

INTRODUCTION AND SPREAD OF LUMPY SKIN DISEASE IN CENTRAL AND EASTERN ALGERIA: EPIDEMIOLOGICAL AND BIOCHEMICAL INSIGHTS

INTRODUÇÃO E DISSEMINAÇÃO DA DERMATOSE NODULAR CONTAGIOSA NA ARGÉLIA CENTRAL E ORIENTAL: INSIGHTS EPIDEMIOLÓGICOS E BIOQUÍMICOS

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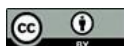
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Abstract

Lumpy Skin Disease (LSD) is a major transboundary viral disease affecting cattle, characterized by cutaneous nodules, fever, and systemic manifestations. In Algeria, its recent emergence poses significant threats to livestock health and the agricultural economy. This study aimed to analyze the spatiotemporal distribution of LSD outbreaks and assess associated biochemical alterations in infected cattle. Epidemiological data were collected from veterinary surveillance reports and analyzed using Geographic Information Systems (GIS). The results revealed a wide geographic spread of LSD, with a higher concentration of outbreaks in northern regions during the summer, highlighting the role of climatic conditions and vector activity in disease transmission. Biochemical analysis showed significant differences between infected and healthy cattle. Infected animals exhibited lower glucose levels and significant increases in urea and creatinine, along with decreased total proteins, albumin, and globulins. Liver enzymes (AST and ALT) were significantly elevated, while calcium levels were markedly reduced ($p < 0.05$). These findings indicate that LSD is a systemic disease associated with metabolic and organ dysfunctions. Integrating biochemical parameters with epidemiological surveillance could improve disease monitoring and control strategies.

Keywords: Lumpy Skin Disease. Cattle. Epidemiology. Outbreaks. Biochemical Parameters. Algeria.

Resumo

A Doença da Dermatose Nodular Contagiosa (Lumpy Skin Disease – LSD) é uma importante doença viral transfronteiriça que afeta bovinos, caracterizada por nódulos cutâneos, febre e manifestações sistêmicas. Na Argélia, seu surgimento recente representa uma ameaça significativa à saúde do rebanho e à economia agrícola. Este estudo teve como objetivo analisar a distribuição espaço-temporal dos surtos de LSD e avaliar as alterações bioquímicas associadas em bovinos infectados. Os dados epidemiológicos foram coletados a partir de relatórios de vigilância veterinária e analisados utilizando Sistemas de Informação Geográfica (SIG). Os resultados revelaram uma ampla distribuição geográfica da doença, com maior concentração de surtos nas regiões do norte durante o verão, destacando o papel das condições climáticas e da atividade dos vetores na transmissão da doença. A análise bioquímica mostrou diferenças significativas entre bovinos infectados e saudáveis. Os animais infectados apresentaram níveis mais baixos de glicose e aumentos significativos de ureia e creatinina, além de redução das proteínas totais, albumina e globulinas. As enzimas hepáticas (AST e ALT) estavam significativamente elevadas, enquanto os níveis de cálcio estavam marcadamente reduzidos ($p < 0,05$). Esses achados indicam que a LSD é uma doença sistêmica associada a disfunções metabólicas e orgânicas. A integração de parâmetros bioquímicos com a vigilância epidemiológica pode melhorar o monitoramento e as estratégias de controle da doença.

Palavras-chave: Dermatose Nodular Contagiosa. Bovinos. Epidemiologia. Surtos. Parâmetros Bioquímicos. Argélia.

1 INTRODUCTION

Lumpy Skin Disease (LSD) is a transboundary viral disease primarily affecting cattle and water buffaloes (Sudhakar *et al.*, 2020). It is clinically characterized by fever, lacrimation, and the development of characteristic skin nodules that initially appear on the head, neck, and abdomen before spreading across the entire body (Tuppurainen *et al.*, 2017; WOA, 2023).

LSD represents a major threat to livestock production systems due to its

significant economic impact. Indeed, the disease causes permanent skin damage, reduced milk yield during illness, sterility, infertility in both sexes, abortion, mastitis, emaciation, loss of draft power, and death (Gupta *et al.*, 2020), as well as trade restrictions. Consequently, it is listed as a notifiable disease by the World Organisation for Animal Health (WOAH, 2024).

The disease is caused by Lumpy Skin Disease Virus (LSDV), a member of the *Poxviridae* family within the genus *Capripoxvirus* (WOAH, 2021), also referred to as the Neethling virus (Kiplagat *et al.*, 2020). LSDV, goatpox virus (GTPV), and sheeppox virus (SPPV) are members of the *Poxviridae* family within the genus *Capripoxvirus* (CaPVs). CaPVs are double-stranded DNA viruses (L. Whittle *et al.*, 2023).

Morbidity rates typically range from 5% to 45%, while mortality remains relatively low, usually below 3% (Ayelet *et al.*, 2014).

Transmission of LSDV occurs mainly through mechanical vectors, particularly blood-feeding arthropods such as mosquitoes, biting flies, and ticks, which facilitate rapid dissemination of the virus within and between herds (Babiuk *et al.*, 2008), as well as through saliva, nasal secretions, and semen of infected animals (Annandale *et al.*, 2010).

In severe cases, the disease may lead to secondary complications and increased mortality, further exacerbating its economic consequences (Mason *et al.*, 2019). Over the past decade, LSD has expanded geographically across Africa, the Middle East, Asia, and parts of Europe, highlighting its emergence as a globally significant transboundary disease (Klement *et al.*, 2021).

In response to its rapid spread and economic burden, affected countries have implemented control strategies such as vaccination campaigns, movement restrictions, and enhanced surveillance systems aimed at limiting outbreaks and achieving endemic stability (FAO, 2022).

Despite extensive vaccination programs, the disease has continued to spread in various regions.

In Algeria, LSD has recently emerged as a major animal health concern. The first officially reported cases were recorded in June 2024, raising serious questions regarding the origin, introduction, and rapid dissemination of the virus. This situation has led to considerable economic losses and has posed significant challenges for farmers, veterinarians, and animal health authorities, particularly in implementing control

measures such as emergency vaccination campaigns.

The livestock sector plays a crucial role in the Algerian economy, especially in rural areas where cattle production contributes significantly to household income through milk, meat, and by-products. The emergence of LSD has therefore threatened both animal health and the livelihoods of farming communities, while also placing considerable pressure on veterinary services and surveillance systems.

In this context, understanding the spatial and temporal dynamics of LSD is essential for guiding effective control strategies. Therefore, the present study aimed to conduct a retrospective and spatiotemporal analysis of LSD outbreaks in Algeria, with particular emphasis on identifying epidemiological patterns, tracing disease spread, and assessing potential risk factors associated with its emergence and dissemination.

In addition, this study evaluated biochemical alterations in cattle naturally infected with LSD by analyzing key serum parameters, in order to better understand the systemic effects of the disease and to identify potential biomarkers associated with its clinical progression

2 MATERIALS AND METHODS

2.1 Study area and period

This study investigated the emergence and spatiotemporal spread of lumpy skin disease (LSD) outbreaks in Algeria between June and August 2024.

Algeria, the largest country in Africa (approximately 2.3 million km²), shares extensive borders with several countries, including Tunisia, Libya, Niger, Mali, Mauritania, Western Sahara, and Morocco, making it particularly vulnerable to transboundary animal diseases.

The country encompasses diverse agro-ecological zones, including the northern coastal belt, the central highlands and steppe regions, and the southern Sahara. These ecological variations may influence the distribution and transmission dynamics of vector-borne diseases such as LSD.

The first official outbreak of lumpy skin disease (LSD) in Algeria was reported on June 18, 2024, in Ghardaia province, approximately 600 km south of Algiers, and was

associated with significant cattle mortality (Rahim, 2024). The outbreak was subsequently reported to the FAO Emergency Prevention System (EMPRES). Additional outbreaks were later recorded in several provinces, including Algiers, El Oued, Ghardaia, Sétif, and Mila (Lounis, 2024).

2.2 Study design and data collection

A retrospective descriptive and spatiotemporal case-series study was conducted. Data on LSD outbreaks were collected from multiple sources, including the World Organisation for Animal Health (WOAH), national veterinary services, and laboratory reports.

A case of LSD was defined based on clinical suspicion, characterized by the presence of typical cutaneous nodules, fever, and associated clinical signs. When available, laboratory confirmation was performed using enzyme-linked immunosorbent assay (ELISA) at the Central Veterinary Laboratory of Algiers.

Geographical data were structured according to Algeria's 58 provinces (wilayas), grouped into four main regions (central, eastern, western, and southern).

For each outbreak, the following variables were recorded: date of occurrence, geographic location (wilaya) and number of affected animals.

Only outbreaks occurring in cattle between June and August 2024 were included in the analysis.

2.3 Spatial and spatiotemporal analysis

Spatial and spatiotemporal analyses were conducted to characterize the distribution and clustering of LSD outbreaks. Spatial cluster detection methods were applied to identify significant geographic aggregations of cases. In addition, spatiotemporal scan statistics were used to detect clusters in both space and time.

Geographic Information System (GIS) tools were used to map outbreak distribution and visualize disease spread. These approaches allowed the identification of high-risk areas and provided insights into the epidemiological dynamics of LSD transmission.

2.4 Data analysis

Descriptive and exploratory data analysis techniques were applied to assess the temporal and spatial patterns of LSD outbreaks.

Outbreak frequency was summarized across provinces and over time. Epidemic curves and spatial distribution maps were generated to illustrate disease dynamics.

These analyses aimed to:

- describe the temporal evolution of the epidemic,
- identify spatial clusters and hotspots,
- highlight high-risk regions.

2.5 Sample collection and biochemical analysis

To complement the epidemiological investigation, a comparative study was conducted between March and May 2025 in cattle farms located in the Algiers region affected by LSD. A total of 20 cattle were included and divided into two groups: an infected group ($n = 10$) showing clinical signs consistent with LSD and a control group ($n = 10$) consisting of clinically healthy animals.

Blood samples were collected from the coccygeal vein under aseptic conditions. Serum was obtained after centrifugation and stored at $-20\text{ }^{\circ}\text{C}$ until analysis.

Biochemical parameters (glucose, urea, creatinine, total proteins, albumin, globulins, ALT, AST, and calcium) were measured using spectrophotometric methods with standardized commercial kits. Statistical analysis included normality testing (Shapiro–Wilk test) followed by comparative tests (ANOVA or Mann–Whitney), with a significance threshold set at $p < 0.05$.

2.6 Study limitations

Several limitations should be acknowledged. Incomplete and non-standardized reporting may have led to underestimation of cases and potential reporting bias. In addition, not all suspected cases were laboratory-confirmed, which may have resulted in misclassification. Furthermore, environmental and ecological factors such as climate,

vector abundance, and animal movement were not fully integrated into the analysis. The lack of high-resolution spatial data may also have limited the precision of spatial modeling. Future studies incorporating these variables and advanced geospatial data are recommended to improve risk assessment and epidemiological understanding.

3 RESULTS

3.1 Overall epidemiological situation

The epidemiological analysis of Lumpy Skin Disease (LSD) in Algeria during 2024 revealed a wide spatiotemporal distribution of outbreaks across the country. The disease spread predominantly during the summer season, a period characterized by climatic conditions favorable to arthropod vector proliferation, including high temperatures and increased humidity.

Outbreaks were mainly concentrated in northern Algeria, with a marked predominance in the Kabylie region, an area characterized by high cattle density and intensive livestock activity.

3.2 Geographic distribution of LSD outbreaks

LSD outbreaks were reported in multiple wilayas covering diverse agro-ecological zones, including coastal, mountainous, and semi-arid regions. This distribution indicates the ability of LSDV to circulate under heterogeneous environmental conditions.

The most affected wilaya was Tizi Ouzou, where several localities (Tadmaït, Maatkas, Draa El Mizan, Aït Bouadou, and Aïn Zaouia) reported clustered outbreaks.

Ghardaïa (DhayetBendhahoua) recorded the highest number of cases at the onset of the epidemic (49 cases), representing the earliest and most intense outbreak.

Additional affected wilayas included Blida, Batna, Boumerdès, Bouira, Béjaïa, Jijel, Médéa, Skikda, Sétif, Mila, El Tarf, Tipaza, Tébessa, Algiers, and Bordj Bou Arréridj, highlighting the extensive geographic spread of the disease across Algeria.

Overall, outbreak distribution suggests an association with cattle density, animal movements, and environmental conditions favorable to vector activity.

3.3 Temporal distribution

Outbreaks occurred between early June and late August 2024.

The epidemic curve showed three distinct phases:

- **Onset phase (early June):** Initial outbreaks reported in Ghardaïa and Blida.
- **Peak phase (late June to mid-July):** Highest number of reported cases.
- **Decline phase (late July to August):** Progressive decrease in outbreak frequency, with the last cases reported in Tipaza and Algiers.

The duration of outbreaks ranged from 2 to 6 weeks, with an average duration of approximately 3–4 weeks.

3.4 Epidemic spread pattern

The analysis of outbreak progression revealed a heterogeneous distribution of cases over time. An initial peak was observed in early June in Ghardaïa, followed by secondary peaks in Tizi Ouzou during mid-June and early July. Subsequently, a gradual decline in case numbers was observed from July onwards, with more dispersed and less intense outbreaks.

This pattern suggests a two-phase epidemic dynamic:

- A rapid expansion phase during early summer
- A progressive decline phase toward the end of the study period

Table 1

Spatiotemporal Distribution of Lumpy Skin Disease Outbreaks in Algeria (2024)

Date (Onset)	Wilaya	Locality	Region
04 June 2024	Ghardaïa	Dhayet Bendhahoua	South
05 June 2024	Blida	Bouinan	North-Central
05 June 2024	Batna	Ouled Derradj	East
13 June 2024	Tizi Ouzou	Tadmaït	Kabylie
13 June 2024	Jijel	Taher	East
20 June 2024	Boumerdès	Timezrit	Kabylie
20 June 2024	Bouira	Taghzout	Central
22 June 2024	Tizi Ouzou	Maatkas	Kabylie
23 June 2024	Tizi Ouzou	Draa El Mizan	Kabylie
23 June 2024	Béjaïa	Tala Hamza	Kabylie
23 June 2024	Médéa	El Hamdania	Central
26 June 2024	Tizi Ouzou	Aït Bouadou	Kabylie

30 June 2024	Tizi Ouzou	Aïn Zaouia	Kabylie
01 July 2024	Algiers	Ouled Chebel	North-Central
02 July 2024	Skikda	Tamalous	East
03 July 2024	Tébessa	Chréa	East
06 July 2024	Sétif	Beida Bordj	East
09 July 2024	Mila	Sidi Merouane	East
10 July 2024	Bordj Bou Arréridj	Hasnaoua	East
15 July 2024	El Tarf	Hammam Ben Salah	East
28 July 2024	Tipaza	Hattatba	North-Central
01 August 2024	Algiers	Douera	North-Central

Figure 1

Geographic distribution of reported LSD cases visualized using QGIS software. (Open Street Map)



3.5 Biochemical parameters

3.5.1 Energy profile

A significant decrease in serum glucose levels was observed in infected cattle compared to the control group (78.06 ± 1.14 vs. 97.56 ± 2.65 mg/dL, $p < 0.001$).

3.5.2 Protein and renal profile

Urea and creatinine levels were significantly higher in infected animals than in controls (47.87 ± 1.31 vs. 40.80 ± 0.63 mg/dL, $p < 0.001$; and 1.68 ± 0.05 vs. 1.40 ± 0.05 mg/dL, $p = 0.004$, respectively).

Total protein concentrations were significantly reduced in infected cattle (6.12 ± 0.25 vs. 8.06 ± 0.17 g/dL, $p < 0.001$). Albumin (2.99 ± 0.06 vs. 3.66 ± 0.15 g/dL, $p = 0.001$) and globulin levels (3.14 ± 0.27 vs. 4.40 ± 0.26 g/dL, $p = 0.004$) were also significantly lower.

No significant difference was observed for the albumin/globulin ratio ($p = 0.304$).

3.5.3 Liver enzyme activity

Serum transaminases were significantly elevated in infected cattle.

AST levels were higher in infected animals (62.89 ± 1.48 vs. 33.26 ± 1.41 IU/L, $p < 0.001$), as well as ALT (60.02 ± 1.07 vs. 38.60 ± 0.49 IU/L, $p < 0.001$).

3.5.4 Calcium levels

Serum calcium levels were significantly decreased in infected cattle compared to controls (8.39 ± 0.18 vs. 11.78 ± 0.30 mg/dL, $p < 0.001$).

4 DISCUSSION

The present study provides a comprehensive spatiotemporal analysis of the spread of Lumpy Skin Disease (LSD) in Algeria between June and August 2024. The results highlight a complex epidemic dynamic characterized by rapid dissemination, localized amplification, and subsequent decline, reflecting the multifactorial nature of LSD transmission.

The epidemic curve revealed a pronounced initial peak in Ghardaïa (June 4, 2024), suggesting a potential index introduction point of the virus. Given the geographical position of Ghardaïa, near the southern borders of Algeria, this finding strongly supports

the hypothesis of cross-border virus introduction, likely through the movement of infected livestock. Similar patterns have been documented in other North African and Middle Eastern countries, where transboundary animal movement plays a critical role in the introduction and spread of LSDV (Mercier *et al.*, 2018; Tageldin *et al.*, 2014).

Following this initial outbreak, a secondary wave was observed in Tizi Ouzou in mid-June, with subsequent outbreaks persisting throughout July. This pattern suggests local transmission and secondary spread, rather than repeated introductions. The recurrence of outbreaks in the same region indicates that endemic circulation may have been established locally, facilitated by:

- High cattle density
- Limited biosecurity practices
- Frequent animal movements within and between farms

These findings are consistent with previous studies demonstrating that once introduced, LSD can rapidly become self-sustaining in susceptible populations, particularly in areas with favorable ecological and management conditions (Tuppurainen *et al.*, 2017).

The progressive decline in case numbers from mid-July onward likely reflects the combined effect of control measures and environmental factors. The implementation of movement restrictions, increased veterinary surveillance, and early vaccination campaigns may have contributed to limiting further spread. Additionally, changes in climatic conditions or vector dynamics could have reduced transmission efficiency. This dual influence of intervention and seasonality has been reported in similar outbreaks across Africa, where timely control measures significantly reduced epidemic intensity (FAO, 2017; Seufi and Galal, 2010).

From an epidemiological perspective, the outbreak displayed two distinct phases:

- An acute phase, characterized by rapid expansion and high transmission intensity
- A declining phase, marked by reduced incidence and spatial dispersion of cases

This temporal pattern aligns with classical epidemic models of vector-borne diseases, where initial rapid spread is followed by a decline due to depletion of susceptible hosts, increased immunity, or intervention measures.

The spatial distribution of cases further emphasizes the importance of environmental and anthropogenic factors. Regions such as Tizi Ouzou, Bouira, and

Boumerdès experienced multiple localized outbreaks, suggesting that topography, climate, and livestock practices played a significant role. In particular, Tizi Ouzou, characterized by a humid and mountainous environment, provides favorable conditions for the proliferation of hematophagous vectors, which are known to mechanically transmit LSDV. The role of vectors such as *Stomoxys calcitrans*, *Culicoides* spp., and mosquitoes is well established in the literature and is considered a major driver of LSD epidemiology (Ayelet *et al.*, 2014).

In contrast, the initial outbreak in Ghardaïa occurred in a semi-arid to Saharan environment, where vector abundance is typically lower. This suggests that the introduction of the virus was likely anthropogenic, rather than vector-driven, reinforcing the hypothesis of infected animal movement as the primary introduction pathway.

Another critical factor contributing to the rapid spread of LSD in Algeria is the lack of prior immunity in cattle populations. In naïve herds, LSD can achieve very high morbidity rates, sometimes approaching 100%, facilitating rapid viral amplification and dissemination (Tuppurainen *et al.*, 2017). The absence of systematic vaccination prior to the outbreak may have further exacerbated the situation.

Additionally, the study highlights potential iatrogenic transmission pathways, particularly the use of contaminated equipment during routine veterinary procedures. The possibility of mechanical transmission through shared needles or inadequate sterilization practices should not be overlooked, as it may contribute to localized spread in certain contexts.

The role of transboundary animal movements must also be considered. Algeria shares borders with several countries where LSD has been reported, including Libya and Tunisia. The detection of LSD in neighboring regions prior to or during the study period increases the likelihood of regional virus circulation and cross-border spread, especially in the context of informal livestock trade.

The introduction of the Dermapox vaccine represents a critical step in controlling the outbreak. As a heterologous live attenuated capripoxvirus vaccine, it provides cross-protection against LSD, sheeppox, and goatpox. Its deployment in field conditions reflects a pragmatic approach to disease control in resource-limited settings. However, the effectiveness of this vaccine in the Algerian context requires further evaluation, particularly in terms of duration of immunity, coverage, and field effectiveness.

The field observation in Cheraga, where a vaccinated animal developed cutaneous lesions several months post-vaccination, raises important questions regarding:

- Possible vaccine breakthrough infections
- Duration of protective immunity
- Or adverse post-vaccinal reactions

Such findings highlight the need for long-term serological and clinical monitoring to assess vaccine performance under field conditions.

Despite the valuable insights provided by this study, several limitations should be acknowledged. The analysis is based on reported cases, which may be subject to underreporting, reporting delays, or incomplete spatial coverage. In addition, the absence of detailed data on animal movements, vector density, and vaccination coverage limits the ability to fully quantify risk factors. Future studies should integrate geospatial modeling, vector surveillance, and molecular epidemiology to better understand transmission pathways.

In addition to the epidemiological findings, the present study highlights significant biochemical alterations in cattle naturally infected with LSD, reflecting the systemic nature of the disease.

A marked decrease in serum glucose levels was observed in infected animals, indicating a disruption of energy metabolism. This finding is consistent with previous studies reporting hypoglycemia in infected cattle, often associated with reduced feed intake, increased metabolic demands, and systemic inflammatory responses (Molla *et al.*, 2017).

Alterations in protein metabolism were also evident, with increased urea and creatinine levels suggesting enhanced protein catabolism and possible renal involvement. Concurrently, the significant reduction in total proteins, albumin, and globulins indicates a state of hypoproteinemia, likely linked to hepatic dysfunction, increased vascular permeability, or altered immune response (Radostits *et al.*, 2007).

Furthermore, the significant elevation of AST and ALT activities strongly suggests hepatocellular damage in infected cattle. While ALT is considered more liver-specific, the increase in AST may also reflect muscular involvement, which is commonly reported in systemic viral infections (Elhaig *et al.*, 2017).

The observed hypocalcemia in infected animals indicates a disturbance in mineral metabolism, which may result from reduced intake, impaired absorption, or systemic inflammatory processes affecting calcium homeostasis (Kaneko *et al.*, 2008).

From an epidemiological perspective, these biochemical alterations provide additional evidence that LSD is not limited to cutaneous manifestations but induces systemic physiological disturbances. The integration of biochemical parameters with epidemiological surveillance may therefore enhance disease monitoring, improve early detection, and support clinical management strategies.

5 CONCLUSION

The emergence and rapid spread of Lumpy Skin Disease (LSD) in Algeria, a country previously considered disease-free, represents a major epidemiological turning point and underscores the urgent need to better understand the drivers of its introduction and dissemination. The spatiotemporal dynamics observed in this study highlight the combined influence of animal movement, vector activity, and environmental conditions in shaping the epidemic pattern.

Beyond its well-described clinical manifestations, the present study demonstrates that LSD is associated with significant systemic biochemical alterations in infected cattle. The observed hypoglycemia, increased urea and creatinine levels, reduced total proteins and albumin concentrations, elevated transaminase activities (AST and ALT), and decreased calcium levels collectively indicate metabolic disruption, hepatic involvement, and possible renal impairment. These findings confirm that LSD is not merely a cutaneous disease but a multisystemic infection affecting key physiological functions. Therefore, integrating biochemical profiling into epidemiological surveillance could enhance disease monitoring, improve clinical assessment, and support early detection of subclinical cases.

The economic impact of LSD remains substantial, driven by decreased milk production, weight loss, reproductive disorders, and trade limitations, ultimately threatening livestock productivity and the sustainability of the agricultural sector.

Effective control of LSD requires a coordinated and multidisciplinary approach. Strengthening surveillance systems for early detection and rapid reporting is essential to limit disease spread. In parallel, mass vaccination using live attenuated vaccines should

remain the cornerstone of control strategies, ensuring broad coverage and long-term immunity across cattle populations.

Given the vector-borne nature of LSD, integrated vector control measures must also be implemented, including habitat management, insecticide application, and the use of repellents. Additionally, strict regulation of animal movements, particularly in affected and high-risk areas, is crucial to prevent further dissemination.

Finally, enhancing farmer awareness through targeted training programs, improving biosecurity practices, and implementing effective communication and compensation strategies will be critical to ensure stakeholder engagement and the success of control measures

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