous monitoring of animal behaviour, physiology, and production. These technologies provide real-time information on body temperature, activity patterns, feed intake, rumination, heart rate, and milk yield, allowing farmers to detect health problems before clinical symptoms become evident.

Infrared thermography (IRT) has emerged as a promising non-invasive tool for monitoring thermal stress, inflammation, mastitis, lameness, and animal welfare. By detecting subtle changes in body surface temperature, IRT facilitates early diagnosis while minimizing animal handling and stress. Artificial intelligence (AI) algorithms integrated with thermal imaging, wearable sensors, and farm management software can automatically identify abnormal physiological responses and generate timely alerts for farmers and veterinarians. Such precision technologies improve disease detection, reduce economic losses, and support evidence-based management decisions.

Early Disease Surveillance and Climate Forecasting:

Climate change increases the frequency of emerging and re-emerging animal diseases, making proactive surveillance systems essential. The next-generation animal health system should integrate meteorological information, remote sensing, Geographic Information Systems (GIS), epidemiological databases, and AI-based predictive models to forecast disease outbreaks before they occur. Weather variables such as temperature, humidity, rainfall, and vegetation indices can be combined with disease surveillance data to predict the seasonal occurrence of vector-borne and infectious diseases.

Digital disease reporting through mobile applications, cloud-based databases, and centralized surveillance platforms can facilitate rapid communication between farmers, veterinarians, diagnostic laboratories, and government agencies. Such integrated surveillance systems would enable early warning, targeted vaccination campaigns, and timely implementation of biosecurity measures.

Digital Veterinary Services and Telemedicine:

Digital veterinary healthcare has become increasingly important, particularly in remote rural areas where veterinary infrastructure is limited. Telemedicine platforms, mobile veterinary applications, video consultations, electronic health records, and decision-support tools allow farmers to obtain expert advice without travelling long distances. Mobile-based advisory services can also provide real-time recommendations regarding heat stress management, disease prevention, vaccination schedules, nutrition, and reproductive management based on prevailing weather conditions. The integration of digital platforms with livestock identification systems and electronic medical records will improve continuity of healthcare while facilitating nationwide disease surveillance and livestock management.

One Health Approach:

Climate change affects the health of animals, humans, and ecosystems simultaneously. Therefore, the One Health framework should form the foundation of future climate-smart animal health systems. This interdisciplinary approach promotes collaboration among veterinarians, physicians, environmental scientists, epidemiologists, wildlife experts, and policymakers to address zoonotic diseases, antimicrobial resistance, food safety, and environmental sustainability.

Strengthening coordination between the animal health, public health, wildlife, and environmental sectors will improve preparedness for emerging zoonotic diseases while supporting national and global health security.

Vaccination, Biosecurity, and Preventive Healthcare:

Preventive healthcare remains the most cost-effective strategy for climate resilience. Climate-smart animal health systems should prioritize strategic vaccination programmes, routine health monitoring, quarantine procedures, vector control, sanitation, and farm biosecurity to minimize disease transmission. AI-assisted risk assessment models can help identify high-risk areas and optimize vaccination schedules according to climatic conditions and disease forecasts. Reducing unnecessary antibiotic use through preventive health programmes will also contribute to controlling antimicrobial resistance and improving food safety.

Climate-Smart Housing, Welfare and Nutrition:

Improved housing design plays a critical role in reducing heat stress and enhancing animal welfare. Climate-smart livestock shelters should incorporate adequate ventilation, thermal insulation, shaded resting areas, evaporative cooling systems, foggers, sprinklers, fans and access to clean drinking water. These interventions reduce physiological stress, improve feed intake, and sustain milk production during hot weather.

Nutritional management is equally important for enhancing resilience.

support systems. These platforms can predict heat stress risk, optimize feeding schedules, recommend cooling strategies, identify disease outbreaks, and assist veterinarians in diagnosis and treatment planning.

Machine learning algorithms continuously improve prediction accuracy by analysing large datasets generated from commercial farms. Such intelligent systems reduce management costs, improve resource utilization, and support climate-

Precision feeding strategies involving balanced ration formulation, climate-resilient fodder crops, silage production, hydroponic fodder, feed additives, antioxidants, electrolytes, probiotics, and methane-mitigating supplements can improve health, productivity, and environmental sustainability. Integration of nutritional interventions with precision livestock technologies enables individualized feeding programmes based on animal requirements, physiological status, and environmental conditions.

Artificial Intelligence-Based Decision Support Systems

Artificial intelligence has the potential to revolutionize animal healthcare by integrating weather forecasts, sensor data, production records, disease surveillance information, and genomic databases into comprehensive decision-

resilient livestock production under diverse Indian farming conditions.

Future Roadmap:

The future climate-smart animal health system should be proactive, predictive, and data-driven. Artificial intelligence (AI), machine learning, big data analytics, cloud computing, and the Internet of Things (IoT) will increasingly support continuous health monitoring and precision decision-making at both farm and national levels. AI-powered algorithms capable of integrating physiological data, environmental conditions, and production records can provide early warnings for heat stress, disease outbreaks, and reproductive disorders, allowing timely interventions. The concept of Smart Livestock Villages can play a transformative role by integrating digital veterinary services, renewable energy, climate-resilient infrastructure, precision feeding, and automated environmental monitoring into rural livestock production systems. Such villages would demonstrate sustainable livestock farming while improving farmers' incomes and resilience to climate variability.

Conclusion:

Climate change presents unprecedented challenges to animal health, livestock productivity, and food security in India. Rising temperatures, changing disease dynamics, feed and water scarcity, and increasing environmental stress require a paradigm shift from conventional veterinary healthcare toward integrated climate-smart animal health systems. The next- generation of animal healthcare must combine climate-resilient breeding, precision livestock farming, artificial intelligence, digital disease surveillance, One Health principles, preventive healthcare, climate-smart nutrition, and animal welfare-oriented management practices.

India possesses unique strengths in its rich indigenous livestock genetic resources, extensive veterinary infrastructure, and expanding digital ecosystem. Harnessing these resources through coordinated policies, technological innovation, interdisciplinary research, and farmer-centred extension programmes will be essential for building resilient livestock production systems. Ultimately, designing a climate-smart animal health system is not only an investment in livestock productivity but also a strategic step toward achieving sustainable agriculture, rural prosperity, environmental conservation, and national food and nutritional security in an era of climate change.

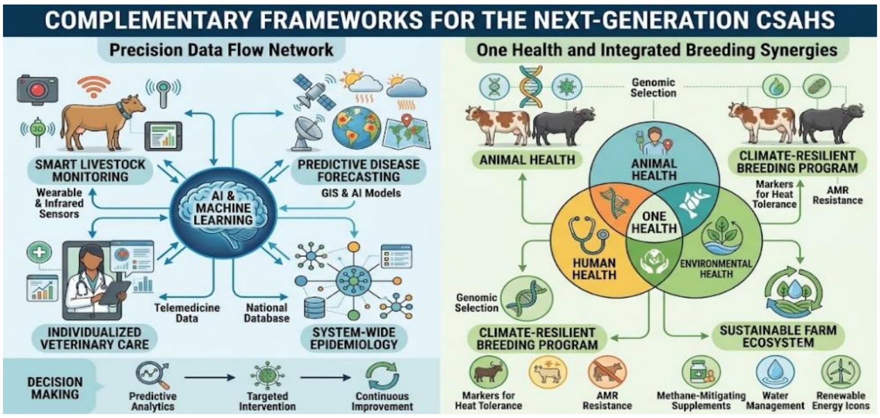

Figure 1. A comprehensive framework mapping real-time data, AI analytics, and One Health principles to build a climate-resilient animal health system (CSAHS) for Indi

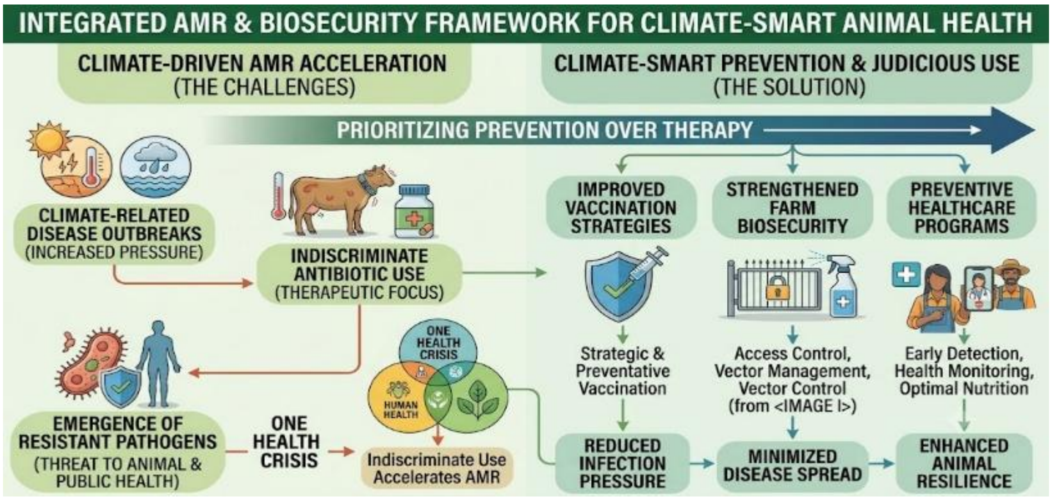

Figure 2. An integrated framework shifting from climate-driven antimicrobial overuse toward proactive biosecurity, strategic vaccination, and preventive animal healthcare

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Please contact the corresponding author.

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A One Health Approach to Prevent Antimicrobial Resistance for Sustainable Livestock Production in India

[1*]Mekapothula Hima Bindu, [2]Kasani Tirupataiah
[1]Assistant Professor, Department of Animal Genetics and Breeding, IVSAH, SOA (Deemed to be University), Bhubaneswar, Odisha-751003.
[2]Assistant Professor, Department of Mechanical Engineering, ITER, SOA (Deemed to be University), Bhubaneswar, Odisha-751030.
Email id: [*]himabindu9617@gmail.com

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Abstract

Antimicrobial resistance (AMR) is emerging as one of the greatest challenges to global health security, and livestock production systems have been identified as a key hotspot for its emergence and spread. This review summarizes the available evidence on the epidemiology, drivers, and control of AMR at the human, animal, and environmental interfaces, with a focus on AMR in India's livestock sector. The development of the One Health concept and its institutionalization within the FAO-OIE-WHO (now Quadripartite) framework are discussed. In-depth detail is provided on the degree of antimicrobial use in food animals, antimicrobial resistance trends from global and national surveillance networks, and the major drivers of antimicrobial use in both intensive and smallholder food production systems, including antimicrobial use at sub-therapeutic levels, inadequate biosecurity measures, the management of effluent, and inadequate regulation implementation. Spread within the food chain and directly from organisms, as well as from the water and manure-amended soils, is discussed, and problems with placing the responsibility for the burden of resistance on one side or the other of the food chain are outlined. Surveillance architecture and policy instruments, specifically India's National Action Plan on AMR, are discussed. Promising One Health interventions are evaluated, and the structural, economic, and governance barriers to their implementation in Low- and middle-income countries are identified. This article reveals that simultaneous, coordinated action across all areas of the health sector, including human, animal, and environmental health, is necessary to slow AMR. This requires context-specific research, farmer-level behavior change, and improved intersectoral governance. The antimicrobial resistance and One Health themes focus on zoonoses involving poultry and livestock production.

Keywords: Antimicrobial resistance, One Health, Zoonoses, Poultry, Livestock production.

Introduction:

The recent scenario of antimicrobial resistance (AMR) in India is alarming, and health authorities have emphasized the need to slow the rising burden of antibiotic-resistant infections and the importance of antimicrobial stewardship in managing AMR in food animals and other zoonoses. AMR has become a tangible and quantifiable burden on morbidity and mortality in both human and veterinary medicine. Around five million deaths are estimated to occur each year due to conditions related to bacterial AMR, and AMR is recognized as one of the threats to the capacity of health systems, particularly in resource-limited contexts in the South Asian region (Laxminarayan et al., 2013; Jindal et al., 2015; Antimicrobial Resistance Collaborators, 2022). India is one of the major antibiotic-consuming and producing nations in the world and has a high incidence of antimicrobial resistance among clinically important human pathogens (Van Boeckel et al., 2015; Laxminarayan & Chaudhury, 2016). In both industries, resistant organisms could be generated and shared between sectors due to increased livestock and poultry stocking density, high levels of human-animal-environmental contact, inadequate veterinary regulatory oversight, and easy access to informal antimicrobials (Kakkar et al., 2017).

Today, the One Health vision and framework are agreed upon, conceptually and operationally, to monitor and control AMR globally (Zinsstag et al., 2011; Mackenzie & Jeggo, 2019). This article discusses AMR as a One Health problem and highlights a global picture in the Indian epidemiological and policy context in the livestock sector. The objectives of this article were to review the conceptual evolution of the One Health paradigm and its applicability to tackle AMR; to understand the magnitude and drivers of AMR in livestock production systems; to understand how AMR is transmitted from animals to humans and from humans to their environment; to review the AMR surveillance and policy architecture; to critically appraise intervention strategies and barriers to their implementation, with particular attention to the Indian context; and to identify research and policy priorities.

Historical development and basic theory behind the one health concept:

The principles of One Health began in the nineteenth century with the understanding that infectious diseases in humans and animals were interconnected and evolved into "One Medicine" in the 1960s through the work of Calvin Schwabe, who identified a connection between human and animal health (Gibbs, 2014). The concept was greatly extended over the coming couple of decades to encompass the health of the ecosystem and of the environment, and, in fact, by the emergence of highly pathogenic avian influenza (H5N1) and other zoonotic epidemics in the early 2000s, the current "One Health" paradigm was established, which is now more 'institutionalized' (Destoumieux-Garzón et al., 2018). Growing awareness that the different environmental compartments are reservoirs and carriers of resistant organisms has generated formalization of collaborative mechanisms among the Food and Agriculture Organization of the United Nations (FAO), the World Organization for Animal Health (OIE, now WOAH), and the World Health Organization (WHO) in the Tripartite Agreement that was extended to a Quadripartite Agreement (Ruegg et al., 2019). AMR is an example of the One Health problem type: resistant bacteria and resistance genes emerge in human, animal, and environmental compartments and readily spread among them, and interventions limited to a single sector are unlikely to succeed if they affect the other sectors (Robinson et al., 2016; McEwen & Collignon, 2018). Livestock systems are an excellent example in this regard, as animals are used for therapeutic, prophylactic and growth promotion uses of antimicrobials; farm workers and communities are in close and repeated contact with animals and their waste; and manure, effluent and abattoir discharge are released into soil and water systems where resistant organisms can subsequently be re-introduced to human food and drinking water (Hernando-Amado et al., 2019).

The global and Indian scenario of the use and resistance to antibiotics:

The global consumption of antimicrobials in food animals, estimated to be above 63,000 tonnes in 2010, is projected to grow markedly by 2030, primarily driven by the growing demand in the developing world in middle-income nations as they become more livestock-intensive, such as India, China, and Brazil (Van Boeckel et al., 2015). The percentage of tested food-animal bacteria showing resistance to antimicrobials above 50 percent has increased significantly in low- and middle-income countries since 2000, and "resistance hotspots" have been identified in northern India, north-eastern China, and the Nile Delta (Van Boeckel et al., 2019). The resistance of Enterobacteriaceae to 3rd-generation cephalosporins, fluoroquinolones, and, more recently, carbapenems has remained high, as reported by the hospital- and community-based surveillance system of the Indian Council of Medical Research Antimicrobial Resistance Surveillance Network (ICMR-AMRSN) (Walia et al., 2019; Taneja & Sharma, 2019). On the veterinary side, high levels of multidrug-resistant (MDR) Escherichia coli (E. coli), Salmonella, and Staphylococcus species from poultry, dairy, and small ruminant production systems have been reported, as well as high levels of antimicrobial residues detected in milk, meat, and eggs in some of the states, as reported through ICAR's All India Network Program and related institutional surveillance. Many other countries in South and South-East Asia also have similar patterns, with the informal distribution of antimicrobial agents and limited access to diagnostic services compounding the difficulty of making reliable estimates of antimicrobial use and resistance (Chereau et al. 2017, Van et al. 2020).

The role of factors in the emergence of antimicrobial resistance in livestock production systems Antimicrobial use practices:

The use of antimicrobials for sub-therapeutic and prophylactic purposes – traditionally in poultry and swine – continues to be a major selection pressure in intensive systems (Marshall & Levy, 2011; Manyi-Loh et al., 2018). The implementation of growth-promotant bans has been lacking in consistency, such as in low- and middle-income countries; in parts of India, for instance, it has never been enforced (Chattopadhyay 2014), and antimicrobials are still easily available as over-the-counter drugs without veterinary prescription, including critically important ones like colistin and fluoroquinolones (Collignon et al. 2018).

Production system intensification and the lack of biosecurity:

Rapidly increasing the production of poultry and dairy products, frequently outpaced by biosecurity infrastructure, veterinary extension capacity, and waste management systems, increases disease pressure and thus the demand for antimicrobials and the density of animal–animal and animal-human contact in which resistant organisms can spread (Founou et al., 2016; Kimera et al., 2020). Smallholder systems (which make up the bulk of livestock keepers in India) face unique constraints: limited access to veterinary diagnostics can result in empirical, sometimes inappropriate, antimicrobial use, and the informal supply chain of input suppliers creates fewer opportunities for traceability of the products used (Grace 2015).

Aquaculture and related industries:

Aquaculture in India is a fast-growing sub-segment of the country where there is correlated antimicrobial resistance selection in aquatic bacterial communities, and it is an under-evaluated component of the One Health antimicrobial resistance burden (Cabello, 2006; Ma et al., 2021).

Transmission pathways between humans, animals, and the environment:

There are several routes of transfer of mobile genetic elements and resistant determinants between the compartments and resistant bacteria. The food chain is a direct route followed by resistant organisms that may be found in raw milk, meat, eggs, and fish, which then enter the food of consumers when the food has not been processed or cooked sufficiently (Landers et al., 2012). A second pathway is direct contact between farm workers, veterinarians, slaughterhouse workers, and colonized or infected animals, which has repeatedly been shown to confer a higher carriage of resistant organisms than the general population (Woolhouse et al., 2015). Even environmental pathways are on the rise in terms of quantity, with manure, etc. being applied to farmland, effluent from antimicrobial manufacturing facilities discharged to water bodies, resistant bacteria and resistance genes in seed soil and aquatic ecosystems, that may return to the food and drinking water systems (Booton et al., 2021; Rahman et al., 2020). Wildlife and peri-domestic animals, such as rodents, wild birds, and stray dogs, which are commonly seen in Indian urban and peri-urban areas, can be additional poorly quantified reservoirs and vectors between these compartments (Sharma et al., 2019). Assessing the contribution of each pathway, and each sector to the overall burden of human resistance is methodologically complex and is a work in progress – recently, modelling studies indicated that, for many resistance phenotypes, the burden of human-to-human transmission and human antimicrobial use is more important than the burden of livestock-associated transmission and that the latter is more important in contexts where there is intense human–animal contact (Booton et al. 2021, Mughini-Gras et al. 2019 as cited in Hernando-Amado et al. 2019). This is an indicator of the need to conduct pathogen- and context-specific risk assessment and intervention design, rather than a uniformly generalized approach.

Surveillance systems & policy frameworks Global architecture:

The key international surveillance architecture includes the Global Antimicrobial Resistance and Use Surveillance System (GLASS) of the WHO and the OIE Antimicrobial Use in Animals database (WOAH, 2019), the World Health Assembly Global Antimicrobial Resilience Action Plan of 2015, which includes commitments of the member states to multisectoral national action plans (WHO, 2015). The Jim O'Neill Independent Review on Antimicrobial Resistance had an influential impact by providing an economic estimate of the human and economic consequences of leaving AR unabated and by building momentum for political commitment at the global level (O'Neill, 2016).

Current Indian policy landscape:

Indian policy is a work in progress. In 2017, the Government of India implemented a National Action Plan on Antimicrobial Resistance (NAP-AMR) that closely aligns with the WHO Global Action Plan (Kakkar et al., 2018) and adopts six strategic priorities: awareness, surveillance, infection prevention, antimicrobial optimization, research and innovation, and collaborative leadership. These have since been trailed by a few states declaring their own state action plans, and the Food Safety and Standards Authority of India (FSSAI) has set Maximum Residue Limits (MRLs) for antimicrobials in food of animal origin (Sharma et al., 2020). Despite this, implementation is still not consistent: the veterinary and agricultural components of the plan are still funded less than the human health components; coordination with inter-ministerial is still weak (including Ministries of Health, Fisheries, Animal Husbandry and Dairying and Environment); the capacity in the states to monitor veterinary surveillance is still limited, especially for the monitoring of resistance genes by whole genome-sequencing, according to (Gandra et al., 2017; Walia et al., 2019).

One health intervention and mitigation strategies - The use of antimicrobials in veterinary care:

Evidence in other countries shows that veterinary antimicrobial use reduction programmes (VAPs) have led to measurable decreases in antimicrobial use and for prevalence of antimicrobial resistance in food animals and meta-analytical evidence has indicated that a reduction in antimicrobial use in food animals is associated with a reduction in prevalence of antimicrobial resistance in bacteria from animal associated animals, and in a smaller, but measurable, impact of antimicrobial resistance in human associated animals (Tang et al., 2017; Chandy et al., 2014).

Vaccination, biosecurity, and alternatives to antimicrobials:

Improved vaccination coverage for key bacterial and viral diseases of poultry, dairy cattle, and small ruminants will decrease the incidence of these diseases, and as a result, antimicrobial use; best practices in biosecurity, such as all-in-all-out management, controlled access of visitors, and good ventilation, will reduce baseline infection pressure (Robinson et al., 2016). Other feed additives, such as probiotics, prebiotics, organic acids, and, in the early stages of development, bacteriophage therapy, are being explored as alternatives to antimicrobials to prevent disease; however, limited evidence of consistent efficacy and cost-effectiveness for these alternatives in Indian smallholder systems exists (Manyi-Loh et al., 2018).

Integrated surveillance and genomic approaches:

Surveillance of human, animal, food and environmental sampling having a One Health lens for antimicrobial resistance (AMR) is increasingly reliant on whole genome sequencing and metagenomic approaches that have the capacity to track the movement of AMR resistance genes from one compartment of the One Health enterprise to the other (previously not possible to do so by phenotypic surveillance) and is a priority for investment in India through ICMR, ICAR and state veterinary laboratory networks (Queenan et al., 2016; Hernando-Amado et al., 2019).

Challenges to implement the one health approach in India:

While the Indian livestock sector is working towards implementing One Health, a significant number of structural barriers have been identified that hinder its effective implementation. Smallholder farmers who constitute majority of livestock holders lack access to affordable veterinary services and there are limited formal coordination mechanisms across ministries/ departments to coordinate use of antimicrobials in the field; weak veterinary regulatory capacity to ensure that only professionals prescribe antimicrobials; and limited capacity for diagnostic microbiology across the district and block level, giving farmers economic reasons to rely on informal use of antimicrobials rather than professional use (Prasad et al., 2018; Sharma et al., 2020). There is ongoing limited data sharing between human and animal health surveillance systems; the numbers of which are required to be working together as a single team to undertake joint risk assessment exercises, similar to what is proposed with the One Health approach (Kakkar et al., 2017); and funding for veterinary and environmental aspects of AMR containment remains limited compared to funding for human health aspects of containment (Kakkar et al., 2017).

The future directions and research Priorities:

Future research and investment needs include developing representative quantitative attribution models for the Indian context to share the burden of resistance amongst sources of human, animal and environmental origin; scaling up the One Health approach to genome sequencing and metagenomics surveillance from existing reference laboratories to district veterinary and public-health laboratories; rigorously testing non-antimicrobial alternatives in the field under smallholder production conditions; studying the behavioural drivers of use of antimicrobials in informal production systems, and developing strategies to reduce this use; and strengthening institutional mechanisms for One Health data sharing and joint risk communication between ministries responsible for Health, animal husbandry, fisheries and environment (Rahman et al. 2020, Chandra Bhusan Singh et al. 2021). It will be essential that political commitment, multisectoral coordination with adequate resources, and a context-appropriate response come from within India, rather than being uncritically imported from elsewhere, if the livestock sector is to play a significant role in curbing antimicrobial resistance.

Conclusion:

The issue of antimicrobial resistance in the livestock sector can only be understood through a multisectoral approach that helps monitor and manage it, and is a human, animal, and environmental health issue that requires multisectoral actions grounded in science. India's high livestock density and its growing livestock sector, with high levels of interactions between humans, animals, and the environment, make the country highly susceptible to, and could play an important role in tackling, the global AMR burden. To achieve sustainable containment, the most credible approach is veterinary stewardship, intersectoral governance, and integrated One Health surveillance.

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Please contact the corresponding author.

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Super El Niño and India's Animal Husbandry Sector: Assessing Risks, Strengthening Preparedness, and Building Climate Resilience

*[1]**Dr. Pulikanti Radhakriisshna**, [2]**Dr. M. V. Reddy, IAS (Retd.)**

[1]*Head, Department of Veterinary Physiology*
Officer Incharge of Student Activities, CVSc, Korutla
P. V. Narsimha Rao Telangana Veterinary University
[2]*Former Director, Department of Animal Husbandry and Dairying (DAHD), Government of Andhra Pradesh and Former Collector & District Magistrate, Bhadradri & Medchal Districts, Government of Telangana*
Email id: *radhakrishnapulikanti@gmail.com

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Abstract

Super El Niño is an exceptionally intense phase of the El Niño–Southern Oscillation (ENSO), characterized by unusually warm sea surface temperatures across the central and eastern tropical Pacific Ocean. Such events significantly alter global atmospheric circulation and frequently disrupt the Indian monsoon, leading to prolonged droughts, severe heat waves, erratic rainfall, water scarcity, and increased climate variability. India's animal husbandry sector, which contributes about 31% of the agricultural and allied Gross Value Added (GVA) and approximately 5.5% of the national GVA, while supporting the livelihoods of over 20 million people, is particularly vulnerable to climatic disturbances (DAHD, 2025). Livestock experience heat stress, reduced feed intake, declining reproductive efficiency, increased disease susceptibility, water shortages, and lower productivity. Poultry, dairy, sheep, goat, and pig production systems are all affected directly or indirectly. The economic consequences include rising production costs, declining farm incomes, disruptions in milk, meat, and egg supply chains, and increased price volatility. However, scientific preparedness and climate-smart livestock management can substantially reduce these risks. This review discusses the anticipated impacts of Super El Niño on India's animal husbandry sector and highlights practical adaptation and mitigation strategies, including climate-resilient housing, nutritional interventions, genetic improvement, precision livestock farming, disease surveillance, early warning systems, digital advisory services, One Health approaches, and supportive public policies. Building resilient livestock systems will be essential for ensuring food security, sustainable rural development, and long-term climate resilience.

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Introduction:

India possesses the world's largest livestock population and ranks among the leading producers of milk, eggs, meat, and fisheries. Livestock contribute significantly to rural livelihoods, especially among small and marginal farmers. Super El Niño events are much stronger than ordinary El Niño episodes and can profoundly influence India's climate by weakening the southwest monsoon, increasing temperatures, delaying rainfall, and intensifying drought conditions. These climatic anomalies create multiple challenges for livestock production systems and threaten national food security. Super El Niño affects livestock production through prolonged heat stress, water scarcity, feed and fodder shortages, and increased disease risks. These stresses reduce feed intake, growth, milk yield, reproductive efficiency, and egg production while increasing mortality and production costs. Climatic changes also alter the distribution of pathogens and vectors, increasing disease incidence and threatening livestock productivity, food security, and rural livelihoods, particularly in countries such as India (IPCC, 2022).

1. Understanding Super El Niño:

The El Niño–Southern Oscillation (ENSO) is a naturally occurring climate phenomenon involving periodic warming of the equatorial Pacific Ocean. A Super El Niño generally refers to an exceptionally strong El Niño event associated with:

- Sea surface temperature anomalies exceedingly approximately 2°C
- Weakening of trade winds
- Major shifts in global rainfall patterns
- Increased frequency of climate extremes

India generally experiences:

- Below-normal southwest monsoon
- Delayed onset of rainfall
- Heat waves
- Droughts
- Erratic rainfall distribution
- Occasional extreme rainfall events in localized regions despite overall rainfall deficits.

3. Importance of Animal Husbandry in India:

Animal husbandry contributes significantly to:

- National food security
- Nutritional security
- Agricultural Gross Value Added
- Rural employment
- Women's empowerment
- Export earnings
- Sustainable farming systems

More than two-thirds of rural households depend partly or fully on livestock, making climate resilience a national priority.

4. Effects on Feed and Fodder Resources:

Super El Niño frequently reduces fodder availability through:

- Poor pasture growth
- Reduced crop residues
- Decline in fodder crop production
- Drying of grazing lands
- Increased fodder prices

Consequently:

- Feed shortages become widespread.
- Farmers are forced to purchase expensive concentrates.
- Livestock body condition deteriorates.
- Production costs increase.

5. Heat Stress and Animal Physiology:

Heat stress is among the most serious consequences.

Animals experience:

- ✓ Increased body temperature
- ✓ Elevated respiration rate
- ✓ Panting
- ✓ Increased water intake
- ✓ Reduced feed intake
- ✓ Hormonal imbalance
- ✓ Oxidative stress

Heat stress increases the production of reactive oxygen species (ROS) beyond the capacity of endogenous antioxidant defenses, resulting in oxidative stress that damages cellular lipids, proteins, and DNA. This oxidative damage impairs immune function, reproduction, metabolism, and overall livestock productivity (Bernabucci et al., 2010).

Physiological effects include:

- Increased cortisol secretion
- Reduced thyroid hormone activity

- Electrolyte imbalance
- Altered immune function
- Disturbed metabolic homeostasis

These changes ultimately reduce productivity.

6. Impact on Milk Production:

Dairy animals are highly susceptible to thermal stress.

Major effects include:

- Lower feed consumption
- Reduced milk yield
- Decreased milk fat percentage
- Lower milk protein content
- Increased mastitis incidence
- Poor udder health
- Reduced lactation persistence

High-yielding crossbred cattle are generally more vulnerable to heat stress than indigenous cattle because of their greater metabolic heat production associated with higher milk yield. Under elevated temperature–humidity index (THI) conditions (>72), crossbred cows may experience a 10–25% decline in milk yield and a 20–30 percentage-point reduction in conception rate, whereas indigenous Bos indicus breeds such as Sahiwal and Hariana exhibit significantly greater heat tolerance, maintaining higher productivity and reproductive performance under similar conditions due to superior thermoregulatory adaptations (Frontiers, 2026; Behl et al., 2006).

7. Reproductive Consequences:

Heat stress severely affects reproduction.

Observed problems include:

- Silent estrus
- Delayed puberty
- Poor conception rate
- Early embryonic mortality
- Increased abortion
- Reduced semen quality
- Lower libido in breeding males

These effects prolong calving intervals and reduce herd productivity.

8. Disease Risks During Super El Niño:

Climate variability alters disease ecology.

Potential risks include:

- ✓ Vector-borne diseases
- ✓ Tick infestations
- ✓ Fly populations
- ✓ Internal parasites
- ✓ Water-borne infections
- ✓ Food-borne diseases
- ✓ Stress-induced immunosuppression further increases susceptibility to infectious diseases.
- ✓ Continuous surveillance is

essential.

9. Poultry Production Challenges:

The poultry industry is particularly sensitive to heat stress.

Heat stress causes:

- Reduced feed efficiency
- Lower egg production
- Thin eggshells
- Increased mortality
- Poor broiler growth
- Reduced hatchability
- Immunosuppression

Feed shortages further increase production costs.

10. Sheep, Goat and Pig Production:

Small ruminants generally tolerate harsh climates better than cattle.

However, prolonged drought leads to:

- Reduced grazing
- Weight loss
- Poor reproductive performance
- Increased kid and lamb mortality
- Reduced meat production

Pig production is also adversely affected by heat stress and water scarcity.

11. Socio-economic Impacts:

Climate-induced livestock losses directly affect:

- Smallholder farmers
- Landless livestock keepers
- Women farmers
- Dairy cooperatives
- Meat industries
- Poultry enterprises

Economic consequences include:

- Declining household income
- Rising livestock mortality
- Reduced market supply
- Increased consumer prices
- Rural indebtedness

12. Climate-Smart Livestock Management:

Adaptation measures include:

- ✓ Heat-resistant housing
- ✓ Shade structures
- ✓ Foggers and sprinklers
- ✓ Adequate ventilation
- ✓ Cool drinking water
- ✓ Precision feeding
- ✓ Balanced mineral supplementation
- ✓ Electrolyte supplementation
- ✓ Antioxidants
- ✓ Climate-resilient fodder production

These interventions improve animal comfort and productivity.

13. Genetic Improvement and Breed Conservation:

Indigenous livestock breeds possess:

- Better heat tolerance
- Disease resistance
- Lower maintenance requirements

- Superior adaptability

Future breeding programmes should incorporate:

- Genomic selection
- Heat tolerance markers
- Climate-resilient breeding objectives
- Conservation of indigenous germplasm

14. Early Warning Systems and Digital Technologies:

Modern technologies can substantially improve preparedness.

Useful tools include:

- Weather forecasting
- Heat stress alerts
- Satellite monitoring
- Remote sensing
- Artificial Intelligence (AI)
- Internet of Things (IoT)
- Precision livestock farming
- Mobile advisory services

Timely information enables farmers to reduce production losses.

15. Policy Priorities and One Health Approach:

Government agencies should strengthen:

- Climate-resilient livestock infrastructure
- Livestock insurance
- Emergency fodder banks
- Water harvesting
- Disease surveillance
- Vaccination programmes
- Farmer training
- Extension services

The One Health approach integrating animal, human, and environmental health provides a comprehensive framework for climate adaptation.

Additional Strategic Measures for Enhancing Livestock Resilience During Super El Niño:

- ✓ Special attention should be given to small and marginal farmers, landless households, and wage-labour families owning livestock. Sustaining and enhancing livestock production during El Niño can compensate for crop income losses while safeguarding household nutrition.
- ✓ Promote drought-resistant and low water-consuming fodder crops, perennial grasses, fodder trees, and horti-pasture systems.
- ✓ Encourage drip and sprinkler irrigation, rainwater harvesting, and efficient water-use practices for fodder production.
- ✓ Provide mineral mixtures and concentrate feed, especially to productive animals, along with electrolytes and balanced nutrition.
- ✓ Implement preventive healthcare

through vaccination, deworming, de-ticking, surveillance, and biosecurity.

- ✓ Reduce heat stress through shade, ventilation, cooling, and adequate drinking water.
- ✓ Conduct extensive farmer awareness programmes on El Niño preparedness and climate-smart livestock management.
- ✓ Ensure coordinated action by Animal Husbandry, Agriculture, Horticulture, Irrigation, Rural Development and allied departments to promote fodder crops, crop residues, intercropped fodders, fodder trees and horti-pastures.
- ✓ Strengthen government support through backward and forward linkages, including fodder banks, veterinary services, insurance, credit, processing and marketing support for vulnerable livestock-owning families.

16. Conclusion:

Super El Niño represents a major emerging challenge for India's livestock sector. Heat stress, water scarcity, feed shortages, reproductive failure, and disease outbreaks collectively threaten livestock productivity. Economic losses arising from these challenges also jeopardize rural livelihoods. Nevertheless, scientific planning, resilient production systems, climate-smart technologies, precision livestock management, conservation of indigenous breeds, digital advisory platforms, and supportive public policies can substantially reduce vulnerability. Strengthening preparedness today will enable India's animal husbandry sector to withstand future climate extremes while ensuring food security, farmer welfare, and sustainable agricultural growth

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Please contact the corresponding author.

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Quality control of vaccines

Dr. Himanshu Sharma

Assistant Commissioner
C.C.S. National Institute of Animal Health Baghpat-250609, Uttar Pradesh
Email id:

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Abstract

Quality control (QC) in vaccines is a critical component of vaccine development, production, and distribution that ensures vaccines are safe, effective, potent, pure, and consistent. It involves a series of standardized tests and regulatory procedures conducted throughout the manufacturing process, from raw material selection to final product release. Quality control evaluates key parameters such as identity, sterility, purity, potency, stability, and safety to ensure that each vaccine batch meets established national and international standards. Adherence to Good Manufacturing Practices (GMP), quality assurance systems, and regulatory guidelines established by organizations such as the World Health Organization (WHO) and national regulatory authorities helps maintain the integrity and reliability of vaccines. In addition, proper storage, transportation, and maintenance of the cold chain are essential to preserve vaccine potency until administration. Continuous monitoring, documentation, and post-marketing surveillance further support vaccine quality by identifying potential issues related to safety or effectiveness. Effective quality control not only safeguards animal and public health but also enhances confidence in vaccination programs, contributes to the prevention and control of infectious diseases, and supports sustainable livestock production and global disease control efforts.

Keywords: Quality control (QC), Vaccines, Vaccine quality, Vaccine safety, Vaccine efficacy

Introduction:

Vaccination is a cornerstone of disease prevention in veterinary medicine, playing a crucial role in protecting animal health, ensuring food security, and mitigating zoonotic risks. The development and production of veterinary vaccines involve complex biological processes that require stringent quality control measures to guarantee safety, efficacy, and consistency.In biomedical research and testing, certain methods have remained largely unchanged since their inception, particularly in vaccine potency measurement. Potency testing is a crucial evaluation parameter that involves in vitro and in vivo tests to determine the vaccine's specific ability to produce the intended immune response. These tests ensure that vaccines elicit a sufficient and reproducible immune response to protect animals against infectious diseases.

Veterinary vaccines, derived from living organisms, differ significantly from chemical pharmaceuticals due to their complex molecular structures and potential batch-to-batch variability. Unlike synthetic drugs, which have precise and consistent chemical compositions, biological products such as vaccines are subject to variations inherent to biological systems. This variability necessitates strict control measures to ensure product consistency, safety, and efficacy. The production of veterinary vaccines requires advanced biotechnological methods, including cell culture, genetic engineering, and fermentation processes, to create immunogenic and stable products.

Manufacturers bear the legal responsibility for the quality, safety, and efficacy of vaccines produced and marketed, adhering to national and international regulatory guidelines. These regulations, established by organizations such as the World Organisation for Animal Health (WOAH), the European Medicines Agency (EMA), and the United States Department of Agriculture (USDA), set stringent criteria for vaccine approval, batch release, and post-marketing surveillance.

The primary goal of vaccine manufacturers is to ensure quality through rigorous in-process and final product testing. This objective is achieved through Good Manufacturing Practices (GMP) and the continuous improvement of testing methodologies, including the adoption of alternative methods aligned with the principles of the 3Rs

(Replacement, Reduction, and Refinement). The integration of innovative approaches, such as molecular assays, in-vitro immunoassays, and computational modeling, has enhanced vaccine quality assessment, reducing reliance on traditional in-vivo testing while maintaining robust quality assurance standards.

Rules Governing Quality Control:

1. Every regulatory approval holder must establish an independent quality control department with adequate resources and qualified personnel.
2. The head of QC is responsible for:
   - Approval or rejection of materials and products.
   - Evaluation of batch records.
   - Execution of necessary testing and validation.
   - Approval of specifications, test methods, and quality control procedures.
   - Oversight of contract analysts, equipment maintenance, and personnel training.
3. The QC department must establish, validate, and implement all quality control procedures, manage reference samples, monitor product stability, and handle product quality complaints.
4. Finished product assessment involves reviewing production conditions, in-process testing, compliance with specifications, and final product examination.
5. In-process controls should be conducted at appropriate production stages to ensure product quality.
6. Continuous monitoring of production data, such as fermentation parameters, is required for specific processes.

Good Practices for Quality Control in Laboratories:

Laboratory Premises and Equipment:

- Facilities and equipment must comply with QC requirements based on manufacturing scale and nature.
- External laboratories may be used for testing under documented regulatory guidelines.

Documentation:

- The QC department must maintain:
- Specifications and sampling procedures.
- Testing methods, records, and analytical reports.
- Environmental monitoring data, equipment calibration records, and

validation documents.

- Retention of batch records for at least one year after expiry or as per regulatory requirements.
- Records structured for trend evaluation of analytical data.

Sampling Procedures:

- Sampling must follow written procedures detailing the method, equipment, sample quantity, storage, and handling conditions.
- QC personnel must have access to production areas for sampling and investigation.
- Two types of retained samples:
  - **Reference Sample:** Stored for potential future analysis.
  - **Retention Sample:** Fully packaged unit for identification and re-testing.
- Samples must be representative of each batch and stored at recommended conditions.

Testing:

- Analytical methods must be validated and executed per approved protocols.
- Test records must include product details, batch numbers, specifications, testing results, dates, personnel signatures, and approval status.
- In-process control methods must be documented and approved by QC.

Batch Tests for Immunological Products:

Batch or Serial Release for Distribution:

- Each batch must be tested for purity, potency, and safety before release.
- In regions with regulatory re-testing programs, batches must be submitted for independent governmental testing.
- Unsatisfactory batches must be withheld, and subsequent batches prioritized for re-testing.

Batch or Serial Purity Test:

- Purity testing involves screening for contaminants in master seeds, cell cultures, animal-origin ingredients, and final products.
- Special documentation is required for fetal or calf serum to verify freedom from contaminations as well as specific immunoglobulins.
- Vaccine manufacturers must follow measures to minimize contamination risks.

Batch or Serial Safety Test:

- Many regulatory authorities waive batch safety testing for seed-lot-based vaccines.
- Where required, safety tests are performed in target or laboratory

animals using fewer subjects than during initial licensing tests.

- Local and systemic reactions must align with regulatory approvals and product literature.

Batch or Serial Potency Test:

- Potency tests correlate with host animal efficacy studies.
- Inactivated vaccines may be tested in laboratory animals or using validated in-vitro antigen quantification.
- Live vaccines are tested via bacterial counts or viral titration.
- Recombinant vaccines undergo similar testing to traditional live vaccines.
- Regulatory bodies set specific bacterial or viral content thresholds to ensure vaccine efficacy throughout its shelf life.

Additional Quality Control Tests:

- Depending on the vaccine type, additional tests may include:
  - Moisture content in desiccated vaccines.
  - Residual inactivant levels in killed vaccines.
  - Completeness of inactivation.
  - pH, preservative, and antibiotic levels.
  - Adjuvant stability.
  - Vacuum retention in desiccated products.
  - General physical examination of the final product.
- Samples tested for sterility must be representative of the batch.

Regulatory Framework:

Veterinary regulatory protocols are enforced by national and international organizations responsible for overseeing veterinary product development. Regulatory agencies ensure that all veterinary products, including vaccines, meet specific standards before they can be marketed and used.

International Standards:

Organizations such as the WOAH and the Codex Alimentarius Commission establish global guidelines for veterinary product registration and safety assessment. These guidelines help harmonize regulatory approaches across different countries, facilitating the approval and trade of veterinary medicines.

National Regulatory Authorities:

Each country has its regulatory body responsible for evaluating and approving veterinary medicines. For example:

- **United States**: The Food and Drug Administration (FDA) oversees veterinary medicinal products through its Center for Veterinary Medicine (CVM).

- **European Union**: The European Medicines Agency (EMA) coordinates the approval of veterinary vaccines and medicines across member states.
- **India**: The Central Drugs Standard Control Organization (CDSCO) regulates veterinary pharmaceuticals.
- **Other Regions**: Various nations have established independent regulatory frameworks to ensure the safe use of veterinary products.

Legislative Framework:

Most regulatory agencies operate under a legal framework that mandates the submission of clinical trial data, adherence to Good Manufacturing Practices (GMP), and post-market surveillance of veterinary pharmaceuticals. The legislative framework also includes:

- **Risk-Benefit Analysis**: Ensuring that the benefits of a veterinary vaccine outweigh potential risks before approval.
- **Data Protection and Intellectual Property**: Protecting proprietary information related to vaccine formulations and clinical trial results.

Vaccine Approval Process:

The approval of veterinary vaccines follows a structured process to ensure their efficacy and safety before they reach the market. This process includes the following stages:

Preclinical Research:

This phase involves laboratory testing and in-vitro studies to assess vaccine viability, antigen stability, and initial safety profiling. Researchers evaluate immunogenicity and possible side effects before advancing to animal trials.

Clinical Trials:

Conducted in multiple phases, these trials evaluate the vaccine's effectiveness in target animal species and identify any potential adverse reactions.

Phase I: Small-scale studies to assess safety and appropriate dosage.

Phase II: Expanded trials to evaluate immune response and protection levels.

Phase III: Large-scale trials to confirm efficacy and monitor side effects under field conditions.

Regulatory Submission:

Manufacturers must submit a comprehensive dossier to the relevant regulatory authority, including safety data, efficacy studies, and production protocols. The dossier typically includes:

- Pharmacological and Toxicological Data

- Efficacy and Immunogenicity Studies
- Production and Manufacturing Processes
- Environmental Impact Assessments

Evaluation and Licensing:

Regulatory authorities review submitted data, conduct inspections of manufacturing facilities, and assess risk-benefit analysis before granting approval. This stage may involve expert panels reviewing the data to ensure thorough vetting before licensing.

Post-Marketing Surveillance:

Once approved, vaccines undergo continuous monitoring to detect any long-term safety concerns or adverse effects through pharmacovigilance programs. These include:

- Adverse Event Reporting Systems
- Lot Release Testing
- Field Performance Monitoring

Quality Control & Safety Standards:

Ensuring the quality and safety of veterinary vaccines is paramount in regulatory protocols. Quality control measures include:

Good Manufacturing Practices (GMP):

Regulatory agencies mandate compliance with GMP to ensure consistent production standards and prevent contamination. Key aspects of GMP include:

- Standard Operating Procedures (SOPs)
- Facility and Equipment Standards
- Personnel Training Requirements

Batch Testing and Validation:

Every batch of vaccine produced must undergo rigorous testing for purity, potency, and sterility before release. This ensures:

- Consistency Across Batches
- Sterility and Stability Verification
- Absence of Contaminants

Stability Studies:

Long-term and accelerated stability studies are conducted to determine the shelf life and storage requirements of veterinary vaccines. This includes:

- Temperature Sensitivity Testing
- Impact of Storage Conditions

Adverse Event Monitoring:

Veterinary pharmacovigilance systems track reports of adverse reactions to identify potential risks and implement corrective actions if necessary. Monitoring systems include:

- Surveillance Programs
- Veterinary Practitioner Reports
- Manufacturer Follow-Ups

Implementation & Compliance:

To maintain compliance with veterinary regulatory protocols, manufacturers, distributors, and veterinary professionals must adhere to several key implementation strategies:

Documentation and Record-Keeping:

Accurate and complete records of vaccine production, distribution, and adverse event reports are essential for regulatory audits and inspections. Required documentation includes:

- Batch Production Records
- Shipping and Distribution Logs
- Adverse Event Reports

Inspections and Audits:

Regulatory authorities conduct routine inspections of manufacturing facilities and distribution networks to ensure ongoing compliance. Inspections focus on:

- Production Facility Standards
- Testing and Quality Control Measures
- Adherence to Approved Manufacturing Protocols

Conclusion:

Veterinary regulatory protocols play a crucial role in safeguarding animal and public health by ensuring that veterinary vaccines meet rigorous safety and efficacy standards. The approval process involves multiple layers of evaluation, including preclinical and clinical trials, regulatory review, and post-market surveillance. Adherence to GMP, quality control measures, and compliance guidelines is essential for maintaining the integrity of the veterinary pharmaceutical industry. As regulations evolve, continuous monitoring and adaptation will be key to sustaining the effectiveness and reliability of veterinary vaccines. In an era of emerging zoonotic diseases and increasing global trade, maintaining robust regulatory oversight is more important than ever.

References:

Please contact the corresponding author.

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Success Story: Control of Bovine Mastitis through Microbiological Diagnosis and AST

Dr.Shubhangi Warke

Professor & Head
Department of Veterinary Microbiology,
Nagpur Veterinary College, Nagpur
Email: shubhangiwarke@mafsu.ac.in

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Abstract:

Bovine mastitis is a major constraint in dairy farming, causing reduced milk production, increased treatment costs, and economic losses. This success story describes the effective control of recurrent clinical and subclinical mastitis in a dairy herd of 25 lactating cows at Koradi, Nagpur, through microbiological diagnosis and antimicrobial susceptibility testing (AST). Milk samples from affected cows were subjected to bacterial isolation, identification, and AST, which revealed mastitis-associated bacteria including *Staphylococcus aureus*, *Streptococcus agalactiae*, and *Escherichia coli*, with resistance to several commonly used antibiotics.

Based on laboratory findings, targeted antimicrobial therapy was recommended, along with improved milking hygiene, post-milking teat dipping, regular screening for subclinical mastitis, and judicious antibiotic use. Within 3–4 months, mastitis cases declined from 8–10 to 1–2 cases per month, while average milk yield increased from 9 to 13 litres/cow/day. Treatment costs were reduced by approximately 40%, with a shift from frequent empiric antibiotic use to rational, targeted therapy. This case highlights the importance of microbiological diagnosis and AST-guided treatment in controlling bovine mastitis, improving dairy productivity and profitability, and promoting responsible antimicrobial use to minimise the risk of antimicrobial resistance.

Background

Mastitis is one of the most important diseases affecting dairy cattle, leading to reduced milk production, poor milk quality, increased treatment costs, and economic losses. Many farmers treat mastitis empirically without identifying the causative organism, often resulting in treatment failure and antimicrobial resistance.

Farmer Profile

- Farmer: Mr. Vicky Prakash Dhoke
- Location: Rural dairy farm in Maharashtra (Koradi, Nagpur)
- Herd Size: 25 lactating cows
- Major Issue: Recurrent clinical and subclinical mastitis with reduced milk yield

Problem Identified

The farmer observed:

- Swollen udders and abnormal milk secretion in several cows.
- Frequent recurrence of mastitis despite antibiotic treatment.
- Milk yield reduction from 12–14 L/day to 8–10 L/day in affected animals.
- Increased expenditure on veterinary medicines.

Veterinary Microbiology Intervention

Milk samples from affected cows were collected aseptically and analysed in the veterinary microbiology laboratory.

California Mastitis Test (CMT)

The **California Mastitis Test (CMT)** is a simple, rapid, cow-side screening test used to detect **subclinical mastitis** by indirectly estimating the somatic cell content of milk.

Why it is done: Subclinical mastitis may not produce visible changes in the udder or milk. CMT helps identify affected udder quarters so that appropriate milk samples can be selected for microbiological examination.

How it is done: A small quantity of milk from each udder quarter is placed separately in the wells of a CMT paddle. An equal quantity of CMT reagent is added and mixed gently. The reagent reacts with DNA released from somatic cells, producing varying degrees of **gel formation or thickening**. Greater gel formation indicates a higher somatic cell count and a stronger likelihood of mastitis.

CMT Test

Laboratory Findings

- Isolation of mastitis-causing bacteria such as:
    - *Staphylococcus aureus*
    - *Streptococcus agalactiae*
    - *Escherichia coli*
- Confirmation through cultural and biochemical tests.

Mannitol-fermenting and non-fermenting colonies of *Staphylococcus* spp.on Mannitol Salt Agar

Gram-positive cocci - *Staphylococcus aureus*

Antimicrobial Susceptibility Testing (AST): The isolates were subjected to AST using the Kirby–Bauer disc diffusion method.

Antimicrobial Susceptibility Testing (AST) is a laboratory procedure used to determine whether a bacterial isolate is **susceptible or resistant to different antimicrobial agents**.

Why it is done: In mastitis, empirical or repeated antibiotic treatment may result in treatment failure and contribute to antimicrobial resistance. AST helps veterinarians select an antimicrobial that is likely to be effective against the specific bacterial isolate, thereby promoting **targeted and judicious antimicrobial therapy**.

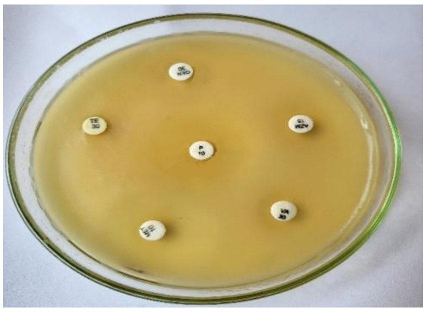
How it is done: In your study, AST was performed using the **Kirby–Bauer disc diffusion method**. A standardized bacterial suspension is inoculated uniformly onto an agar plate, and antimicrobial discs are placed on the surface. After incubation, the **zones of inhibition** around the discs are measured and interpreted according to appropriate standard guidelines to categorize the isolate as susceptible, intermediate/increased exposure where applicable, or resistant.

In this case, AST demonstrated resistance to several commonly used antimicrobials, and the results were used to guide targeted treatment

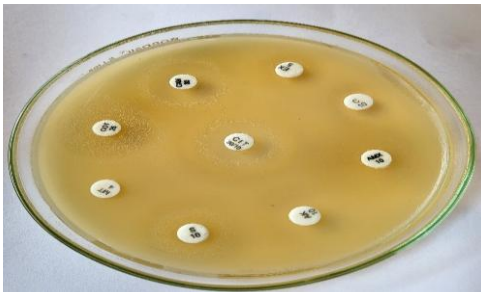
Results showed:

Resistance to some commonly used antibiotics. : The sample was resistant to Penicillin G, Streptomycin, Ceftriaxone /Tazobactam, Enrofloxacin, Metronidazole, Chloramphenicol, Amoxicillin, Methicillin, Amikacin, Co-Trimoxazole, Tetracycline

High susceptibility to selected antibiotics i.e., Cephalexin, , Gentamicin & Amikacin, recommended by the laboratory.



In vitro* antibiogram of *S.aureus



Multiple drug resistance of *S.aureus*

Based on AST results:

1. Targeted antibiotic therapy (Cephalexin, , Gentamicin & Amikacin) was initiated.
2. Milking hygiene practices were improved.:Good milking hygiene is essential to prevent the spread of mastitis-causing organisms between cows and reduce new intramammary infections. The following practices were advised:

   a.Washing hands thoroughly before and during milking and preferably using clean disposable gloves.

   b.Cleaning the udder and teats before milking and drying each cow with a separate clean towel.

   c.Examining the first few streams of milk for abnormalities before milking.

   d.Milking healthy cows first and mastitis-affected cows last to minimize transmission.

   e.Avoiding contamination of teat ends and maintaining clean, dry bedding and the milking environment.

   f.Proper cleaning and disinfection of milking utensils/equipment after every milking.

   g.Separating milk from mastitic or treated cows and observing the prescribed milk-withdrawal period after antimicrobial treatment
3. Post-milking teat dipping (iodine-based solution) was adopted. Following each milking, teats were dipped in an approved iodine-based post-milking teat disinfectant to reduce bacterial contamination and prevent new intramammary infections.

4. Regular screening for subclinical mastitis by CMT test was implemented.
5. Judicious use of antibiotics, which showed sensitivity by IM, was encouraged.

Outcomes

After 3–4 months:

Parameter	Before Intervention	After Intervention
Mastitis cases/month	8–10	1–2
Average milk yield/cow/day	9 L	13 L
Treatment cost	High	Reduced by ~40%
Antibiotic use	Frequent	Rational and targeted

Farmer's Statement

"Earlier, we treated mastitis based on trial and error. After the Guidance and Supervision of Dr.Shubhangi Warke, Professor & Head, Department of Veterinary Microbiology, Nagpur Veterinary College, Nagpur, laboratory testing and AST-guided treatment, mastitis cases reduced significantly, milk production increased, and medicine expenses decreased."

Mr. Vicky Prakash Dhoke

Impact

- Enhanced milk production and quality.
- Reduced economic losses.
- Rational use of antimicrobials.
- Lower risk of antimicrobial resistance development.
- Improved farmer awareness regarding laboratory-based disease diagnosis.

Conclusion

This case demonstrates that integration of veterinary microbiology diagnostics and AST can effectively control mastitis, improve dairy profitability, and promote responsible antimicrobial use. Such interventions can serve as a model for sustainable dairy farming.

References:

Please contact the corresponding author.

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Comprehensive Physiological, Hematological, Biochemical, Immunological and Molecular Diagnostic Investigations

Dr. Maloth Pallavi
Dr. Pulikanti Radhakrishna*

Department of Veterinary Physiology
College of Veterinary Science, Korutla
P. V. Narsimha Rao Telangana Veterinary University
Corresponding Author: radhakrishnapulikanti@gmail.com

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1. Introduction

Diagnostic investigations integrate physiological assessment with laboratory evaluation to identify disease, assess organ function, monitor therapy and predict outcomes.

2. Physiological Diagnostic Investigations

- Cardiovascular: ECG, Holter, BP, echocardiography, cardiac output, stress testing, pulse oximetry.
- Respiratory: spirometry, lung volumes, capnography, blood gases, diffusion capacity.
- Nervous: EEG, EMG, nerve conduction, evoked potentials, reflexes.
- Renal: GFR, creatinine clearance, urine concentration, renal blood flow.
- Gastrointestinal: motility, gastric acid, pH, absorption tests.
- Endocrine & metabolic: glucose tolerance, ACTH stimulation, dexamethasone suppression, TRH/GnRH tests, basal metabolic rate.
- Reproductive: semen evaluation, estrous monitoring, fertility testing, pregnancy diagnosis.
- Musculoskeletal: gait analysis, muscle strength, bone mineral density.

3. Hematological Investigations

CBP, hemoglobin, PCV, RBC, WBC, platelet count, differential leukocyte count, erythrocyte indices (MCV, MCH, MCHC), reticulocyte count, ESR, blood smear, coagulation profile (PT, aPTT, thrombin time, fibrinogen, D-dimer).

4. Clinical Biochemical Investigations

Carbohydrate: glucose, HbA1c, fructosamine, lactate.

Liver: ALT, AST, ALP, GGT, SDH, GLDH, bilirubin, albumin, total protein.

Kidney: urea, creatinine, SDMA, cystatin-C, uric acid.

Lipid profile: cholesterol, HDL, LDL, VLDL, triglycerides.

Electrolytes: Na, K, Cl, Ca, Mg, P, HCO3.

Cardiac biomarkers: Troponin I/T, CK-MB, BNP.

Muscle: CK, LDH, myoglobin.

Pancreas: amylase, lipase, pancreatic lipase immunoreactivity.

Oxidative stress: MDA, SOD, catalase, glutathione peroxidase, TAC.

5. Endocrine Investigations

Thyroid (T3, T4, FT4, TSH); Adrenal (cortisol, ACTH, Aldosterone, Renin); pancreatic (insulin, C-peptide, glucagon); pituitary (GH, IGF-1, prolactin, FSH, LH); gonadal (testosterone, estrogen, progesterone, AMH); calcium regulation (PTH, calcitonin, vitamin D).

6. Immunological Investigations

ELISA, immunofluorescence, AGID, Western blot, immunohistochemistry, flow cytometry, cytokine assays, complement assays, immunoglobulin estimation, autoantibody assays, interferon-gamma release assays, neutralization tests.

7. Molecular Biological Investigations

Conventional PCR, RT-PCR, real-time PCR, multiplex PCR, nested PCR, digital PCR; Sanger sequencing, NGS, WGS, WES; Southern/Northern/Western blotting, FISH, microarrays; RT-qPCR, RNA sequencing; SNP analysis, microsatellites, DNA fingerprinting; CRISPR diagnostics (SHERLOCK, DETECTR); genomics, transcriptomics, proteomics, metabolomics, lipidomics and glycomics.

8. Biomarkers

Cardiac, inflammatory, renal, hepatic, neurological, reproductive, tumor and oxidative stress biomarkers for early diagnosis and monitoring.

9. Techniques and Instrumentation

Spectrophotometry, chromatography, electrophoresis, immunoassays, molecular diagnostics, mass spectrometry, biosensors, flow cytometry and automated analyzers.

10. Clinical Significance

Diagnosis, prognosis, screening, monitoring treatment, herd health surveillance, preventive medicine and precision medicine.

11. Future Perspectives

Artificial intelligence, digital pathology, wearable biosensors, point-of-care diagnostics, telemedicine and personalized medicine will further enhance diagnostic accuracy.

12. Conclusion

Integration of physiological, hematological, biochemical, immunological and molecular diagnostic investigations enables comprehensive assessment of health and disease, supporting accurate diagnosis and evidence-based clinical decision-making.

References

Please contact the corresponding author.

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Successful Management of Recumbency Associated with Suspected Enteritis in a Horse

Dr. Jessy[1]
Dr. Pulikanti Radhakrishna[2]

[1]Veterinary Doctor
1962 Mobile Veterinary Unit
EMRI Green Health Services
Telangana

[2]Head, Department of Veterinary Physiology, College of Veterinary Science, Korutla
P. V. Narsimha Rao Telangana Veterinary University
radhakrishnapulikanti@gmail.com

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Abstract:

A horse presented with prolonged recumbency and clinical signs suggestive of enteritis was managed successfully using supportive fluid therapy, antimicrobial therapy and metabolic support over three days. Progressive improvement culminated in complete recovery and return to standing posture.

Keywords

Horse, Enteritis, Recumbency, Fluid therapy, Equine medicine, Clinical case

Introduction

Enteritis in horses may result in severe dehydration, electrolyte imbalance and systemic weakness leading to recumbency. Early supportive therapy is essential to improve survival and recovery.

Case History

A horse from Rejarla Village, Sathupally Mandal, Khammam District, Telangana, was presented in lateral recumbency with marked depression and inability to rise. Clinical findings suggested acute enteritis with dehydration and weakness.

Clinical Examination

The animal was dull, recumbent and unable to stand. Clinical assessment indicated dehydration and systemic illness. The case was managed conservatively with intensive supportive therapy.

Treatment

Treatment for three consecutive days consisted of: Inj. Intalyte + Neuroxin (500 mL IV + 10 mL), Inj. Biosulpha (10 mL IM), and Inj. Tonophosphon (10 mL IM).

Outcome and Follow-up

The horse showed progressive improvement each day and regained normal standing posture after completion of therapy.

Discussion

Supportive fluid therapy restores circulating volume and electrolyte balance, while antimicrobial therapy addresses suspected bacterial enteritis. Tonophosphon provides metabolic support during recovery. Early intervention contributed to the successful outcome in this case.

Key Learning Points

- Prompt fluid therapy is critical.
- Early supportive treatment improves prognosis.
- Continuous monitoring is essential during recumbency.
- Timely intervention can prevent complications.

Conclusion

This case demonstrates that early diagnosis, supportive fluid therapy and appropriate antimicrobial treatment can successfully manage selected cases of enteritis-associated recumbency in horses.

Clinical Photographs

Figure 1. Horse presented in lateral recumbency.

Figure 2. Clinical examination and treatment.

Figure 3. Horse standing after successful treatment.

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