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Seroprevalence of Lumpy Skin Disease and Livestock Owners' Knowledge, Attitudes and Practices in Selected Districts of Kazakhstan

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ABSTRACT

Background: Lumpy skin disease is a transboundary viral disease of cattle associated with substantial economic losses and increasing geographic spread. Although Kazakhstan is currently considered free from active LSD outbreaks, the presence of transboundary risk necessitates continued surveillance. This study aimed to estimate the animal- and herd-level seroprevalence of lumpy skin disease virus in cattle, assess associations between seropositivity, herd size and geographic region, and evaluate livestock owners' knowledge, attitudes and practices regarding the disease in selected regions of Kazakhstan.

Methods: A cross-sectional study was conducted between April and September 2025 in 12 districts across the West Kazakhstan, North Kazakhstan, Pavlodar and Aktobe regions. Serum samples from 338 cattle were tested for LSDV-specific antibodies using a commercial ELISA, and structured questionnaires were administered to 533 livestock owners.

Results: The overall animal-level seroprevalence was 23.4% (95% CI: 19.0–28.1), while 18.8% (95% CI: 13.6–24.9) of herds had at least one seropositive animal. Seropositivity varied significantly by region and herd size; however, because vaccination traceability data were unavailable and the serological assay could not differentiate antibodies induced by natural infection from those associated with previous vaccination, the findings should be interpreted cautiously. KAP assessment revealed high general awareness of LSD; however, limited recognition of vector-borne transmission and inconsistent implementation of preventive measures were evident.

Conclusion: These findings highlight regional heterogeneity in exposure risk and underscore the importance of risk-based surveillance, strengthened biosecurity and targeted farmer education to support LSD prevention in Kazakhstan.

1 | Introduction

Lumpy skin disease (LSD) is a viral infection of cattle that results in substantial economic losses (Sharma and Kumar, 2025). The causative agent, lumpy skin disease virus (LSDV), is classified within the family Poxviridae and the genus *Capripoxvirus* (Babiuk et al., 2008; Tuppurainen et al., 2018). Antigenically, LSDV is closely related to sheep-pox and goatpox viruses. Over recent decades, the virus has become endemic throughout most of Africa and has expanded beyond the continent into the Middle

East, Central Asia, China and several Southeast Asian countries, including Indonesia, Laos, Cambodia, Thailand, Singapore, Malaysia and Vietnam (Arjkumpa et al., 2021; Khoo et al., 2022; Lu et al., 2020; Nugroho et al., 2024; Tran et al., 2021). Its continued geographic expansion highlights its increasing international transboundary importance for animal health and livestock production (Shumilova et al., 2022). Epidemiological reports from regions such as mainland China, Africa, the Middle East and South Asia indicate that LSD outbreaks occur predominantly between April and October. This marked seasonal pattern is thought to be linked to increased activity of haematophagous insect vectors during these months (Acharya and Subedi, 2020; Lu et al., 2020; Tuppurainen et al., 2017).

According to the World Organisation for Animal Health (WOAH), the epidemiological situation of LSD in Kazakhstan is currently considered as stable. During 2016–2017, outbreaks were recorded to have spread from Russia's Astrakhan and Chelyabinsk regions into several areas of Kazakhstan, including Mangystau, Atyrau and Kostanay (Amirgazin and Ragatova, 2020; Orynbayev et al., 2021). Subsequent evidence suggested that by 2018, LSDV had also reached the northern and southern regions of the country (Issimov et al., 2022). However, these occurrences were not officially documented, and their epidemiological implications remain unclear. Considering the presence of epizootic foci of LSD in transboundary regions adjacent to Kazakhstan, coupled with the large cattle population in the country's western and northern areas, there exists a tangible risk of disease re-entering the western and northern regions of the Republic of Kazakhstan, including the Mangystau, West Kazakhstan, Aktobe, North Kazakhstan and Pavlodar regions.

Studies on the risk factors that influence the occurrence of LSD showed a prevalence of 10.2% at animal level and 49.2% at herd level in West Kazakhstan regions (Issimov et al., 2022). However, no studies have been carried out on the seroprevalence of LSD across the country. In Kazakhstan, moreover, agriculture constitutes a critical component of rural livelihoods, with livestock production serving as a primary source of income for smallholder farms (Kulpiisova et al., 2024; Seisenov et al., 2023). Evidence from recent studies demonstrates that small-scale livestock producers in Kazakhstan generally rely on basic husbandry practices and have limited awareness of animal disease risks and biosecurity measures (Bayantassova et al., 2023; Ginayatov et al., 2025; Kulpiisova et al., 2024; Kulpiisova et al., 2025; Tursunkulov et al., 2026; Urazayeva et al., 2024). In light of these gaps, the objectives of the present study were: (i) to estimate the animal- and herd-level seroprevalence of lumpy skin disease virus in selected regions of Kazakhstan; (ii) to assess associations between seropositivity, herd size and geographic region and (iii) to evaluate livestock owners' knowledge, attitudes and practices regarding the disease.

2 | Materials and Methods

2.1 | Ethics

The questionnaire-based component of this study involving livestock owners was reviewed and approved by the Local Bioethics Committee (Protocol No. 21). The study was conducted according to the principles of the Declaration of Helsinki (2013), and participants' rights were observed. Prior to enrolment, all participants were informed about the objectives and procedures of the study, and oral informed consent was obtained. Oral consent was considered appropriate because the study involved minimal-risk interviews conducted under field conditions in rural livestock-producing communities, and no personal identifiers were collected. Participation was entirely voluntary, and no personal identifiers were collected. All questionnaire data were anonymised prior to analysis.

The animal sampling component of the study was conducted in accordance with national and international guidelines for the care and use of animals in research. The protocol for blood sample collection from cattle was approved by the Biological Ethics Commission of the Research Institute for Biological Safety Problems, Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Protocol No. 1). All procedures complied with the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes.

2.2 | Study Area

The study was carried out between April and September 2025 across twelve administrative locations within the North Kazakhstan, Pavlodar, West Kazakhstan and Aktobe regions. Together, these regions encompass an area of approximately 779,000 km^2 and are home to an estimated population of 3 million people and 30.2 million livestock (Agricultural Census, 2025). The selected regions were chosen based on their high livestock density and the documented occurrence of brucellosis among agricultural animals, domestic species and wildlife (Mukhanbetkaliyeva et al., 2024). Spatial visualisation and cartographic outputs were generated using ArcGIS Pro version 2.8 (ESRI, Redlands, CA, USA), a geographic information system (GIS) platform for spatial data analysis and mapping (Figure 1). All geographic datasets were projected using the World Geodetic System 1984 (WGS 84, Springfield, VA, USA), the standard global reference system for latitude and longitude coordinates (MapTiler Team, 2022). Field-collected data were subsequently integrated with supplementary spatial layers, including Sentinel-2 satellite imagery (10 m resolution; Land Use/Land Cover), topographic features and administrative boundaries (Abdi, 2020).

2.3 | Study Design and Sample Size

A cross-sectional study was conducted to investigate the seroprevalence of LSD among cattle purposively selected from designated districts. Blood samples were obtained from randomly chosen animals, with sampling proportional to herd size within each livestock-owning household, and subsequently subjected to serological analysis. The minimum required sample size was calculated using the protocol described by Thrusfield (Thrusfield et al., 2018). The calculation was based on a 95% confidence level, an assumed expected prevalence of 50% due to the absence of prior data from the study area, and a desired absolute precision of 5%. Using these parameters, the required minimum sample size was estimated to be 338 animals, all of which were

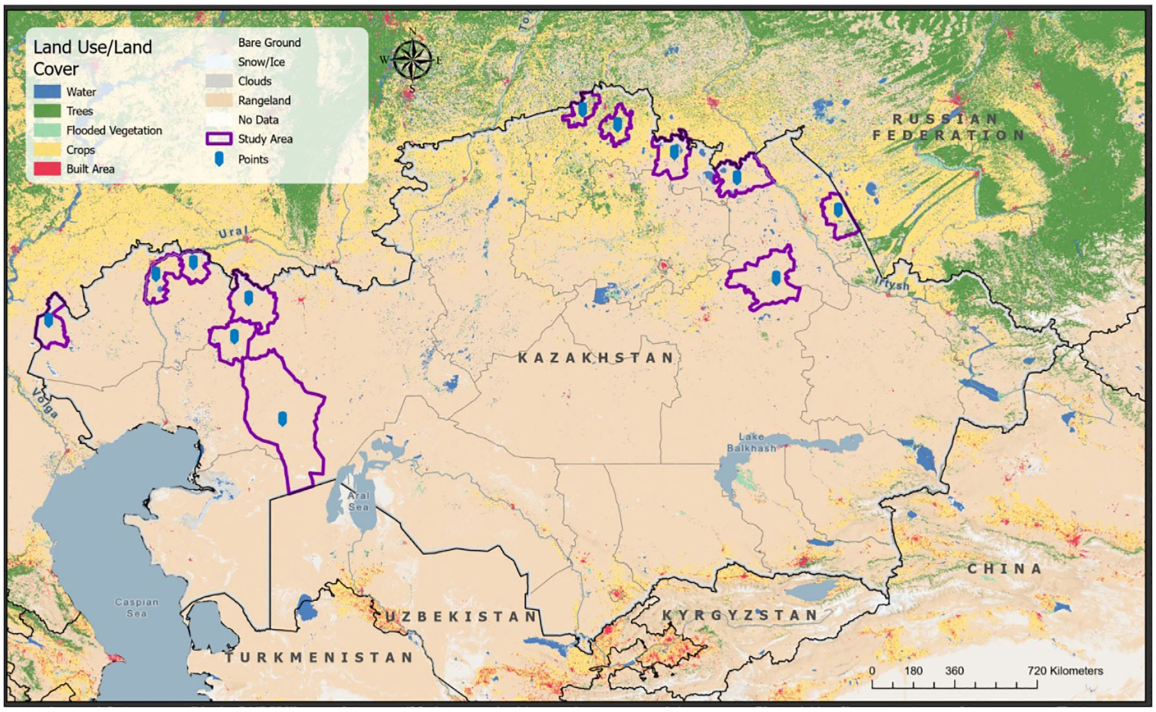

FIGURE 1 | Selected districts of the North Kazakhstan, Pavlodar, West Kazakhstan and Aktobe regions included in the LSD seroprevalence and KAP study. The regions marked in purple illustrates cattle density distribution. Cattle population data were obtained from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (Agricultural Census, 2025).

included in the study. In addition, data on livestock owners' characteristics and management practices were collected using semi-structured questionnaires. The number of respondents was determined using a statistical approach described by Arsham (2020). Assuming a standard error of 5%, a precision level of 0.05, and a 95% confidence interval, the calculated sample size for the questionnaire survey was 533 farmers, who were subsequently selected and interviewed.

2.4 | Sampling Method and Sample Collection

Twelve districts across the North Kazakhstan, Pavlodar, West Kazakhstan and Aktobe regions were purposively selected for inclusion in the study, taking into account cattle population density, reported occurrence of lumpy skin disease, and the absence of prior vaccination within the study areas. Data regarding confirmed outbreaks of LSD within the selected districts were obtained from the corresponding District Veterinary Offices. Livestock owners possessing a minimum of two cattle were eligible to participate. Field visits were conducted in coordination with district veterinary personnel. Eligible livestock-owning households were identified from local veterinary records and visited sequentially within each selected district. The number of animals sampled from each locality was determined proportionally according to the total cattle population of the area. Within each herd, animals were selected using random sampling procedures to ensure population representativeness. All cattle older than six months, regardless of body condition, were considered equally eligible for inclusion without classification. In medium-sized herds, up to 5 animals were randomly sampled, whereas in small-sized herds with fewer than five animals, a single animal was selected at random. Based on the cattle herd size classification proposed by Molla et al. (Molla et al., 2018), a total of 226 animals were sampled from small herds (2–5 cattle) and 112 animals from medium-sized herds (6–10 cattle).

Approximately 10 mL of whole blood was aseptically collected from the tail vein of selected cattle using plain Vacutainer tubes containing a clot activator (Ecopharm Ltd., Kazakhstan). Each specimen was assigned a unique identification code to link the sample to the individual animal and its corresponding herd. The collected samples were kept at room temperature and allowed to clot overnight. On the following day, sera were separated by centrifugation at $3000 \times g$ for 10 min, yielding clear serum, which was subsequently stored at −20°C until analysis at the serology laboratory of Zhubanov University. Detection of antibodies specific to LSDV was performed using a commercially available ELISA kit (ID Screen Capripox Double Antigen Multi-species; ID Vet, Grabels, France) following the manufacturer's protocol.

2.5 | Questionnaire

A structured questionnaire was developed to evaluate livestock owners' knowledge, attitudes and practices regarding LSD. The instrument containing open questions was organised into two principal sections. The first section captured respondents' knowledge and attitudes toward LSD, including awareness of disease occurrence, clinical recognition and perceived routes of transmission. The second section focused on practices toward

TABLE 1 | Animal-level seroprevalence of LSDV and logistic regression analysis by herd size and region in Kazakhstan.

Variable	Level	No. sampled	No. positive	OR (95% CI)	*p*-value
Herd size	Small (ref)	226	29	1.00	—
	Medium	112	51	5.68 (3.31–9.73)	< 0.001
Region	Pavlodar (ref)	80	3	1.00	—
	North Kazakhstan	83	29	13.78 (3.99–47.56)	< 0.001
	West Kazakhstan	85	46	6.47 (1.82–22.94)	< 0.01
	Aktobe	90	1	0.29 (0.03–2.83)	0.286

Note: Pavlodar region was used as the reference category due to the very low number of seropositive animals observed in Aktobe region. Odds ratios were estimated using exploratory univariable logistic regression models with animal-level LSDV seropositivity as the outcome variable. Multivariable modeling was not retained due to the limited number of explanatory variables consistently available across sampled herds.
Abbreviations: CI, confidence interval; OR, odds ratio.

disease prevention and control methods. Each enroled farm owner was provided with a detailed explanation of the clinical manifestations of LSD to minimise potential confusion with other dermatological conditions, including ringworm, bovine herpes mammillitis, dermatophilosis and demodicosis. Prior to data collection, the questionnaire was pilot-tested through ten interviews and subsequently refined to enhance clarity and comprehension. Interviews were conducted in either Kazakh or Russian, depending on the preferred language of the participants.(Supproting Information)

2.6 | Data Analysis

All collected data were entered into Microsoft Excel and carefully screened for completeness and accuracy prior to analysis. Statistical analyses were performed using Python programming, version 3.9.7. (Jupyter Notebook, San Francisco, CA, USA). Animal-level and herd-level seroprevalence estimates were calculated with corresponding 95% confidence intervals (CIs). Associations between animal-level LSDV seropositivity and selected explanatory variables, including herd size and geographic region, were explored using univariable logistic regression analysis. Odds ratios (ORs) with 95% confidence intervals were calculated, and statistical significance was assessed at $p < 0.05$. Data obtained from the knowledge, attitudes and practices (KAP) questionnaire were summarised descriptively using frequencies and percentages. In addition, selected KAP variables considered epidemiologically relevant to LSD transmission, including grazing practices, livestock introduction and preventive measures, were explored using exploratory univariable logistic regression analysis against herd-level seropositivity outcomes.

3 | Results

3.1 | Seroprevalence

Exploratory univariable logistic regression analysis demonstrated regional differences in animal-level LSDV seropositivity (Table 1): therefore, these findings should be interpreted as associations derived from cross-sectional data. A total of 338 cattle were sampled, of which 79 tested seropositive for LSDV yielding an animal-level seroprevalence of 23.4% (95% CI: 19.0–28.1) and a herd-level seroprevalence of 18.8% (95% CI: 13.6–24.9).However, because serological assays cannot differentiate antibodies induced by natural infection from those associated with previous vaccination, the observed seropositivity should be interpreted with caution. Herd size was significantly associated with seropositivity. Cattle originating from medium-sized herds showed substantially higher odds of LSDV seropositivity compared with those from small herds (OR = 5.68; 95% CI: 3.31–9.73; $p < 0.001$). In addition, LSDV seropositivity varied significantly by region. Using Pavlodar region as the reference category, cattle from the North Kazakhstan region exhibited significantly increased odds of seropositivity (OR = 13.78; 95% CI: 3.99–47.56; $p < 0.001$). Similarly, animals sampled in the West Kazakhstan region showed a significantly higher likelihood of LSDV seropositivity ($p < 0.01$).

3.2 | Knowledge, Attitude and Practices of Farmers Regarding Lumpy Skin Disease

A summary of farmers' KAPs ($n = 533$) toward LSD is presented in Table 2. Overall awareness of LSD was high, with 85.2% of respondents reporting prior knowledge of the disease. Animal health workers were the primary source of information (57.7%), followed by neighbours (20.5%) and media (12.0%). Nearly half of the farmers (47.3%) indicated that LSD cases had occurred previously in their villages. Introduction of new animals (31.1%) and contaminated feed (33.8%) were the most frequently perceived transmission pathways, whereas only 15.7% identified biting insects as a route of spread. Communal grazing was the predominant production system (77.1%). Most respondents (70.0%) reported that they would immediately notify veterinary authorities if LSD was suspected, although 21.2% indicated reliance on antibiotic treatment. Exploratory logistic regression analysis demonstrated that several management-related practices were associated with herd-level LSDV seropositivity (Table 3). Herds managed under communal grazing systems showed higher odds of seropositivity compared with non-communal systems (OR = 2.41; 95% CI: 1.18–4.92; $p = 0.015$). Similarly, introduction of animals from uncertain or high-risk sources was associated with increased odds of seropositivity (OR = 2.87; 95% CI: 1.36–6.04; $p = 0.006$). In contrast, implementation of at least one preventive

TABLE 2 | Knowledge, attitude and practices of farmers (n = 533) towards control of LSD.

Variables	Frequency	Percentage (95% CI)
Have you heard of lumpy skin disease		
Yes	454	85.2 (76.4–93.6)
No	79	14.8 (11.2–27.4)
Source of information about LSD		
Friends	51	9.5 (7.4–13.3)
Neighbours	109	20.5 (18.8–24.4)
Animal health workers	308	57.7 (44.3–68.0)
Media	65	12 (8.2–14.6)
Knowledge about symptoms of LSD		
Skin nodules	169	31.7 (25.2–41.0)
Fever	77	14.4 (10.0–19.6)
Lameness	148	27.8 (20.3–34.4)
Excess salivation	40	7.5 (3.6–11.4)
Do not know	99	18.5 (11.8–26.6)
Farmers had heard of LSD cases in their village (anytime in the past)		
Yes	252	47.3 (27.5–68.4)
No	281	52.7 (34.4–70.6)
How is LSD most commonly transmitted between cattle?		
Biting insects	84	15.7 (10.2–22.7)
New animal introduction	166	31.1 (24.4–42.4)
Direct contact between animals	103	19.3 (11.3–29.0)
Contaminated feed	180	33.8 (20.8–43.6)
Type of grazing		
Communal pasture	411	77.1 (60.6–91.8)
Nomadic	10	1.8 (0.3–4.2)
River plains	112	21 (13.7–38.8)
What would you do if your herd had LSD?		
Report immediately	371	70 (62.7–76.2)
Treat the affected animals (using antibiotics)	113	21.2 (15.5–28.4)
Do nothing	11	2 (0.5–5.4)
Sell the cattle	8	1.5 (0.2–4.7)
Slaughter cattle for meat	17	3.2 (0.8–6.6)
Other	13	2.4 (0.6–5.2)
What do you think is necessary to prevent or control LSD?		
Early LSD detection by local veterinary workers	177	33.2 (24.7–41.4)
Regular visits by the veterinary authorities	108	20.2 (17.2–26.6)
Quarantine of new animals introduced to herd/village	87	16.3 (10.4–20.7)
Control of infected animal movements	60	11 (6.4–17.3)
Reduce contact between herds	51	9.6 (5.1–13.7)
Provide compensation for farmers	37	6.9 (3.8–10.5)
Do not know	13	2.4 (0.9–5.0)
How do you currently protect your herd from LSD?		
Not buying cattle or other livestock from risky sources	289	54.2 (43.8–61.0)
Doing nothing	119	22.3 (17.8–29.4)
Other	79	14.8 (9.7–20.0)
Disinfecting animal premises regularly	46	8.6 (4.4–15.7)
Are you interested in receiving further information on LSD?		
Yes	435	81.6 (73.3–90.7)
No	98	18.4 (12.4–26.6)
What specific information on LSD would you like to receive?		
How to prevent the disease	297	55.7 (48.6–61.5)
How to treat diseased animals	134	25.1 (19.7–29.5)
Basic knowledge about the disease	102	19.1 (13.8–23.3)

(Continues)

measure was associated with reduced odds of seropositivity (OR = 0.48; 95% CI: 0.24–0.95; $p = 0.034$).

3.3 | Regional Patterns of Seroprevalence and Preventive Practices

Marked regional heterogeneity in animal-level LSDV seroprevalence was observed (Figure 2A). The highest seroprevalence occurred in West Kazakhstan, followed by North Kazakhstan, whereas substantially lower levels were recorded in Pavlodar and Aktobe regions. Regional differences were also apparent in preventive practices against LSD (Figure 2B). Although avoidance of risky livestock purchases was the most frequently reported measure across all regions, West Kazakhstan characterised by the highest seroprevalence also showed a higher proportion of farmers reporting no preventive measures. In contrast, regions with lower seroprevalence demonstrated greater uptake of at least one preventive practice.

TABLE 3 | Exploratory logistic regression analysis of selected KAP variables associated with herd-level LSDV seropositivity in Kazakhstan.

Variable	Category	OR (95% CI)	*p*-value
Grazing system	Non-communal (ref)	1.00	—
	Communal grazing	2.41 (1.18–4.92)	0.015
Livestock purchase source	Low-risk (ref)	1.00	—
	Risky/unknown source	2.87 (1.36–6.04)	0.006
Preventive measures	At least one measure (ref)	1.00	—
	No preventive measures	2.09 (1.05–4.18)	0.034

Note: Estimates were derived from exploratory univariable logistic regression models using herd-level LSDV seropositivity as the outcome variable.
Abbreviations: CI, confidence interval; OR, odds ratio.

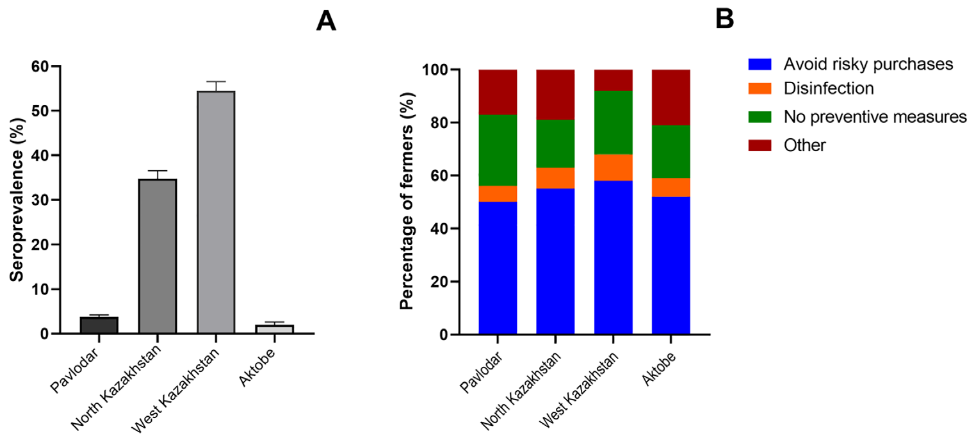

FIGURE 2 | Regional distribution of LSDV seroprevalence and preventive practices among farmers in Kazakhstan. (A) Animal-level seroprevalence of LSDV by region, illustrating marked geographic variation in exposure. (B) Distribution of preventive measures reported by farmers against lumpy skin disease by region, expressed as percentages of respondents (n = 533). Data are presented descriptively; statistical analyses are reported in the corresponding tables.

4 | Discussion

This study was designed to determine the seroprevalence of LSD and to assess farmer' awareness of the disease. The detected level of LSDV seropositivity suggests prior immunological exposure among cattle in the surveyed regions; however, these findings should be interpreted cautiously because serological assays cannot distinguish between antibodies resulting from natural infection and those induced by vaccination. Given that lumpy skin disease is classified as a transboundary animal disease and is associated with both direct and indirect economic losses, including temporary reductions in milk yield, impaired reproductive performance, damage to hides and restrictions on animal movement and trade (WOAH, 2026). Accordingly, serological evidence of exposure should be interpreted as an indicator of potential production losses and ongoing vulnerability within the production system. Comparison with international field studies demonstrates that reported seroprevalence levels vary widely depending on vector ecology, husbandry systems and the history of outbreaks or vaccination. For example, investigations conducted in Ethiopia and Uganda have documented pronounced regional heterogeneity and highlighted the importance of herd management factors; notably, moderate animal-level seroprevalence may coexist with substantially higher herd-level prevalence due to clustering effects (Molla et al., 2018; Ochwo et al., 2018). Similarly, studies from Egypt have described marked seasonal and spatial variation, as well as the contribution of communal grazing areas, shared water sources and the introduction of new animals into herds (Selim et al., 2021). In this context, the present findings provide an important snapshot of LSDV seropositivity patterns during the peak vector activity season and underscore the need for continued surveillance in regions considered at transboundary risk (WOAH, 2026).

The pronounced differences in seroprevalence observed between regions with higher levels in western and northern locations compared with other areas are epidemiologically plausible for LSDV. Disease spread is largely shaped by the interaction between local abundance of haematophagous arthropod vectors and long-distance movement of infected animals (WOAH, 2025). In Kazakhstan, LSDV circulation has been documented since at least 2016, and investigations of early outbreaks detected viral DNA in ticks and blood-feeding insects, supporting the central role of vectors in LSD epidemiology (Orynbayev et al., 2021). In the present study, higher seroprevalence in the West Kazakhstan and North Kazakhstan regions may reflect differences in the local force of infection, which is influenced by cattle density, livestock trade networks, seasonal movements and environmental conditions favourable for vector survival, such as proximity to water bodies, floodplains and suitable pasture microclimates. International studies consistently report associations between geographic features, rainfall, humidity, communal watering points and increased risk of LSDV exposure (Ochwo et al., 2019). Additional support for the epidemiological relevance of these regional contrasts is provided by recent disease dynamics: in 2025, LSD was officially reported for the first time in several European countries, highlighting the continued risk of re-introduction and rapid geographic expansion facilitated by animal movements and vector activity (WOAH, 2025).

In the current study, farmers' KAP were evaluated to support the identification of suspected LSD cases within their herds based on reported clinical signs. Local veterinary practitioners were involved in verifying the information related to outbreak events reported by farmers in the surveyed regions. The KAP data reveal a pattern commonly observed in the context of transboundary animal diseases: high general awareness of the disease coexists with incomplete understanding of key transmission mechanisms and inconsistent implementation of preventive measures. Similar profiles have been reported in KAP studies on other livestock diseases in Kazakhstan, such as foot-and-mouth disease, rabies and brucellosis, where familiarity with the disease name and expressed willingness to engage in control measures often contrast with persistent gaps in knowledge of transmission pathways and continued engagement in risk-prone practices (Bayantassova et al., 2023; Ginayatov et al., 2025; Tursunkulov et al., 2026). Exploratory regression analysis further suggested that several livestock management practices may contribute to variation in herd-level LSDV seropositivity. In particular, communal grazing systems and the introduction of animals from uncertain or high-risk sources were associated with increased odds of seropositivity, supporting previous epidemiological observations that animal movement and inter-herd contact facilitate LSDV transmission (Ochwo et al., 2019; Selim et al., 2021). Conversely, implementation of at least one preventive measure was associated with lower seropositivity, emphasising the potential value of basic biosecurity practices under field conditions. Although these associations should be interpreted cautiously due to the cross-sectional design and partial linkage between questionnaire and serological data, the observed relationships should be interpreted as epidemiological associations rather than evidence of direct causal effects. Nevertheless, the findings reinforce the epidemiological importance of management-related practices in shaping disease exposure risk.

Of particular concern is the limited recognition of haematophagous insects as the primary route of LSDV transmission, despite strong experimental evidence and emphasis in international guidelines (WOAH, 2026). Comparable knowledge gaps regarding the vector-borne nature of LSD have been documented in KAP study conducted in Tanzania, where general awareness did not translate into adequate understanding of vector control, prevention, or vaccination (Makoga et al., 2023). Furthermore, the reliance of a subset of respondents on antibiotic treatment in response to suspected LSD reflects a risk of inappropriate antimicrobial use, given the viral aetiology of the disease. Similarly, from personal communication, herd owners from our study used antibiotic treatment oxytetracycline (300 mg) and flunixin meglumine (20.0 mg) (Nitox Forte, Russia), to treat generalised LSD. In addition, antibiotics were sometimes applied prophylactically with the intention of limiting disease spread within herds. In contrast, herd owners who did not administer antimicrobial therapy described more severe clinical manifestations, increased secondary complications and prolonged recovery periods. This finding underscores the need for targeted educational interventions focusing on biosecurity and rational antimicrobial use, which are increasingly prioritised within veterinary training and extension programmes (FAO, 2025).

A major limitation of this study is the inability of the serological assay to differentiate antibodies induced by natural infection from those associated with previous vaccinations. Kazakhstan is currently regarded as free from active LSD outbreaks, and the districts included in this investigation had no documented history of routine vaccination against LSD at the time of sampling. Consequently, the detection of LSDV-specific antibodies should not be interpreted as evidence of ongoing local virus circulation or endemicity. One plausible explanation for isolated seropositive results is the introduction of animals from other districts or regions where vaccination against LSD may have been implemented previously. In such cases, seropositivity may reflect vaccine-induced antibodies rather than natural exposure to field strains. Given the frequent movement of cattle between regions for trade, breeding or seasonal grazing, this scenario represents a realistic and epidemiologically consistent source of serological positivity. Furthermore, the purposive selection of districts based on livestock density, transboundary risk and historical reports of LSD may have introduced selection bias and limited the generalizability of the findings to the national cattle population of Kazakhstan. Consequently, the results should be interpreted primarily within the epidemiological context of the surveyed regions. In addition, potentially important epidemiological variables, including grazing system, animal movement patterns and quantitative vector exposure, were not incorporated into the regression analysis because detailed exposure data could not be consistently linked to individual animals and herds under the cross-sectional study design. These factors may substantially influence LSDV transmission dynamics and should be investigated in future longitudinal studies. Nevertheless, the results provide valuable baseline information for risk assessment and highlight the importance of integrating serological monitoring with movement control and vaccination traceability within national surveillance programmes.

From a practical standpoint, the observed patterns of LSDV seropositivity, together with marked regional heterogeneity and identified gaps in KAP, supports the need for risk-based surveillance and prevention strategies. Nevertheless, because vaccination history could not be fully verified, the detected seropositivity should not be interpreted as conclusive evidence of active virus circulation. International guidelines consistently emphasise that effective LSD control relies on early detection, movement restrictions, and widespread use of high-quality vaccines with sufficient coverage (WOAH, 2024). Experience from South-eastern Europe has demonstrated the high effectiveness of live-attenuated Neethling-type vaccines under field conditions and the importance of coordinated, region-wide implementation (Klement et al., 2020). At the same time, vaccination policies must account for emerging challenges. In previous studies, vaccine-like recombinant strains and recombination events between vaccine and field strains have been documented, strengthening the case for stringent vaccine quality control and molecular surveillance of circulating viruses (Shumilova et al., 2024; Sprygin et al., 2020). For the regions examined in this study, priority actions should include: (i) enhanced farmer education on the vector-borne nature of LSD and on measures that effectively interrupt transmission (vector control, manure management and animal protection); (ii) stricter adherence to quarantine protocols when introducing new animals and (iii) strengthening trust in veterinary services through timely response and transparent risk communication.

Author Contributions

Nadezhda Burambayeva: investigation, methodology, supervision, writing – original draft. **Arman Issimov**: investigation, methodology, supervision, writing – original draft. **Gulmira Abulgazimova**: investigation, methodology, supervision, writing – original draft. **Lespek Kutumbetov**: investigation, methodology, supervision, writing – original draft, conceptualization, data curation, formal analysis, funding acquisition, software. **Leila Kassymbekova**: investigation, methodology, supervision, writing – original draft, conceptualization, data curation, formal analysis, funding acquisition, software. **Assylay Sarzhigitova**: conceptualization, data curation, formal analysis, funding acquisition, software. **Kuandyk Zhugunissov**: conceptualization, data curation, formal analysis, funding acquisition, software. **Raikhan Nissanova**: conceptualization, data curation, formal analysis, funding acquisition, software. **Nazerke Kemalova**: conceptualization, data curation, formal analysis, funding acquisition, software. **Aigul Kaliyeva**: conceptualization, data curation, formal analysis, funding acquisition, software. **Sarsenbay Abdrakhmanov**: conceptualization, data curation, formal analysis, funding acquisition, software. **Yerzhan Ospanov**: conceptualization, data curation, formal analysis, funding acquisition, software.

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Ethics Statement

The questionnaire-based component of this study involving livestock owners was reviewed and approved by the Local Bioethics Committee (Protocol No. 21). The study was conducted according to the principles of the Declaration of Helsinki (2013), and participants' rights were observed. Prior to enrolment, all participants were informed about the objectives and procedures of the study, and oral informed consent was obtained. Participation was entirely voluntary, and no personal identifiers were collected. All questionnaire data were anonymised prior to analysis.

The animal sampling component of the study was conducted in accordance with national and international guidelines for the care and use of animals in research. The protocol for blood sample collection from cattle was approved by the Biological Ethics Commission of the Research Institute for Biological Safety Problems, Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Protocol No. 1). All procedures complied with the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The datasets containing all data analysed, supporting the results of this study will be available upon request from corresponding author.

Peer Review

For transparency, the peer review documents associated with this article are available at https://doi.org/10.1002/vms3.71129.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Supporting file 1: vms371129-sup-0001-SuppMat.docx