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Disease Prevention and Control for Improved Animal Welfare

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Abstract Animal welfare is intricately linked to effective disease prevention and control measures. This study explores the various strategies and methodologies employed in veterinary epidemiology, biosecurity, and infection control to enhance animal health and welfare, highlights the critical role of veterinary epidemiology in identifying risk factors and implementing control measures for livestock diseases, and discusses the importance of systematic reviews in synthesizing research on animal health, welfare, and food safety, providing a scientifically defensible summary of current knowledge. Effective infection control practices within veterinary settings are examined, emphasizing the need for consistent implementation and the challenges posed by antimicrobial resistance. Additionally, this study underscores the necessity of evaluating subsidized veterinary services to ensure their effectiveness in controlling zoonotic diseases and promoting animal welfare. The findings suggest that a multifaceted approach, including biosecurity, systematic reviews, and robust infection control practices, is essential for improving animal welfare through better disease prevention and control.

Keywords Animal welfare; Disease prevention; Veterinary epidemiology; Biosecurity; Infection control

1 Introduction

Animal welfare is a multifaceted discipline that intersects with veterinary medicine, animal husbandry, and applied animal ethology. It encompasses the ethical treatment of animals, ensuring their well-being, and minimizing suffering through proper management and care (Fraser, 1989). The importance of animal welfare extends beyond ethical considerations; it is also crucial for maintaining the health and productivity of animals, which in turn impacts human health and economic outcomes (Fraser, 2008; Hemsworth et al., 2015). The scientific assessment of animal welfare involves evaluating the physical and psychological states of animals, often through indirect physiological and behavioral indices (Broom, 1988). This comprehensive approach helps in understanding and improving the living conditions of animals, thereby promoting their overall well-being.

The relationship between disease prevention, control, and animal welfare is intricate and deeply interconnected. Good management practices and high standards of animal welfare are essential in reducing the risk of infections and diseases in farm animals. Environments that promote positive affective states and reduce stress can enhance the immune response, thereby lowering susceptibility to diseases (Düpjan and Dawkins, 2022). Conversely, poor welfare conditions can lead to increased stress and compromised immune function, making animals more vulnerable to infections (Heath, 2012; Hemsworth et al., 2015). Effective disease control measures, including preparedness and proven management techniques, are vital in minimizing the adverse impacts of disease outbreaks on animal welfare. Thus, improving animal welfare is not only an ethical imperative but also a practical strategy for disease prevention and control.

This study explores the role of disease prevention and control in enhancing animal welfare, examining scientific frameworks and methods for assessing animal welfare and its correlation with disease prevention, investigating the impact of good welfare practices on disease resistance and overall health, identifying effective management strategies to mitigate the adverse effects of disease outbreaks on animal welfare, comprehensively understanding the dynamic interactions between welfare, immunity, and disease, and highlighting future research areas aimed at contributing to ongoing efforts to improve animal welfare through better disease prevention and control strategies.

2 The Impact of Disease on Animal Welfare

2.1 Physical health implications

Disease significantly impacts the physical health of animals, leading to adverse welfare outcomes. For instance, diseases in sheep can cause pain, reduce mobility, and lead to other health complications that affect both individual animals and entire flocks (Roger, 2008). The physical health of animals is closely linked to their overall welfare, as poor health can lead to decreased productivity and increased mortality rates. Effective management and preventive measures are essential to mitigate these impacts and ensure the physical well-being of animals (Heath, 2012; Düpjan and Dawkins, 2022).

2.2 Behavioral and psychological effects

The behavioral and psychological effects of disease on animals are profound. Animals suffering from diseases often exhibit signs of stress, anxiety, and depression, which can further exacerbate their physical health issues (Düpjan and Dawkins, 2022). For example, sheep are capable of experiencing emotions and memory, and diseases can significantly alter their behavior and cognitive functions (Roger, 2008). Environments that promote positive emotions and reduce stress can help in mitigating these adverse effects, highlighting the importance of good welfare practices in disease prevention.

2.3 Economic and ethical considerations

The economic and ethical considerations of disease prevention and control are critical in the context of animal welfare. Economically, disease outbreaks can lead to significant financial losses due to decreased productivity, increased veterinary costs, and potential loss of livestock (Heath, 2012). Ethically, there is a moral obligation to ensure the well-being of animals under human care. This includes implementing preventive measures and maintaining high standards of animal welfare to minimize suffering and promote health (Roger, 2008). The ethical approach to disease control is a major determinant of the standards for the generally accepted treatment of animals, emphasizing the need for a multidisciplinary approach to understanding and improving animal welfare (Roger, 2008).

3 Strategies for Disease Prevention

3.1 Biosecurity measures

Biosecurity measures are critical in preventing the introduction and spread of infectious diseases within and between animal herds. Effective biosecurity practices include external barriers to prevent disease entry and internal measures to control disease spread within a herd. For instance, the Norwegian Control Program for Bovine Respiratory Syncytial Virus (BRSV) and Bovine Coronavirus (BCoV) emphasizes external biosecurity by classifying herds based on antibody testing and implementing strict regulations on animal trade to reduce virus transmission (Figure 1) (Stokstad et al., 2020). Similarly, a study on Belgian cattle farms highlighted the need for improved biosecurity practices, such as quarantining new animals and using farm-specific protective clothing, to prevent disease transmission. Additionally, the implementation of biosecurity measures in pig herds across four European countries showed that higher biosecurity levels were associated with healthier animals and reduced disease incidence (Postma et al., 2016).

3.2 Vaccination programs

Vaccination is a cornerstone of disease prevention in livestock, providing immunity against specific pathogens and reducing the overall disease burden. An economic assessment of bluetongue virus control in Austria and Switzerland demonstrated the cost-effectiveness of vaccination programs in managing disease outbreaks and reducing the need for other interventions (Stärk, 2018). In Cambodia and Laos, knowledge-based interventions, including vaccination, significantly improved livestock health and farmers' attitudes towards disease prevention (MacPhillamy et al., 2021). Furthermore, the association between vaccination and improved internal biosecurity in pig herds suggests that a comprehensive preventive approach, including vaccination, is essential for maintaining animal health (Postma et al., 2016).

3.3 Nutritional interventions

Proper nutrition plays a vital role in enhancing the immune system of animals, making them less susceptible to diseases. Nutritional interventions can include the provision of balanced diets, supplementation with vitamins and

minerals, and ensuring access to clean water. While specific studies on nutritional interventions were not highlighted in the provided data, it is well-established that good nutrition supports overall animal health and resilience against infections.

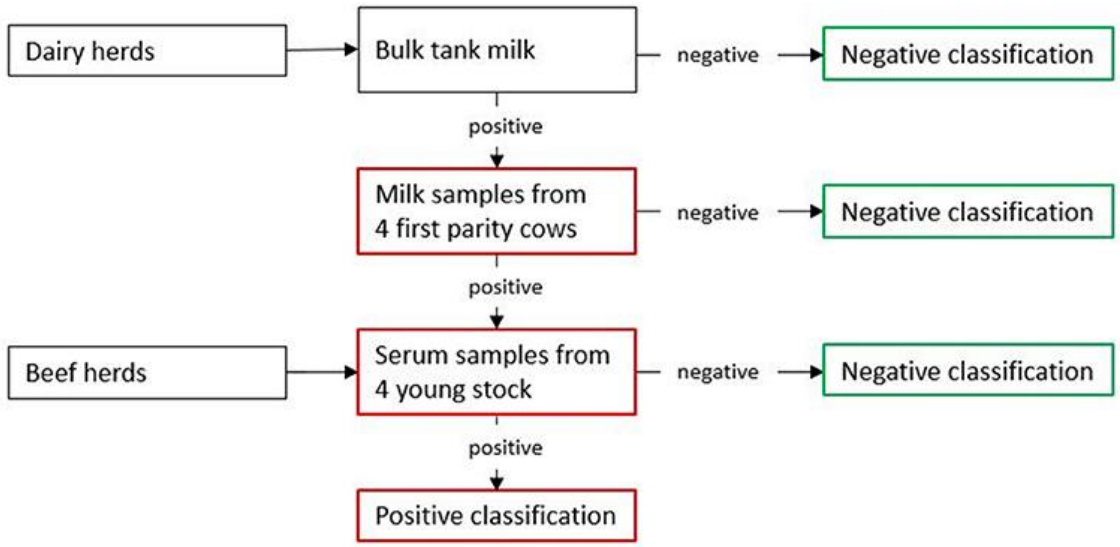

Figure 1 Classification of herds in the Norwegian control program for bovine respiratory syncytial virus (BRSV) and bovine coronavirus (BCoV). Samples of milk and serum are analyzed for antibodies against BRSV and BCoV using a BCoV/BRSV multiplex immunoassay (Adopted from Stokstad et al., 2020)

3.4 Environmental management

Environmental management involves maintaining clean and hygienic living conditions for animals to reduce the risk of disease. This includes regular cleaning and disinfection of animal housing, proper waste disposal, and ensuring adequate ventilation. The Norwegian BRSV/BCoV control program also emphasizes the importance of improving the animal's environment as part of a comprehensive disease prevention strategy (Stokstad et al., 2020). Additionally, a study on biosecurity practices in Belgian cattle farms found that better environmental management practices, such as reducing animal-to-animal contact and controlling professional visits, could significantly lower the risk of disease transmission (Sarrazin et al., 2014). Effective environmental management is thus a crucial component of disease prevention and control in livestock farming.

4 Disease Control Methods

4.1 Early detection and diagnosis

Early detection and diagnosis are critical components in the control of animal diseases. Effective surveillance systems are essential for the timely identification of disease outbreaks, which allows for prompt intervention and minimizes the spread of infections. Diagnostic tests play a crucial role in this process, enabling the early detection of infected animals and facilitating the implementation of control measures. For instance, the availability of adequate diagnostic tests is vital for the early detection of notifiable diseases, which can significantly impact livestock health and human health (Álvarez et al., 2019). Surveillance systems systematically collect, collate, and analyze data on disease occurrence, helping to detect changes in disease trends and distribution (Fenner et al., 1987). In animal shelters, diagnostic tools are used to identify infectious diseases such as heartworm, with protocols in place for testing and managing infected animals (Colby et al., 2011; DiGangi, 2020).

4.2 Quarantine and isolation practices

Quarantine and isolation practices are fundamental in preventing the spread of infectious diseases among animal populations. These measures involve separating healthy animals from those that are suspected or confirmed to be infected. Quarantine is particularly important during the introduction of new animals into a herd or shelter, as it helps to prevent the introduction of new pathogens. Effective quarantine and isolation protocols are essential for controlling diseases such as canine parvovirus and feline upper respiratory disease in animal shelters (Steneroden et al., 2011). Movement control and quarantine are also key strategies in the broader context of disease eradication

and control, helping to prevent the spread of diseases from infected to clean animals (Modisane, 2009). The implementation of these practices requires collaboration between animal health authorities, livestock industries, and veterinary research institutions (Álvarez et al., 2019).

4.3 Treatment protocols

Treatment protocols are designed to manage and mitigate the impact of diseases once they have been detected. These protocols can include the administration of medications, supportive care, and other therapeutic interventions. For example, in the case of heartworm infection in dogs, treatment protocols may involve the use of melarsomine and adjunctive therapies such as doxycycline and prednisone (Colby et al., 2011; DiGangi, 2020). The choice of treatment protocol can vary depending on the resources available and the specific needs of the animal population. In some cases, treatment may also involve the use of vaccines to prevent the spread of the disease (Fenner et al., 1987). However, the effectiveness of treatment protocols can be limited by factors such as cost and the availability of veterinary expertise, particularly in animal shelters.

4.4 Eradication programs

Eradication programs aim to completely eliminate specific diseases from animal populations. These programs often involve a combination of strategies, including vaccination, culling of infected animals, and strict biosecurity measures. The success of eradication programs depends on the strength and capacity of veterinary services, cross-border efforts for disease surveillance, and the availability of financial support (Modisane, 2009). For example, the global eradication of Rinderpest was achieved through coordinated efforts involving vaccination and surveillance (Heath, 2012). In developed countries, countrywide eradication programs are commonly practiced for serious exotic diseases that pose significant threats to livestock health (Fenner et al., 1987). The implementation of eradication programs requires the commitment of animal industries and relevant authorities to develop and regularly test contingency plans (Rubira, 2007).

5 Technological Advances in Disease Prevention and Control

5.1 Genetic resistance breeding

Genetic resistance breeding involves selecting and breeding animals that possess natural resistance to specific diseases. This approach can significantly reduce the incidence of diseases in livestock populations, thereby improving overall animal welfare. By focusing on genetic traits that confer resistance, farmers can develop herds that are less susceptible to infections, reducing the need for medical interventions and enhancing the sustainability of livestock farming.

5.2 Precision livestock farming

Precision Livestock Farming (PLF) leverages advanced technologies such as sensors, cameras, and microphones to monitor the health and welfare of animals in real-time. These technologies enable farmers to detect early signs of disease, stress, or discomfort, allowing for timely interventions. For instance, sensors can track vital signs and behaviors, while algorithms analyze the data to provide actionable insights. This approach not only improves animal welfare but also enhances productivity and sustainability in livestock farming (Benjamin and Yik, 2019; Buller et al., 2020; Silva et al., 2022; Džermeikaitė et al., 2023).

5.3 Use of artificial intelligence in disease surveillance

Artificial Intelligence (AI) has revolutionized disease surveillance in livestock by enabling the early detection and management of illnesses. AI systems can analyze vast amounts of data from various sources, such as sensors and cameras, to identify patterns indicative of disease. These systems can predict outbreaks, monitor animal behaviors, and even suggest preventive measures. AI-driven technologies ensure healthier livestock by providing accurate and timely diagnoses, thus improving animal welfare and reducing economic losses (Figure 2) (Racewicz et al., 2021; Morota et al., 2022; Zhang et al., 2023).

5.4 Innovations in veterinary medicine

Innovations in veterinary medicine, including the development of new vaccines, diagnostic tools, and treatment methods, have significantly contributed to disease prevention and control in livestock. Advanced diagnostic tools,

such as biosensors and wearable devices, allow for the continuous monitoring of animal health, enabling early detection of diseases like ketosis or mastitis. These innovations not only improve the effectiveness of disease management but also enhance the overall welfare of animals by reducing the need for invasive procedures and minimizing stress (Racewicz et al., 2021; Silva et al., 2022; Džermeikaitė et al., 2023).

Figure 2 The application of AI in animal welfare (Adopted from Zhang et al., 2023)

5.5 Integrated health management systems

Integrated health management systems combine various technological advancements, such as PLF, AI, and innovative veterinary practices, to create a comprehensive approach to animal health. These systems facilitate the seamless integration of data from multiple sources, providing a holistic view of animal health and welfare. By leveraging these integrated systems, farmers can make informed decisions, optimize disease prevention strategies, and ensure the well-being of their livestock (Benjamin and Yik, 2019; Buller et al., 2020; Racewicz et al., 2021; Silva et al., 2022).

6 Policy and Regulation

6.1 International guidelines and standards

International guidelines and standards play a crucial role in the prevention and control of diseases to improve animal welfare. The World Organisation for Animal Health (OIE) is a key intergovernmental organization that sets global standards for animal welfare. Established in 1924, the OIE has 178 member countries and territories and has developed comprehensive guidelines that address various aspects of animal welfare, including the transport of animals, slaughter for food, disease control, and the use of animals in research and education (Littin et al., 2013). The OIE's guiding principles for animal welfare emphasize the importance of disease prevention, veterinary treatment, appropriate shelter, and nutrition, ensuring that animals are healthy, comfortable, and able to express innate behaviors (Littin et al., 2013).

In 2012, the OIE adopted 10 'General Principles for the Welfare of Animals in Livestock Production Systems', which draw on extensive scientific research. These principles cover genetic selection, environmental influences, group management, air quality, access to feed and water, disease prevention, pain management, human-animal

relationships, and the skills of animal handlers (Fraser et al., 2013). These guidelines provide a robust framework for developing and implementing animal welfare standards globally.

6.2 National policies and implementation

National policies and their implementation are critical for translating international guidelines into actionable measures that improve animal welfare. Countries adopt and adapt the OIE's standards to fit their specific contexts, considering cultural, socio-economic, political, and scientific factors. The flexibility in the OIE's guidelines allows member countries to implement and review standards in ways that support compliance and ensure they remain current (Littin et al., 2013). This adaptability is essential for addressing the unique challenges faced by different nations in disease prevention and control.

6.3 Role of non-governmental organizations

Non-Governmental Organizations (NGOs) play a significant role in advocating for and supporting the implementation of animal welfare standards. NGOs often collaborate with intergovernmental organizations like the OIE and national governments to promote best practices and raise awareness about animal welfare issues. They contribute to the development and review of standards, ensuring that they are based on scientific evidence and ethical considerations (Littin et al., 2013). By engaging both the public and private sectors, NGOs help improve compliance with animal welfare guidelines and foster a culture of care and responsibility towards animals.

7 Case Study

7.1 Background of the case study

This case study focuses on the efforts undertaken in Iraq to control infectious diseases in farm animals. The primary aim of these efforts is to enhance agricultural production, ensure food security and safety, protect public health, and improve animal welfare. The strategies implemented are in line with the guidelines provided by the World Organization for Animal Health, which emphasize the importance of good governance and high-quality veterinary services (Al-Shuwaili and Tarsh, 2022).

7.2 Disease challenge and impact on welfare

Infectious diseases pose a significant threat to farm animals, leading to high morbidity and mortality rates, which in turn affect productivity and animal welfare. The presence of diseases not only causes physical suffering to the animals but also impacts their emotional well-being, as animals are capable of experiencing pain, stress, and other negative emotions (Roger, 2008; Düpjan and Dawkins, 2022). In Iraq, the challenge has been to manage these diseases effectively to prevent outbreaks and minimize their impact on both individual animals and entire herds (Al-Shuwaili and Tarsh, 2022).

7.3 Prevention and control measures applied

Iraq has implemented a comprehensive set of measures to control and prevent animal diseases. These measures include legislation and policy implementation: Enforcing laws and resolutions aimed at combating communicable diseases and setting national policies for disease prevention (Al-Shuwaili and Tarsh, 2022). Vaccination programs: Introducing health and vaccination programs to protect animals from various infectious diseases (Al-Shuwaili and Tarsh, 2022). Biosecurity measures: Implementing biosecurity protocols such as disinfection of establishments, equipment, and vehicles, and imposing temporary bans on animal movements to prevent the spread of pathogens (Robertson, 2020; Al-Shuwaili and Tarsh, 2022). Veterinary services: Ensuring the availability of high-quality veterinary services for early detection and rapid response to disease outbreaks (Robertson, 2020; Al-Shuwaili and Tarsh, 2022). Public awareness and education: Educating farmers about the importance of disease prevention and biosecurity measures to enhance compliance and effectiveness (Laanen et al., 2014).

7.4 Outcomes and lessons learned

The implementation of these measures in Iraq has led to several positive outcomes. Reduction in disease incidence: There has been a noticeable decrease in the incidence of infectious diseases among farm animals, which has contributed to improved animal welfare and productivity (Al-Shuwaili and Tarsh, 2022). Enhanced animal welfare:

By preventing diseases and ensuring timely treatment, the overall welfare of farm animals has improved, as they experience less pain and stress (Roger, 2008; Düpjan and Dawkins, 2022). Strengthened veterinary services: The focus on good governance and high-quality veterinary services has strengthened the overall animal health system in Iraq, making it more resilient to future outbreaks (Robertson, 2020; Al-Shuwaili and Tarsh, 2022). Increased awareness and compliance: Farmers have become more aware of the importance of disease prevention and biosecurity, leading to better compliance with recommended practices (Laanen et al., 2014).

Lessons learned from this case study highlight the importance of a multi-faceted approach to disease prevention and control. Effective legislation, robust veterinary services, comprehensive vaccination programs, and strong biosecurity measures are all critical components. Additionally, educating farmers and ensuring their active participation in disease prevention efforts are essential for long-term success (Laanen et al., 2014; Robertson, 2020; Al-Shuwaili and Tarsh, 2022).

8 Challenges and Future Directions

8.1 Emerging diseases and threats

Emerging infectious diseases pose significant challenges to animal welfare and public health. The increasing globalization of trade, climate change, and evolving human behaviors create opportunities for pathogens to spread and adapt to new environments. Diseases such as avian influenza, rabies, and Rift Valley fever exemplify the global risks associated with zoonotic diseases, which can have devastating impacts on both animal and human populations (Sunstrum et al., 2019). Effective strategies to control these diseases at their source are essential, requiring early detection, prevention, and control measures that integrate new models and partnerships (Sunstrum et al., 2019). Additionally, the threat of bioterrorism and the need for robust preparedness plans highlight the importance of continuous threat analysis and the development of comprehensive response strategies (Cardoen et al., 2017).

8.2 Gaps in current practices

Current practices in disease prevention and control reveal several critical gaps. For instance, there is a need for improved diagnostic tools, vaccines, and pharmaceuticals to address infectious diseases in animals. The DISCONTOOLS database identifies significant gaps in vaccine development and pharmaceuticals, particularly for zoonotic and epizootic diseases (O'Brien et al., 2016). Furthermore, the evaluation of subsidized veterinary services is often inadequate, with limited comprehensive assessments available in the peer-reviewed literature. This lack of evaluation hinders the ability to guide program delivery and future research effectively (Baker et al., 2018). Additionally, the adoption of disease control and welfare practices among livestock producers is inconsistent, with barriers such as costs and insufficient knowledge impeding widespread implementation (Buchan et al., 2023).

8.3 Future research needs

Future research should focus on several key areas to enhance disease prevention and control for improved animal welfare. Interdisciplinary research is crucial to understanding the complex relationships between animal welfare, immunity, and disease resistance. Studies should explore the interactions between affective states, the gut microbiome, and immune function to develop drug-free methods of improving animal health (Düpjan and Dawkins, 2022). Additionally, there is a need for strategic research agendas that address emerging infectious diseases, incorporating both natural and social science perspectives to develop effective prevention and control measures (Wentholt et al., 2012). The development of new diagnostic tools, vaccines, and pharmaceuticals should be prioritized, with a focus on addressing the most critical gaps identified through expert consultations and databases like DISCONTOOLS (O'Brien et al., 2016). Finally, comprehensive evaluations of veterinary services and disease control programs are necessary to ensure their effectiveness and to inform future research and policy decisions (Baker et al., 2018).

9 Concluding Remarks

This study highlights several critical aspects of disease prevention and control in improving animal welfare. Effective veterinary services are essential for controlling and preventing animal diseases, which in turn protect public health and ensure food security. Good management practices and improved animal welfare standards can reduce the risk of infections without relying on medication, emphasizing the complex relationship between

welfare, immunity, and disease. Veterinary epidemiology plays a crucial role in disease prevention and control, with biosecurity measures being vital for maintaining disease-free animal populations. The ethical and legal responsibilities towards animals necessitate preventive measures to ensure their welfare, particularly in the context of specific diseases affecting sheep. Various strategies, including movement control, quarantine, vaccination, and treatment, are employed globally to control animal diseases, with success depending on the strength of veterinary services and cross-border cooperation. The interplay between disease protection and animal protection often results in synergistic benefits, although contradictions can arise, particularly in the context of animal transport. Preparedness and proven management techniques are essential for minimizing the adverse impact of disease outbreaks on animal welfare. Farmers' perspectives on disease prevention and biosecurity highlight the need for better information and motivation to implement preventive measures. Ethical considerations also extend to the welfare of free-living wild animals, where interventions should be carefully weighed. Finally, the development of a modern animal disease prevention and control system is crucial for ensuring animal and public health, as demonstrated by China's progress in this area.

The findings underscore the importance of integrating disease prevention and control measures with animal welfare practices. Effective veterinary services and good management practices not only prevent disease outbreaks but also enhance the overall well-being of animals. The ethical responsibility towards animals necessitates a proactive approach to disease prevention, ensuring that animals are not only healthy but also free from pain and distress. Biosecurity measures are critical in maintaining disease-free environments, which directly impacts animal welfare by reducing morbidity and mortality rates. The synergy between disease protection and animal protection highlights the dual benefits of preventive measures, although care must be taken to address potential contradictions, especially during transport. Preparedness and emergency management are vital for minimizing the impact of disease outbreaks on animal welfare, ensuring that animals receive timely and appropriate care. Understanding farmers' perspectives and providing them with adequate information and motivation can lead to better implementation of preventive measures, ultimately improving animal welfare. Ethical interventions for free-living wild animals should be carefully considered to avoid unintended consequences, ensuring that welfare improvements are genuinely beneficial. The development of robust animal disease prevention and control systems, as seen in China, is essential for safeguarding animal welfare on a broader scale.

In conclusion, the integration of disease prevention and control measures with animal welfare practices is essential for ensuring the health and well-being of animals. Effective veterinary services, good management practices, and robust biosecurity measures are critical components of this integration. Ethical considerations and preparedness are also vital in minimizing the adverse impact of disease outbreaks on animal welfare. By understanding and addressing the perspectives of farmers and other stakeholders, we can enhance the implementation of preventive measures, leading to improved animal welfare. The progress made in countries like China demonstrates the importance of developing modern animal disease prevention and control systems that align with public health and biosafety goals. Continued research and collaboration are necessary to further refine these practices and ensure that animal welfare remains a priority in disease prevention and control efforts.

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Conflict of Interest Disclosure

Author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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