**Indian Farmer**
Volume 12, Issue 11, 2025, Pp. 677-686
Available online at: www.indianfarmer.net
ISSN: 2394-1227 (Online)

**Original article**

OPEN ACCESS

# Role of sentinel animal promoting animal welfare

**Anupam Soni[1], Kanta Godara[1*], Harsimar Preet Kour[1], Divyanshu Sharma[1], Irusappan Ilayaraja[2], Anoop Kumar[3] and Neetu Sonkar[4]**

*[1]Ph.D, Livestock Production Management Division, NDRI, Karnal, Haryana*

*[2]Ph.D, Animal Genetics and Breeding Division, NDRI, Karnal, Haryana*

*[3]Ph.D, Animal Reproduction Gynaecology and obstetrics Division, NDRI, Karnal, Haryana*

**Corresponding author: vetkanta@gmail.com*

*Received: 21/11/2025* *Published:25/11/2025*

## INTRODUCTION

Sentinel animals are organisms that serve as early warning systems for environmental dangers or health threats to humans and other species. The most famous historical example is the canary in the coal mine, when miners employed these perceptive birds to identify hazardous concentrations of carbon monoxide and other harmful gasses. Miners learned to leave right away if the canaries died or exhibited symptoms of distress. This idea has developed into a complex scientific method in which animals act as biological monitors for a variety of hazards, such as infections, contaminants and ecological disruptions. Because animals have shorter lifespans, different metabolic rates and occasionally greater sensitivity to environmental changes, they are valuable because they can often identify hazards before they manifest in human populations. For example, aquatic species may demonstrate the repercussions of water pollution long before it reaches critical levels in human water supplies, but birds usually exhibit susceptibility to airborne pollutants much before humans. In India, a country known for its remarkable biodiversity, intimate human-animal interaction and serious environmental issues, the employment of animal sentinels is especially pertinent. India's fast urbanization, industrialization and intensification of agriculture have put a lot of strain on human and animal health. Animal welfare programs have a solid ethical basis because to India's cultural and religious traditions, which place a high emphasis on ahimsa (non-violence) and compassion for animals. India is a perfect location for creating and executing cutting-edge sentinel animal programs that concurrently promote public health and animal welfare goals because of this special confluence of elements.

### History

Canaries were used in coal mines for gas detection in the 19th century. Rodents from the 20th century were used in labs to track viral or bacterial infections. In 21$^{st}$ century environmental monitoring through the use of technology and sentinel animals.

**What are Sentinel Animals?**

Sentinel animals are species that are purposefully positioned in environments to identify possible health risks, such as environmental pollutants and infectious diseases. Their responses act as early warning systems for humans and other animals.

Sentinel animals "signal" when something is amiss in the population or environment, much like living alarm systems.

**How Sentinel Animals Work**

**Biological Foundations of Sentinel Systems**

Sentinel animals work well as early warning indicators because they react quickly to changes in the environment. Many animals are more sensitive to toxins and diseases than humans and because they cannot move far and have shorter lifespans, signs of illness or environmental problems appear sooner in them. Instead of speaking animals show changes through behavior or physical symptoms, which can signal danger.

The sentinel model includes three parts: the hazard being monitored (like a toxin or disease), the population being protected (humans or valuable animals) and the sentinel animals themselves. Their response may appear as antibody formation, infection, visible symptoms, behavior changes, or even death. The success of the system depends on how often animals are monitored, the accuracy of diagnostic tests and how well the data is analyzed.

**Ideal Characteristics of Sentinel Animals**

Not every animal is a good sentinel. The most valuable sentinel species usually have a number of important traits. They should have quantifiable reactions at exposure levels pertinent to human health and be biologically sensitive to the risks of concern. In order to provide sufficient sample and geographical representation they should be plentiful and widely dispersed in the settings of interest. Additionally, ideal sentinels share exposure paths with human populations making them ecologically representative. Adequate sample size, established baseline health metrics and ecological or economic value that support monitoring activities are other desired traits.

**Table: Characteristics of Effective Sentinel Animals**

| Characteristic | Importance | Examples |
|---|---|---|
| **High Sensitivity** | Early detection of hazards | Canaries for carbon monoxide |
| **Short Life Cycle** | Rapid manifestation of effects | Laboratory mice for toxicity testing |
| **Similar Exposure Pathways** | Relevance to human health | Dogs sharing human environments |
| **Abundant Population** | Sufficient samples for monitoring | Chickens for arbovirus surveillance |

| Characteristic | Importance | Examples |
|---|---|---|
| **Well-Understood Biology** | Interpretation of responses | Standardized laboratory animal models |

In actuality, different species are better sentinels for various threats. Domestic pets, such as dogs, are excellent sentinels for exposures in the home and community because they live in almost the same environments as their human companions and develop similar cancers and chronic diseases. Food animals may store environmental pollutants in their tissues, revealing details about the health of ecosystems and the dangers of human exposure. The health of entire ecosystems is frequently reflected in wildlife species with population shifts indicating more significant environmental imbalances. Because they are stationary and filter-feeding, even invertebrates like shellfish are useful sentinels for monitoring water quality.

**Applications of Sentinel Animals in India**

- **Disease Surveillance and Early Warning Systems**

The sentinel concept is already built into India's animal disease surveillance system. The National Animal Disease Reporting System (NADRS) tracks livestock diseases at the village level for fast emergency response and NADRES uses GIS and remote sensing to forecast major livestock diseases each month. These systems use animals as sentinels to protect both animal and human health. A strong example is the poultry industry, where chickens serve as sentinels for mosquito-borne viruses like West Nile and St. Louis encephalitis. They quickly develop antibodies after infection helping detect disease early. With chicken interferon-α, they become even more sensitive "super-sentinels" for low-path avian influenza. India also runs large serosurveillance programs for zoonotic diseases such as brucellosis, using animals to locate high-risk areas. Similarly, dog rabies surveillance acts as an early warning tool to protect both dogs and humans through vaccination and public health action.

- **Environmental Health Monitoring**

Sentinel animals help detect environmental pollution in India's diverse and sometimes highly contaminated habitats. Pet dogs are useful indicators of urban air pollution studies show that dogs in heavily polluted cities like Delhi and Mumbai develop more severe lung damage and inflammation than those in cleaner areas. Because dogs have shorter lifespan, they show health effects sooner than humans, acting as early warning signals.

In coastal regions, marine mammals such as dolphins indicate ocean health. As top predators, they accumulate pollutants in their bodies, giving long-term information about marine contamination. Their condition reflects the health of ocean ecosystems that support millions of people. India's 2013 ban on keeping dolphins in captivity also helps protect these important environmental sentinels.

- **Anti-Poaching and Wildlife Conservation**

In wildlife protection, sentinel animals can help detect poaching. Research in Africa shows that common herbivores like zebras and wildebeests change their behavior when humans or poachers

are nearby they move faster, spend more energy, stay closer together and change direction more consistently. These measurable changes can be detected with technology and algorithms, giving early warnings before guards notice danger. This approach could be very useful in India's large national parks where ranger staff is limited. By monitoring abundant prey species, authorities can protect both endangered animals and the sentinel species. The system not only prevents poaching but also provides valuable ecological data for conservation planning. This technology offers a strong tool for fighting wildlife crime while improving ecosystem management.

**Sentinel Animals and Animal Welfare Promotion**

- **Direct Welfare Benefits through Enhanced Monitoring**

Using animals as sentinels provides important animal welfare benefits. Sentinel programs involve regular health monitoring, which helps detect diseases earlier and ensures timely veterinary care. In India, systems like the National Animal Disease Reporting System (NADRS) and NADRES improve animal welfare by requiring veterinary investigation of outbreaks and providing disease forecasts so farmers can take preventive steps like vaccination and better management. Modern technologies such as wireless sensors, GPS and automatic health monitoring allow real-time tracking of animal health, identifying issues like injury or illness even before visible symptoms appear. This enables faster treatment and more personalized veterinary care for both domestic and wild animals.

- **Indirect Benefits through Policy and Public Awareness**

Sentinel animal programs provide important data that can guide stronger animal welfare policies. When sentinel animals show health problems caused by pollution or poor management, this evidence can support new regulations and improvements. In India, agencies like the Animal Welfare Board could use such data to identify problem areas and check whether existing laws are effective.

These programs also increase public awareness. When studies reveal that pets or other animals are getting sick because of environmental risks, people better understand how human activities affect animals. This encourages responsible care, public support for welfare initiatives and more funding for veterinary services. Sentinel programs also strengthen the economic case for animal welfare. By showing that protecting animal health can prevent human health threats, they encourage investment in veterinary infrastructure and surveillance. In rural India, where livestock are essential for livelihoods, sentinel systems help safeguard farmers' economic security while improving animal welfare.

**Community-Based Sentinel Systems and Rural Development**

- **Panchayati Raj Institutions in Animal Welfare**

India's decentralized governance system provides strong opportunities for community-based sentinel animal programs. Panchayati Raj Institutions (PRIs) play an important role at the village level by spreading information about animal health schemes, supporting good livestock management, and organizing veterinary camps that offer services like vaccination, deworming, and treatment. These actions improve the welfare and health of animals used in sentinel programs. PRIs also integrate animal welfare with rural development. By connecting animal health monitoring to agriculture, public health and environmental programs, they create holistic community benefits.

Initiatives like livestock insurance motivate farmers to keep animals healthy, improving the quality of sentinel data. Infrastructure such as cattle sheds, water troughs, and fodder storage supports better animal care and helps maintain stable populations for long-term monitoring.

- **Sentinel Animals in One Health Approaches**

The One Health framework links human, animal and environmental health, making it highly suitable for sentinel animal programs. In India, animal disease surveillance systems use this approach to monitor zoonotic diseases that affect both animals and people. By combining animal health data with human health records, authorities can predict and prevent outbreaks for example, tracking rabies in dogs helps guide human vaccine distribution and monitoring avian influenza in poultry provides early warning for human pandemics.

Community participation strengthens this system. Farmers, pet owners and livestock workers can report early signs of disease through mobile apps and local networks. This citizen science approach expands surveillance and increases awareness of animal welfare. When people see that protecting animal health also protects human health, they become more committed to caring for animals.

**Table: One Health Integration through Sentinel Animals**

| Level | Animal Component | Human Health Connection | Environmental Aspect |
|---|---|---|---|
| **Disease Surveillance** | Monitoring Animal populations | Early warning of zoonotic outbreaks | Pathogen circulation in ecosystems |
| **Toxicology** | Bioaccumulation in animal tissues | Warning of human exposure risks | Pollution monitoring Across media |
| **Ecosystem Health** | Wildlife population changes | Resource availability and security | Habitat quality assessment |
| **Climate Change** | Phenological shifts in animals | Health adaptation planning | Ecosystem response Tracking |

**Case Studies and Success Stories**

- **Canine Sentinels for Environmental Health**

Pet dogs can serve as effective sentinels for environmental health risks. Studies show that dogs exposed to environmental tobacco smoke (ETS) have a higher risk of certain cancers, especially long-nosed breeds prone to nasal and sinus tumors. Because companion animals share the same household environment as humans but often develop diseases faster their health can act as an early

warning system for secondhand smoke hazards, highly relevant in Indian homes where smoking indoors is common.

Researchers studied that urban dogs in polluted cities like Delhi and Mumbai has revealed severe respiratory damage, including inflammatory cell infiltration, smooth muscle thickening and peri-bronchiolar fibrosis, similar to changes seen in humans exposed to high air pollution. Since dogs show effects earlier due to shorter lifespans, their health data could support stronger air-quality policies and improve both public and veterinary health.

- **Poultry Surveillance Networks**

India's large poultry sector forms a strong foundation for disease surveillance, especially during avian influenza outbreaks. Routine monitoring in commercial and backyard flocks acts as an early-warning sentinel system, detecting viruses before they spread widely to humans. When combined with wildlife surveillance such as tracking migratory birds this system helps predict virus entry routes and identify when it becomes established in domestic birds, enabling targeted control measures.

Innovative tools like "super-sentinel" chickens treated with interferon-α increase early detection sensitivity. These birds show faster immune responses (rapid seroconversion) to low-pathogenic avian influenza, revealing viral circulation sooner. In India's live bird markets where interactions between wild birds, poultry and people are intense, such enhanced sentinels could provide critical early warnings and help prevent pandemic-risk strains.

- **Wildlife Sentinels in Protected Areas**

Wild herbivores fitted with wearable sensors can detect human intruders by showing distinct movement patterns, helping authorities identify poaching threats early. In India's tiger reserves, monitoring common prey species like deer and antelope could enable rapid response before poachers reach endangered animals.

These wildlife sentinels also act as indicators of ecosystem health. Changes in reproduction, population trends, physiology, or migration can reveal problems such as pollution, climate change, or habitat degradation. With strong conservation infrastructure and many protected areas, India is well positioned to develop advanced wildlife-sentinel systems that enhance both conservation and animal welfare.

- **Lumpy Skin Disease (LSD) Surveillance in India**

Lumpy Skin Disease (LSD) is a viral illness in cattle that causes fever and painful skin lumps, and can sometimes lead to death. In 2022, India faced a major outbreak, with over 97,000 cattle dying and around 1.85 million affected across 15 states such as Rajasthan and Gujarat. To control the spread, sentinel animals healthy cattle placed in risk areas were closely monitored for early signs of infection. Their health data helped authorities quickly detect new hotspots and take timely actions like vaccination and movement control. This early detection reduced animal suffering and prevented large economic losses.

**Challenges and Limitations**

- **Technical and Infrastructural Constraints**

Sentinel animal programs in India face challenges such as poor communication networks in remote areas, limited bandwidth and unreliable electricity, which restrict real-time monitoring. Complex data analysis is also difficult because animal behavior varies with environment and season, requiring advanced algorithms and large training datasets. These issues become more complicated across India's diverse ecosystems.

- **Ethical Considerations**

Using animals as sentinels raises moral concerns because they may be exposed to risks or discomfort without direct benefit to them. Wearable sensors can cause stress or interfere with natural behavior. Ethical decisions must balance benefits with animal welfare and align with principles such as *ahimsa*. Legal safeguards like the Prevention of Cruelty to Animals Act help, but require strict practical implementation.

- **Economic and Policy Barriers**

High costs for sensors, communication systems, and data management make sentinel programs financially demanding, especially in resource-limited settings. Policy support is weak due to fragmented regulations and the absence of a unified national strategy, leading to duplicated efforts and inconsistent standards. Better coordination and standardized guidelines are needed

**Recommendations and Future Directions**

- **Strengthening Institutional Capacity**

Improving expertise in veterinary and wildlife sectors through training, education and upgraded infrastructure will strengthen sentinel programs. Better coordination between animal, human and environmental health agencies under the One Health approach will improve response capability and data use.

- **Technological Innovation and Adaptation**

Advances in sensor miniaturization, battery life and wireless networks can enable more efficient, low-cost, and less invasive monitoring suitable for remote Indian conditions. User-friendly analytical tools will help field workers interpret data effectively.

- **Community Engagement and Education**

Public participation is essential for sustainable programs. Training farmers and community workers, encouraging citizen science and developing accessible educational materials will expand surveillance networks and promote environmental responsibility.

**CONCLUSION**

It is concluded that Sentinel animals act as early-warning indicators for environmental pollution, disease outbreaks and ecological threats. India is well suited for using sentinel systems because of its rich biodiversity, close human–animal contact and cultural values like ahimsa. Animals such as poultry, cattle and dogs are already used to detect diseases like avian influenza and lumpy skin

disease and to monitor urban air pollution. These programs help identify risks before they seriously affect humans and allow timely intervention. Sentinel systems also improve animal welfare by enabling early diagnosis and treatment, guiding better policies and raising public awareness. Modern tools like GPS tracking, biosensors and remote monitoring support conservation and anti-poaching efforts. Community participation through Panchayati Raj institutions and citizen science strengthens these programs within the One Health framework.

However, challenges such as poor digital infrastructure, high costs, limited diagnostics, ethical concerns and fragmented policies limit expansion. Strengthening institutions, improving technology, training professionals and developing supportive policies are essential for successful nationwide implementation. Effective sentinel systems can protect ecosystems, support scientific research and enhance both human and animal health.

**REFERENCES**

Abi Tamim Vanak, N., Panchamia, N., & Banerji, I. (2023). A passive "One Health" surveillance system to track canine rabies in urban India. CABI One Health.

Asaaga, F. A., Shakeer, I., and Sriram, A. (2024). Ties that bind: Understanding One Health networks and participation for zoonoses prevention and control in India. One Health Outlook, 6, 24.

Backer, L. C., Miller, M. W., Cheng, Y.-S., Lynch, M. E., & Chorus, I. (2016). Sentinel animals in a One Health approach to harmful algal blooms. Veterinary Sciences, 3(2), 8.

Bhattacharya, S., & Patra, R. C. (2020). Sentinel animals as biomarkers of environmental health hazards. Environmental Science and Pollution Research, 27(14), 16979–16991. https://doi.org/10.1007/s11356-020-08244-2

Calisi, R. M., & Bentley, G. E. (2009). Laboratory and field experiments: Two approaches to studying

the role of animals as environmental sentinels. ILAR Journal, 50(4), 297–304. https://doi.org/10.1093/ilar.50.4.297

Chen, X., Cao, S., Wen, D., Geng, Y., & Duan, X. (2023). Sentinel animals for monitoring the environmental lead exposure: combination of traditional review and visualization analysis. Environmental Geochemistry and Health, 45(3), 561–584.

Cramp, R. L., & Franklin, C. E. (2018). Environmental monitoring using sentinel species: Lessons from amphibians and fish. Conservation Physiology, 6(1), coy009. https://doi.org/10.1093/conphys/coy009

Das, M., Mahapatro, S., Pathi, B., Pattnaik, S., Mishra, S. S., Mahapatro, S.(2020). Harmonized One Health trans-species and community surveillance for tackling antibacterial resistance in India: Protocol for a mixed methods study. JMIR Research Protocols, 9(10): 120-129.

Dhama, K., Chakraborty, S., Tiwari, R., Saminathan, M., & Malik, Y. S. (2013). Sentinel surveillance and monitoring of zoonotic diseases in India: A key to safeguard human and animal health. Journal of Biological Sciences, 13(5), 257–272. https://doi.org/10.3923/jbs.2013.257.272

Ferrara, G., & Tejeda, C. (2024). Wildlife–domestic animal interface: threat or sentinel? Frontiers in Veterinary Science, Epub ahead of print.

Jukan,A., Bruin,X.M.,and Amla, N.(2016).Smart computing and sensing technologies for animal welfare: a systematic review. (2016). arXiv preprint. https://arxiv.org/abs/1609.00627 arXiv

Krishna, N. (2022). Animal sentience in Indian culture. Wellbeing International Studies Repository.

Kumar, H. B. C., Hiremath, J., Yogisharadhya, R., Balamurugan, V., Jacob, S.S., Reddy, G.B.M., Suresh, K.P., Shome, R., Nagalingam, M., Sridevi, R., Patil, S.S., Prajapati, A., Govindaraj, G., Sengupta, P.P., Hemadri [1], Krishnamoorthy, P., Misri, J., Kumar, A., Tripathi, B.N., and Shome, B.R. (2021). Animal disease surveillance: Its importance & present status. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8204830/

Lower, W., & Kendall, R. J. (1990). Species, sensitivities, and accumulation: key attributes of animals as sentinels. In Animals as Sentinels of Environmental Health Hazards (pp. [pages]). U.S. National Academies Press.

National Centre for Disease Control, Directorate General of Health Services, Ministry of Health & Family Welfare, Government of India. (2023). Operational Guidelines for Sentinel Surveillance Sites on Zoonoses (SSSZ), National One Health Programme for Prevention and Control of Zoonoses.

National Centre for Disease Control, Ministry of Health & Family Welfare, Government of India. (2024). Technical Guidance on Zoonotic Disease: Prevention, Preparedness and Response using One Health Approach

National Research Council (U.S.). (1991). Animals as Sentinels of Environmental Health Hazards. National Academies Press. https://doi.org/10.17226/1570

Rattner, B. A. (2009). History of wildlife toxicology and the role of sentinel species. Environmental Toxicology and Chemistry, 28(1), 3–9. https://doi.org/10.1897/08-338.1

Reif, J. S. (2011). Animal sentinels for environmental and public health. Public Health Reports, 126(Suppl 1), 50–57. https://doi.org/10.1177/00333549111260S108

Sharma, A., Frederick S. Vaz, Swami, U., Balasubramanian, S., Gopi Kumbha, Nimisha Bhuyan, … Pawan Kumar. (2024). Rabies control in Asia through one health interventions: A scoping review. The Evidence, 2(1).

Sharma, R., & Kaushik, A. (2021). Use of sentinel animals in monitoring environmental pollutants in India: A review. Environmental Monitoring and Assessment, 193(12), 797. https://doi.org/10.1007/s10661-021-09538-5

Silverman, J. (2013). Using research animals as sentinels. Lab Animal, 42(2), 47–48.

Sorzano, C.O., Sánchez, I., and Naranjo, A. (2024). Statistical design for health monitoring in laboratory animals: sentinel protocols. Laboratory Animal Science & Research, (SAGE).

Tiwari, R., Dhama, K., & Chakraborty, S. (2014). Sentinel surveillance and its significance in veterinary public health. Advances in Animal and Veterinary Sciences, 2(1), 1–6. https://doi.org/10.14737/journal.aavs/2014.2.1.1.6

World Health Organization (WHO). (2018). Monitoring and surveillance of zoonotic diseases using sentinel animals. WHO Technical Report Series No. 1024. Geneva: World Health Organization.