



The Economic Impact of Lumpy Skin Disease and Cost-Effectiveness of Vaccination for the Control of Outbreaks in Pakistan

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Abstract

Lumpy Skin Disease (LSD) may cause major financial damage to farmers. It is a significant barrier to global trade. The Lumpy Skin Disease Virus (LSDV) is a member of the Capripoxvirus genus. The LSD significantly reduces milk production, which might drop from 10 percent to 85%. Consumption of milk and meat has decreased by 60 percent to 70 percent in Karachi (Pakistan) as a result of LSD usage. Cattle of all species and ages are affected, although lactating cows and young cattle are more at risk. Most LSD outbreaks take place in hot, humid environments when most of the flies that contribute as vectors are present. LSD might be transmitted more quickly by animals. While death is typically low (between 0 and 7%), morbidity ranges from 0.75 to 100%. Lesions can be seen in the reproductive, respiratory, and digestive system tissues. Mastitis, pneumonia, infections of the skin, limping, diarrhea, and myiasis are possible secondary consequences of severe LSD. Consuming milk and meat from diseased animals is dependable and safe. It is vital to choose infection control and preventive techniques. One of the main ways that LSD is spread in areas where it is not endemic is through the restricted mobility of infected animals. Another suggestion for disease control is to reduce the number of insects and vectors. Furthermore, the most effective method for disease control may involve vaccination or immunization with the homologous strain of the LSDV. For control measures to be chosen in time for the LSD to be reduced, diagnosis is therefore of utmost importance and should be rapid and accurate, particularly in endemic regions.



Introduction

The cattle industry is the largest contributor to the nation's agricultural output, adding Rs. 1466 billion in value, a 2.5% increase from the previous years. Agriculture contributes 60.6 percent of the value contributed to the economy, accounts for 3.1 percent of total exports, and accounts for 11.7 percent of overall GDP. Over 8 million families depend on the livestock business for 35 to 40% of their income. The lumpy skin disease outbreak impacted a total of five million farmers. The sheep pox virus and the goat pox virus are also members of the Capripoxvirus, including the virus that causes lumpy skin conditions [1].

According to Morris (1931), the LSDV virus originated in Zambia in 1929, and insects were thought to be the primary disease vector. Later, between 1943 and 1945, the virus was seen in South Africa, Zimbabwe, and Botswana (Von Backstrom, 1945). This outbreak infected eight million cattle, and the illness persisted until 1949 (Thomas and Mare 1945; Diesel 1949). According to Ali and Obeid (1977), LSD was first discovered in Kenya and Sudan in 1957 and 1972. West Africa followed in 1974, Somalia in 1983 (Davies 1991a and b), and Senegal, Mauritius, and Mozambique in 2001. Currently, LSD has grown rapidly and entered most countries, notably African ones, except Algeria, Libya, Tunisia, and Morocco (Tuppurainen and Oura 2012). Under reports from 2009, 1991, 2006, 2002–2003, Oman, Kuwait, Egypt, Israel, and Bahrain (Fayez and Ahmed 2011), it has also been recorded in these places. Then, in 2009, this virus returned from an Oman farm with 3200 cattle [2].

Several more LSD research projects have been conducted in the area, especially in Ethiopia. Zelalem et al. calculated a herd seroprevalence of 6.0% and an individual seroprevalence of 6.4% in West Wolega. According to their research, seroprevalence was shown to be higher in older animals and *Bos taurus* than in *Bos indicus* cattle. It is noted that biting fly populations were denser in the lowland and middle land regions, causing a greater illness burden there. The enhanced opportunity for mechanical virus transmission by *Stomoxys* spp. and mosquitoes is likely to blame for the correlation between communal grazing and watering and an increased incidence of LSD (*Aedes aegypti*) (5). Greater concentrations of LSD were found near Zimbabwean game parks, indicating that the wildlife-cattle interface may play a role in transmission [3].

The African Cape Buffalo is just one of many species of wildlife that has been suspected as a potential host due to the correlation between transhumance and other causes of animal mobility and an elevated risk of outbreaks. LSD manifests itself clinically with the development of nodules on the skin that are elevated, firm, and consolidating in shape; these nodules may also have cores of necrotic material, which are referred to as "sit-fasts." Several arthropod families, including the Glossina, Muscidae, Tabanidae, and some hard tick species, are suspected to be the primary vectors of the Lumpy Skin Disease Virus. Transmission of the virus by personal contact has been documented, but this method is not thought to be very effective. Due to the potential for rapid virus spread in vulnerable cow populations and its substantial economic effects on herds, the World Organization for Animal Health has recognized LSD as a listed ailment [4].

Pakistan is one of the numerous nations where this virus has spread. Pakistan is currently dealing with hazardous LSDV issues in its districts. A recent study in Pakistan found that the median total economic loss of an LSD outbreak at the herd level was

USD 3 million. The biggest loss was death, followed by a drop in milk production. However, no studies estimate farm-level losses due to LSD outbreaks in endemic settings (10). The livestock sector was already facing challenges, such as high feed and energy costs, a lack of credit and training facilities, inadequate advisory, breeding, and veterinary services, as well as exploitation by the middleman, etc., when the Lumpy Skin Disease (LSD) in large animals devastated many small farmers in Sindh, Punjab, and other regions. The situation will worsen when the virus mutates in the local host and enhances its immunity to the medications and immunizations that have thus far been employed to combat it. Neither the federal nor the provincial governments allocated funds in their respective budgets for LSD control [5].

A prolonged loss of production in dairy and beef cattle due to weight loss in diseased animals and loss of traction for farms using cattle as a source of draught power results in economic losses, even though LSD outbreaks are typically associated with lower morbidity and mortality rates in herds compared to some other OIE-listed livestock diseases. Direct losses examples include:

- Decreased milk production in affected herds.
- The culling of sick animals.
- Sterility brought on by severe orchitis.

Indirect losses include things like the cost of replacing lost revenue or the cost of halting the spread of disease and utilizing less-than-ideal breeds, being shut out of domestic and foreign markets, incurring additional costs, and losing money due to vaccinations, vaccine distribution, movement restrictions, diagnostic testing, and animal culling [6].

The recent floods and monsoon season badly impacted Pakistan's milk and meat supplies. The death toll from bumpy skin illness is extremely high this year. In a meeting on September 5, Federal Minister for Finance and Revenue Miftah Ismail discussed the issue with Dr. Shahzad Amin, the CEO of the Pakistan Dairy Association. Miftah Ismail was informed of the Pakistan Dairy Association's positive impact on the country's economy. It was also revealed that recent floods and an outbreak of a disease-causing bumpy skin on animals have killed off many animals, reducing the amount of milk and meat produced. The Minister of Finance acknowledged the Association's efforts and committed to providing full assistance and facilitation and directing the appropriate authorities to address all of the problems plaguing the Pakistan Dairy Association. Meat prices around the country have increased because of the lumpy skin disease. All of the state's regions have felt the epidemic's effects on sales and output. As a result, Khyber Pakhtunkhwa has the highest percentage of animal deaths. As well as succumbing to skin ailments, animals have drowned to their deaths. Approximately 700,000 sheep and livestock were lost in Baluchistan. As a result, meat prices skyrocketed, and meat availability was severely diminished [7].

Review of Literature

lumpy skin disease (LSD)

The Lumpy Skin Disease Virus (LSDV) of the Capripoxvirusgenus, subfamily Chordopoxvirinae, family Poxviridae is the infectious viral disease that causes lumpy skin. LSD is a transboundary, vector-borne, non-zoonotic illness that presently only affects ruminants, such as cattle and water buffaloes. Among the arthropods that transmit illness are biting flies, mosquitoes,

and ticks. However, skin lesions have been observed following experimental infection in sheep, goat, giraffe, Giant gazelles, and impalas. Natural infection of sheep and goat has not been documented, even in close contact with diseased cattle and buffaloes [8].

Background

The lumpy skin disease virus (LSDV), a member of the genus Capri poxvirus, causes lumpy skin disease (LSD), one of the most serious poxvirus diseases causing cattle. The World Organization for Animal Health (OIE) classifies LSD as a reportable illness since an outbreak would have a large financial effect. Regulations on the global trade in live animals and products made from animals, costly control and removal initiatives like vaccination campaigns, as well as indirect expenses carried on by the required restrictions on animal mobility, lead to significant financial losses on a local scale. One of the global diseases, LSD, may be spread via supply and delivery channels [9].

The infection is a threat due to its rapid spread and considerable economic expenses, which include death, hide loss, a decrease in milk production, an increase in body weight, mastitis, and both male and female infertility as well as low semen quality. The illness often manifests as acute, subacute, or subclinical. The symptoms of the acute disease include pyrexia, lymphadenopathy, cutaneous lumps during successive sit-fasts, and occasional orchitis and mastitis. Among the lesions discovered during the post-mortem examination were necrotic plaques in the body mucosa, mostly of the upper respiratory tract, oral cavity, and rumen [10].

Etiology of LSD

The lumpy skin disease virus (LSDV) is a member of the genus Capripoxvirus in the family Poxviridae. The genus Capripoxvirus also includes the viruses that cause sheep pox and goat pox. As a result, LSDV shares genetic ancestry with the viruses that cause sheep pox and goat pox. The LSDV double-stranded DNA virus's genome is around 150 kbp in size, however, it has a noticeably larger size when surrounded by lipids, measuring 290 nm by 270 nm. Transmission electron microscopy (TEM) and electron microscope (EM) observations of adversely stained LSDV was conducted by Cao et al (2021) [11].

The virus causes an animal's skin to alter over time, decreasing the market price of its concealment and having severe detrimental effects on the animal's economy. Other frequent negative effects of the illness include prolonged weakness, decreased milk production, delayed growth, infertility, abortion, and, in rare instances, death. The double-stranded DNA virus known as LSDV causes skin lumps. A species of the Poxviridae subfamily is the Capri poxvirus. One of the eight genera that make up the Chord poxvirus (CPV) subfamily is the Capripoxvirus (CPV). The LSDV, sheep pox, and goat pox viruses are all members of the Capri poxvirus genus. Within specified geographic areas, CPV illnesses are often host-specific but immunologically identical [12].

Like other viruses in the Poxviridae family, Capri poxviruses have a brick-like structure. The wider lateral bodies and more oval appearance of Capri poxvirus virions set them apart from orthopoxvirus virions. Capripoxvirions are typically 320 nm by 260 nm in size. In its 151 kbp genome, the virus has 156 genes. Identical 2.4 kbp-inverted terminal repeats flank the central coding region. Between LSDV and chordopoxviruses of various genera, 146 genes are conserved. Virion structure and assem-

bly, transcription, mRNA biogenesis, nucleotide metabolism, DNA replication, protein processing, viral virulence, and host range, and viral virulence and host range are all made possible by the proteins these genes create. The LSDV genes show considerable collinearity and amino acid identity with the genes of other mammalian poxviruses inside the central genomic region. Suipoxvirus, yatapoxvirus, and leporipoxvirus contain related amino acid identities. However, collinearity is split into terminal zones [13].

In these locations, xenovirus homologs are either absent or share fewer amino acids. The majority of these variations are probably caused by genes related to viral pathogenicity and host range. Due to the homologs of the other poxvirus genera' interleukin-10 (IL-10) binding proteins, IL-1 binding proteins, G protein-coupled CC chemokine receptor, and epidermal growth factor-like protein, LSDV is specific to the Chordopoxviridae family. Blood-feeding insects are the most common vectors for LSD in cattle and water buffalo. Symptoms include the development of firm, round nodules on the skin. They start losing weight and producing less milk right away [14].

Pathogenesis of LSD

Sanz-Bernardo et al. (2020) and Coetzer (2004) have both offered in-depth analyses of the pathogenesis of LSDV. Following LSDV infection, cutaneous tissue experiences viral multiplication, which results in viremia and, consequently, fever. Once the LSDV localizes in the epidermal tissue, the nodules develop. The LSDV multiplies intracellularly in macrophages, fibroblasts, endothelial cells, and pericytes. Inflammation and lymphangitis are caused by this repetition [15].

Cows and buffaloes that are young, weak, and nursing are especially vulnerable to LSD, possibly because their body's immune immunity is weakened. For at least six months after birth, calves of ill mothers are immune to severe disease because they have acquired mother antibodies from colostrum. Although immunity upon recovery from natural LSD is established for the remainder of the animal's life, a propagation condition or condition for LSDV has not been discovered in healthy cattle later in life [16].

Prevalence of disease in Pakistan:

Last November, Pakistan's Jamshoro district in Sindh was the first place where LSD was found. Since then, 31,124 animals in the province have become sick, and 285 have died. According to a poll conducted by Dawn Pakistan, milk and meat sales declined by 60%-70% in Karachi between February and March due to decreased output, diminished animals, and fears surrounding the effects of LSD on humans. Small-scale cattle farmers who rely on milk sales have been hit hard. Most of these farmers are illiterate and unaware of the importance of taking preventative measures to halt the spread of LSD. Dr. Solangi, a veterinarian in the Sindh province's livestock department, elaborates [17].

The Punjab livestock department's director-general of research, Dr. Abdur Rehman, says that the LSD didn't exist in the subcontinent and was first seen in India in 2019. He says they were warned when the first case was found in November in Sindh, but microbiological tests took a long time to show that the disease was widespread. Around 30,000 of them were sent to Sindh immediately, and the results were good. But the use of vaccines for sheep pox and goat pox has caused debate among people working in animal health and farming. Dr. Rehman says that this step was not taken by chance. Instead, the Food and

Agriculture Organization and the World Organization for Animal Health recommend using the goat-pox vaccine for large animals in emergencies. But farmers say that the government is holding up the import of the right vaccine (called a heterologous vaccine), which is causing irreparable damage to the farming community and the country as a whole. Shahbaz Rasool, who is in charge of the Dairy and Cattle Farmers Association, says, "The FAO and WOA recommendations are only for use in an emergency. We raised the alarm long before the disease hit Punjab farms [18].

"The LSD has wiped out the livestock industry in Punjab, which is responsible for 70 percent of the country's livestock. Small farmers have been hit the hardest, as no single cattle farm has been safe from the disease. We told Punjab officials about the problem in meetings and news conferences in February, but they didn't do much to help. Both sides also disagree about the number of deaths and how the losses are counted. Dr. Suhail Manzoor, who is in charge of the Animal Disease Diagnostic and Reporting Centre, says that since the first cases of LSD were found, there have only been 29,620 cases and 765 deaths in Punjab (16). After spreading from Sindh to Punjab, LSD infected up to 2,389 cattle in the Rawalpindi district, killing 170

Mohibullah Khan, the provincial minister for agriculture and livestock, said that more than 6,000 domestic animals have died from lumpy skin disease (LSD) in the province of KPK. LSD has affected more than 100,000 cattle. He said this at an international seminar on preventing and controlling foot-and-mouth disease and LSD in the province. Secretary of Agriculture Dr. Mohammad Israr, DG livestock (extension), Dr. Alamzeb Mohmand, DG livestock (research) Ijaz Ali, a Russian Republic representative, and livestock department officers were there [19].

Transmission of LSD

Water buffalo, cattle, and wild animals have all contracted LSD. Although susceptible to LSDV, sheep, and goats either seem to be hardly or not at all affected. LSDV may persist in the environment for a very long time at room temperature, especially in dry crusts and open sores. The LSDV can survive for up to 33 days or more due to the persistence of skin necrotic lumps, which can harbor the virus for 35 days in burnt scabs and at least 18 days in dry skins. At 55°C and 65°C for 2 hours and 30 minutes, respectively, the virus may be rendered inactive [20].

Skin lesions prove to be a significant cause of the virus because LSDV can survive for a long time in abscesses or open sores. Additionally, the LSDV is released through blood, milk, semen, lachrymal, and nasal sputum. Dairy products infect nursing calves. Infected water and feed transmitted by direct contact in the severe forms of the LSD via lachrymal and nasal effluence, saliva, and even semen, it was demonstrated that blood-sucking arthropods/insects transfer LSDV. The livestock sector and LSD death percentage do not positively correlate during the early stages of LSD, indicating a minimal likelihood of LSD being directly transmitted by the LSDV. There are additional reports of LSDV intrauterine spreading [21].

Economic Losses Caused by LSD

Massive financial losses have been brought about by LSD. The illness causes a significant reduction in milk production, which can range from 10percent to 85%. This could be due to a high temperature and the emergence of secondary mastitis. Additional impacts of LSD may include slowed development, hurtled hides, permanent or temporary infertility, miscarriage,

increased costs for medications and vaccinations, and the demise of diseased cattle. In private commercial cow ranching, post-LSD productivity losses have been estimated to be between 45% and 65% [22].

According to Kiplagat et al. (2020), LSD significantly decreased agriculture income in Nakuru County, Kenya. An LSD pandemic in Ethiopia is estimated to have caused USD 1,176 in financial damage at the herding stage, with severe decreases in milk production and high death. Sheep and goat pox, which are caused by the causative agent Capri poxvirus, are of great economic significance since they severely impede global trade. These viruses could be utilized for financial bioterrorism purposes [23].

According to Klement et al. (2020), vaccinations are crucial for reducing LSD. LSD use among livestock is a concern in Pakistan. According to reports, LSD first appeared in the Punjab animal population, killing more than 570 cows, in Pakistan's Sindh region (Singla 2022). According to estimates, the economic impacts of LSD infection are being felt by five million dairy farmers and meat distributors. Although veterinary professionals' constant assurances that the disease cannot be transferred to people via meat or milk, a report claims that cow producers have been severely harmed by the LSD misinformation, and sales of milk and meat in Karachi, Pakistan, have dropped by 50 to 80%. Sales of meat and milk are down overall as lumpy skin infection progresses to 22 districts in Sindh [24].

Prevention and Control of LSD

There is currently no specific antiviral medication for LSDV. Various techniques are used in LSD epidemics for LSD prevention and control. It is challenging to properly manage and suppress LSDV infection when relying just on one method. Thus, LSDV infection must be prevented and controlled using a variety of strategies. To prevent further bacterial infections, these strategies can include restricting the mobility of ill animals, routine testing, quarantining, and decontaminating the diseased animals, controlling vectors, immunization against the disease, and treating morbid animals [25].

The only effective method to date for controlling LSD in disease-prone areas has been vaccination/immunization, which has also reduced/stopped the movement of sick animals and removed/quarantined sick animals. Many nations have demonstrated their success in containing the LSD pandemic through immunization vaccination campaigns. In this connection, it is said that a cow immunization program using an LSD homologous vaccine strain in Balkan nations reduced breakouts from 7483 to 385 and zero instances, respectively, in 2016, 2017, and 2018. This serves as proof of the vaccine strain's effectiveness. To prevent subsequent bacterial infection, LSD is solely symptomatically treated with anti-inflammatory, therapeutic exercise, antimicrobials, and antiseptic treatments. As a control measure, compulsory and consistent immunization has been recommended together with the culling/slaughtering, limited mobility, and no mobility of afflicted animals. It is very difficult to eradicate LSD without vector control. Educating veterinary physicians and livestock farmers and laborers will enable them to promptly detect clinical manifestations, assisting in reducing the spread of LSD [26].

Vaccination of LSD

The best method to stop the transmission of lumpy skin disease (LSD) and reduce production losses due to outbreaks is

widespread regional vaccination of cattle and Asian water buffalo. The control of disease transmission highly depends on vaccination. The majority of live attenuated vaccines currently used to protect cattle against LSD are based on attenuated strains of wild isolates passed through cell culture. There are three approved vaccinations for bovine dermatosis (LSD): the Gorgan goat pox (GTP) vaccine, the Kenyan sheep and goat pox (KSGP) O-180 strain vaccine, and the Lumpy Skin Disease Virus (LSDV) Neethling vaccine [27].

Types of Vaccination

Neethling Vaccine

The Neethling strain, which was created through several iterations of cell culture and is distributed by Onderstepoort Biological Products in South Africa, does not produce systemic infection or severe disease in cattle. In 50 percent of the vaccinated animals, it results in a local reaction to a granuloma of 1-2 cm in diameter at the site of the injection, and the temporary drop in milk output in dairy cattle has a negative effect on the use of this vaccine. Additionally, Neethling vaccinations have been used in recent decades in Africa and the Middle East, where high vaccination rates have prevented the spread of LSDV.

KSGP O-180 Vaccine

The Kenyan sheep and goat pox (KSGP) O-180 strain vaccine was obtained from a sheep during the same epizootics as the KSGP O-240 strain and has been effectively utilized as a vaccine against SPPV, GTPV, and LSDV in the past. The KSGP O-180 vaccination improves the infectivity of afflicted cattle that have received the vaccine but lessens the severity of LSD illness and decreases susceptibility to LSD virus. Generally speaking, vaccinations do not effectively protect cattle against LSD, either directly through clinical treatment or indirectly through lowering transmission. In order to regulate LSD in popular nations and stop it from spreading to other countries, it is urgently necessary to produce an LSD vaccine.

Gorgan GTP Vaccine

The Middle East produces the live attenuated Gorgan goat pox vaccine for use against goat pox virus (GTPV) and lumpy skin disease virus. The herd responds more strongly to the GTP vaccination than it does to the KSGP O-180 and LSD Neethling vaccines. Cattle that have received the vaccination have a stronger Delayed Type Hypersensitivity (DTH) reaction, suggesting that the Gorgan GTP vaccine is more immunogenic. The tight relationship between the LSDV genomic sequence and the GTPV genomic sequence may account for the GTP vaccine's superior LSDV protection. All calves are successfully protected by the Gorgan GTP strain vaccination against the threat posed by severe LSDV wild-type strains, indicating that the Gorgan GTP strain may be the best candidate vaccine for preventing LSD infection [28].

Public Health Concerns of LSD

There is no viral disease called LSD. The host range of LSD is thought to be fairly restricted because it has mostly been documented in big ruminant animals like cattle and water buffalo. No human illness may be transmitted from infected or ill animals. Their milk is dependable and secure for ingestion by people [29].

Although no negative effects have been documented, it is not advisable to consume the flesh of sick cattle owing to the

possibility of subsequent bacterial infections contaminating the corpse. Therefore, there is no evidence or story to suggest that the virus may harm humans. The virus is not contagious to humans and has a very narrow host range. Eating beef or dairy products poses no harm. Even though there is clear evidence in the research that LSDV does not affect people, one study argues that LSDV has co-infected humans with the herpes virus [30].

Recommendation

For a deeper understanding of the development of this serious illness, future research on the cellular tropism of LSDV and the characteristics of viral receptors on target cell membranes may be helpful.

Conclusion

Massive financial losses are being caused by the illness of lumpy skin, which is increasing in many nations. It is vital to choose illness control and preventive techniques. One of the main ways that LSD is spread in areas where it is not endemic is through the mobility limitations of infected animals. Another suggestion for disease control is to reduce the number of insects and vectors. Additionally, the most effective method for disease control may involve vaccination or immunization with the homologous strain of the LSDV. For control measures to be chosen in time for the LSD to be reduced, identification is therefore of utmost importance and should be swift and accurate, particularly in endemic regions.

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