Smallholder Cattle Farmers' Knowledge, Attitudes, and Practices Regarding Foot-And-Mouth Disease and Lumpy Skin Disease in Bali Province, Indonesia

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ABSTRACT

Foot-and-Mouth Disease (FMD) and Lumpy Skin Disease (LSD) are significant viral transboundary diseases that pose a substantial threat to livestock, particularly cattle. Following their recent emergence and sustained circulation across several Indonesia provinces, increasing concern over their potential spread to other provinces including Bali Province. Despite their recent introduction to the region, limited information exists regarding the knowledge, attitudes, and practices (KAP) of local farmers concerning FMD and LSD. This study aimed to assess the KAP of smallholder cattle farmers in Bali towards FMD and LSD and to identify associated demographic factors. A cross-sectional survey involving 112 smallholder cattle farmers was conducted using a structured questionnaire. KAP scores were calculated, and respondents with scores above the median were classified as having 'adequate knowledge,' 'positive attitude,' or 'proper practices.' Bivariate and multivariate logistic regression analyses were performed to identify factors associated with these outcomes. The results indicate that smallholder cattle farmers in

Bali possess adequate knowledge, positive attitudes, and proper practices concerning FMD. For LSD, farmers demonstrated positive attitudes and moderately proper practices but had inadequate knowledge. Farmer's age and education level were associated with FMD knowledge and attitudes. In contrast, the purpose of farming was an associated factor for LSD knowledge and attitudes. Gender was associated with the adoption of preventative practices for both diseases. The findings highlight a critical need for targeted educational interventions to improve farmers' knowledge and biosecurity practices, particularly for LSD. It is recommended that governmental agencies continue and enhance awareness campaigns to strengthen disease control efforts on Bali Island.

Key words: cattle, foot-and-mouth disease, knowledge-attitude-practices, lumpy skin disease, smallholder farmers

1. Introduction

Foot-and-Mouth Disease (FMD) and Lumpy Skin Disease (LSD) are major viral transboundary diseases of livestock, primarily affecting cattle. Both are characterized by high morbidity, low mortality, and rapid transmission, leading the World Organisation for Animal Health (WOAH) to classify them as notifiable diseases due to their severe economic consequences (1,2).

FMD is endemic in most of Southeast Asia countries. Indonesia, after successfully eradicating the disease and being declared FMD-free in 1986, experienced a re-emergence in May 2022, with outbreaks reported in Aceh and East Java province. The disease subsequently spread to other regions, including Bali Province with 556 positive cases in 2022 (3,4). Meanwhile, LSD, first identified in Zambia in 1929, reached Southeast Asia by 2020. In Indonesia, the disease was detected in Riau Province in early 2022 and has since spread (5,6). Meanwhile Bali Province is officially still LSD-free. However, the area is considered high risk due to its proximity to affected neighbouring regions, such as East Java Province,

which has reported five cases (7).

Effective control and eradication of these diseases rely on strategies such as early detection, movement controls, public awareness, and vaccination, all of which are underpinned by farmers' knowledge (8). Understanding the knowledge, attitudes, and practices (KAP) of cattle farmers is therefore essential for designing and implementing effective, locally relevant prevention and control measures (9). However, there is a scarcity of comprehensive KAP data regarding FMD and LSD in Indonesia, particularly in Bali.

This study was conducted to assess the KAP of smallholder cattle farmers in Bali concerning FMD and LSD and to identify the factors associated with their knowledge, attitudes, and practices. The findings are intended to provide evidence-based recommendations for local animal health authorities to strengthen FMD and LSD management strategies.

2. Material and Methods

2.1 Study Location and Population

The study was conducted in Bali, a province renowned as a centre for the development of Bali cattle (*Bos javanicus domesticus*), an important native breed and national genetic resource (10). Cattle farming in Bali is dominated by smallholder operations, characterized by traditional, non-intensive management systems where cattle graze during the day and are confined at night (11). These farmers are crucial stakeholders in the conservation of Bali cattle and the local agricultural economy.

2.2 Study Design and Sampling

A cross-sectional study was conducted among smallholder cattle farmers across eight regencies of Bali Province. A minimum sample size of 102 was calculated using Cochran's formula (12), and an additional 10% was included to account for potential non-responses, resulting in a final sample of 112 participants. A convenience sampling method was used to select participants from lists provided by local agricultural departments due to the legal accessibility of those individuals. Denpasar, being an urban centre with

minimal smallholder farming, was excluded.

2.3 Data Collection

Data were collected through in-person interviews using a pre-tested, structured questionnaire. The questionnaire comprised 59 questions covering: (a) socio-demographic characteristics, (b) knowledge of FMD and LSD (18 questions), (c) attitudes towards FMD and LSD (16 questions), and (d) preventative and control practices (17 questions). The questionnaire was developed based on relevant literature and validated by veterinary experts. A pre-test was conducted with 10% of the target sample size to ensure clarity and comprehension.

2.4 Data Analysis

Data were entered into Microsoft Excel 2019 and analysed using SPSS Statistics for Windows, Version 22.0. Descriptive statistics (frequencies, percentages) were used to summarize the data.

To assess KAP levels, a scoring system was employed. For each correct or positive response to a KAP question, a score of one (1) was assigned; an incorrect, negative, or "don't know" response received a score of zero (0). The total score for each component (Knowledge, Attitude, Practice) for each disease was calculated. The median score was used as a cut-off point. Respondents with a score above the median were categorized as having 'adequate' knowledge, a 'positive' attitude, or 'proper' practices. Those with scores at or below the median were categorized as 'inadequate,' 'negative,' or 'improper,' respectively.

To identify factors associated with KAP outcomes, a logistic regression analysis was performed. First, a bivariate analysis (chi-square test) was conducted. Variables with a p-value ≤ 0.25 in the bivariate analysis were then included in a multivariate logistic regression model to identify significant associated factors. The final model retained variables with a p-value < 0.05, and results are presented as Odds Ratios (OR) with 95% Confidence Intervals (CI).

3. Results

3.1 Demographic Profile of Respondents

The majority of respondents were male (57.1%), over 40 years of age (53.6%), and had attained less than an undergraduate level of education (53.6%). Farming experience was evenly split, with 50% having over 10 years of experience. The primary motivation for raising cattle was for investment purposes (67.9%) (Table 1).

Table 1. Socio-demographic Characteristics of Smallholder Cattle Farmers (n=112).

Characteristic	Category	Frequency	Percentage (%)
Gender	Male	64	57.1
	Female	48	42.9
Age	> 40 years	60	53.6
	≤ 40 years	52	46.4
Level of Education	High school diploma or less	60	53.6
	Undergraduate or higher	52	46.4
Farming Experience	≥ 10 years	56	50
	< 10 years	56	50
Farming Purpose	Investment	76	67.9
	Non-investment	36	32.1

Note: Non-investment includes culture, fertilizer source, or hobby.

3.2 Knowledge of FMD and LSD

There was a stark contrast in knowledge between the two diseases. All farmers (100%) had heard of FMD, knew it was an infectious disease affecting cattle, were aware of its clinical signs, and understood it caused major economic losses. However, knowledge gaps were evident, with only 12.5% knowing it could spread via processed animal products and only 5.4% aware that FMD could be fatal. Crucially, only 1.8% of farmers knew about the importance of quarantining new animals.

In contrast, knowledge of LSD was significantly lower. Only 30.4% of respondents had heard of LSD and were aware of its clinical signs, transmission, and potential for causing death and economic impact. Encouragingly, all farmers (100%) recognized that farm biosecurity was an important preventive measure for animal diseases in general.

3.3 Attitudes Toward FMD and LSD

Attitudes towards FMD were overwhelmingly positive. All farmers (100%) considered it a serious threat, believed vaccination was an effective control measure, and supported government control policies and movement restrictions.

For LSD, attitudes were also generally positive despite lower knowledge levels. A high proportion of farmers (100%) believed LSD could threaten their farm's sustainability, support reporting suspected cases, and agreed on the importance of vaccination and biosecurity. However, only 30.4% considered it a serious personal threat to their animals at present, and only 8% were confident in their ability to recognize its symptoms.

3.4 Practices for Disease Control

Regarding FMD, all farmers (100%) reported regularly checking their cattle for clinical signs and had vaccinated their animals. However, biosecurity practices were lacking. Only 30.4% had fences to prevent other animals from entering their farms, and only 43.8% restricted visitor access or regularly used disinfectants. Critically, none of the farmers reported suspected cases to authorities, preferring to manage them independently or with traditional remedies.

Practices related to LSD were less developed. No cattle had been vaccinated against LSD, consistent with Bali's LSD-free status. Biosecurity practices were similar to those for FMD, with only 30.4% quarantining new animals. No farmers had attended training on LSD.

3.5 Overall KAP Scores and Associated Factors

Based on the median score cut-off, all farmers (100%) had adequate knowledge of FMD, while 75.9% had positive attitudes and 83.0% had proper practices. For LSD, only 41.1% had adequate knowledge. However, 98.2% demonstrated a positive attitude, and 66.1% had proper practices (Figure 1).

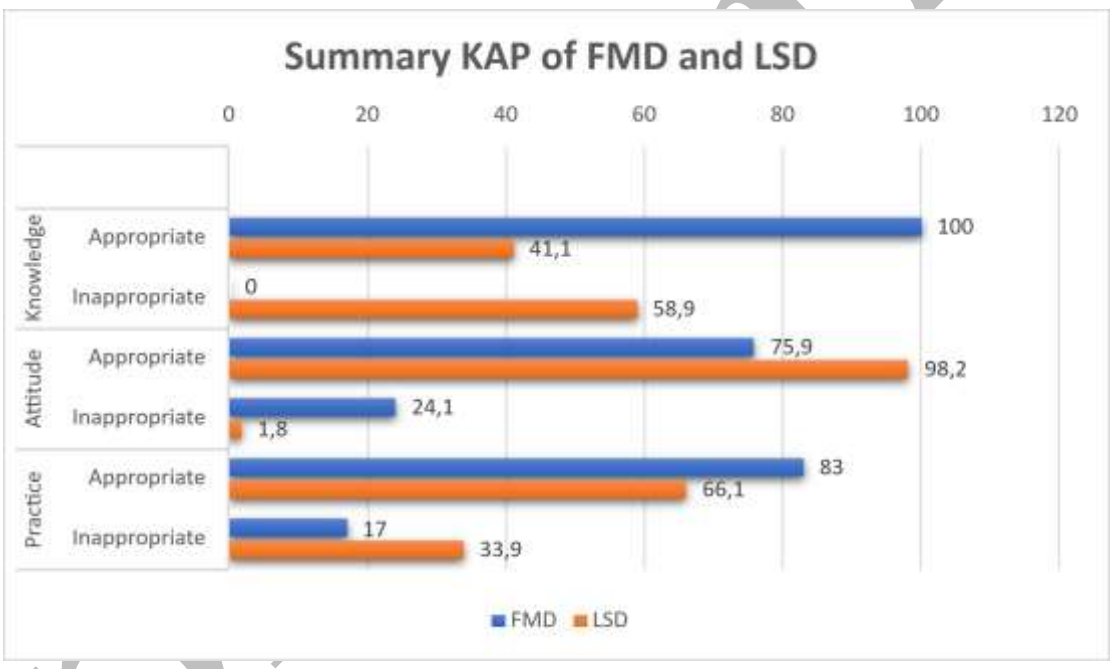

Figure 1. Percentage of Farmers with Adequate/Positive/Proper KAP Scores for FMD and LSD.

The multivariate analysis identified several factors associated with KAP outcomes (Table 2). For FMD, older age (> 40 years old) and higher education (Undergraduate or higher) were associated with adequate knowledge and positive attitudes. For LSD, having an investment-driven farming purpose was associated with adequate knowledge and positive attitudes. Female gender of farmers was associated with proper preventative practices for both FMD and LSD.

Table 2. Factors Associated with Knowledge, Attitudes, and Practices for FMD and LSD from Multivariate Logistic Regression Analysis.

Disease	KAP Component	Significant Factor	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value	Interpretation
FMD	Knowledge	Age (>40 years)	1.38	1.85 – 2.48	<0.05	Significant association; older group more positive
		Education (≥Undergraduate)	2.41	1.11 - 5.23	<0.05	Significant association; Undergraduate or higher more positive
	Attitude	Age (>40 years)	5.59	2.54 - 5.67	<0.05	Significant association; older group more positive
		Education ≥Undergraduate)	3.32	1.01 -10.92		Significant association; Undergraduate

						or higher more positive
	Practice	Gender (Female)	3.57	1.44 - 2.56	<0.05	Significant association; Female more positive
LSD	Knowledge	Farming Purpose (Invest)	1.44	1.17 - 2.13	<0.05	Significant association; invest motivation more positive
	Attitude	Farming Purpose (Invest)	1.68	2.46 - 4.43	<0.05	Significant association; invest motivation more positive
	Practice	Gender (Female)	3.57	1.44 - 2.56	<0.05	Significant association; Female more positive

4. Discussion

This study provides the first comprehensive assessment of smallholder cattle farmer KAP regarding FMD and LSD in Bali, Indonesia. The findings reveal a high level of awareness and positive engagement concerning FMD, which is likely a direct result of intensive government communication, education, and vaccination campaigns following the 2022 outbreak (13). The high scores for FMD-related KAP align with studies in other FMD-endemic regions like Ethiopia (90%) and Thailand (66.06%) (14,15).

However, a critical gap was identified in biosecurity knowledge and application. The low rates of quarantining new animals (1.8%) and implementing basic biosecurity measures (e.g., disinfection, fencing) are alarming. This represents a significant vulnerability for the introduction and spread of not only FMD and LSD but other infectious diseases as well. This discrepancy, where farmers have relatively high disease-specific knowledge but poor general biosecurity practices, has also been observed in Cambodia and Bangladesh ($p > 0.05$) (16,17). It suggests that while emergency disease campaigns are effective at raising awareness about a specific threat, they may fail to instil foundational principles of farm biosecurity.

In stark contrast, knowledge about LSD was poor. This is understandable given Bali's current LSD-free status and the national focus on the FMD emergency. This lack of awareness, combined with poor biosecurity practices, places Bali's cattle population at high risk should the disease be introduced from neighbouring islands. This study serves as an early warning and a baseline for future interventions. To our knowledge, following the initial study in Thailand (18), this is one of the first KAP studies on LSD in Southeast Asia since the disease’s emergence in the region, providing crucial preliminary data.

The factors associated with KAP provide valuable insights for targeting interventions. The association of higher education and age with better FMD knowledge and attitudes is consistent with findings from other studies in Sri Lanka (19). The finding that female farmers were more likely to adopt proper preventive practices is significant and suggests that women play a crucial role in daily animal care and on-farm biosecurity in Bali Province, consistent with a similar study in South Sulawesi (20). Future

196 extension programs should ensure they are inclusive and specifically target female farmers. The link
197 between an investment motive and better LSD-related KAP suggests that farmers who view their cattle
198 as a business are more proactive in seeking information about emerging economic threats.
199 This study has several limitations. The use of convenience sampling may limit the generalizability of
200 the findings to all smallholder farmers in Bali. Furthermore, self-reported data on practices may be
201 subject to social desirability bias. Despite these limitations, the study offers valuable insights into the
202 current KAP landscape and provides a strong evidence base for policy.
203 In conclusion Smallholder cattle farmers in Bali demonstrate adequate knowledge, positive attitudes,
204 and proper practices for managing FMD, though significant gaps in biosecurity remain. Conversely,
205 while attitudes towards LSD prevention are positive, knowledge of the disease is critically low, posing
206 a significant risk to the island. Key factors influencing KAP include age, education, farming purpose,
207 and gender.
208 Based on these findings, we strongly recommend that animal health authorities design and implement
209 targeted educational campaigns to cattle farmer that focus on strengthening foundational biosecurity
210 principles (e.g., quarantine, disinfection, visitor control) applicable to all infectious diseases; urgently
211 increasing awareness and knowledge of LSD, including its clinical signs, transmission, and economic
212 impact and tailoring educational materials to different demographic groups in Bali Province, with a
213 special focus on engaging female farmers who are key to implementing on-farm practices. By addressing
214 these gaps, Bali government can build a more resilient and prepared farming community capable of
215 effectively mitigating the threats of both FMD and LSD.
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Authors' Contribution

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Ethics

This study received ethical approval from the Research Ethics Committee of Udayana University (Certificate No. B/UN14.2.9/PT.01.03/2025). Informed consent was obtained from all participants after the study's objectives were explained. Participation was voluntary and confidential.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Data Availability

The data that support the findings of this study are available on request from the corresponding author.

Artificial Intelligence Assistance

This study was conducted using conventional research methods and manual data processing, with minimal reliance on artificial intelligence tools. All analyses, interpretations, and manuscript drafting were primarily performed by the authors to ensure methodological integrity and scholarly rigor.

References

1. Aslam M, Alkheraije KA. The prevalence of foot-and-mouth disease in Asia. Front Vet Sci. 2023;10:1201578. https://doi.org/10.3389/fvets.2023.1201578
2. Mazloum A, Van Schalkwyk A, Babiuk S, Venter E, Wallace DB, Sprygin A. Lumpy skin disease: history, current understanding and research gaps in the context of recent geographic expansion. Front Microbiol. 2023;14:1266759. https://doi.org/10.3389/fmicb.2023.1266759
3. Blacksell SD, Siengsanan-Lamont J, Kamolsiripichaiporn S, Gleeson LJ, Windsor PA. A history of FMD research and control programmes in Southeast Asia: Lessons from the past informing the future. Epidemiol Infect. 2019;147:e109. https://doi.org/10.1017/S0950268819000578
4. Susila EB, Daulay RSD, Hidayati DN, Prasetyowati SRB, Wriningati, Andesfha E, et al. Detection and identification of foot-and-mouth disease O/ME-SA/Ind-2001 virus lineage, Indonesia, 2022. J Appl Anim Res. 2023;51(1):487–94. https://doi.org/10.1080/09712119.2023.2229414
5. Nugroho W, Mardani HM, Reichel MP, Fitria Y, Miswati Y, Febrianto N, et al. The first outbreak

of Lumpy Skin Disease in Indonesia. Trop Anim Health Prod. 2024;56(7):237. https://doi.org/10.1007/s11250-024-04067-y

6. Ratyotha K, Prakobwong S, Piratae S. Lumpy skin disease: A newly emerging disease in Southeast Asia. Vet World. 2022;15(12):2764–71. https://doi.org/10.14202/vetworld.2022.2764-2771
7. Rehman S, Abuzahra M, Wibisono FJ, et al. Identification of risk factors and vaccine efficacy for lumpy skin disease in Sidoarjo and Blitar Districts of East Java, Indonesia. Int J Vet Sci. 2024;13(5):574–579. doi:10.47278/journal.ijvs/2024.137
8. Knight-Jones TJD, Rushton J. The economic impacts of foot and mouth disease – What are they, how big are they and where do they occur? Prev Vet Med. 2013;112(3–4):161–73. https://doi.org/10.1016/j.prevetmed.2013.07.013
9. Andrade C, Menon V, Ameen S, Praharaj SK. Designing and Conducting Knowledge, Attitude, and Practice Surveys in Psychiatry: Practical Guidance. Indian J Psychol Med. 2020;42(5):478–81. https://doi.org/10.1177/0253717620946111
10. Purwantara B, Noor R, Andersson G, Rodriguez-Martinez H. Banteng and Bali Cattle in Indonesia: Status and Forecasts. Reprod Domest Anim. 2012;47(Suppl 1):2–6. https://doi.org/10.1111/j.1439-0531.2011.01956.x
11. Suwiti NK, Besung INK, Mahardika GN. Factors influencing growth hormone levels of Bali cattle in Bali, Nusa Penida, and Sumbawa Islands, Indonesia. Vet World. 2017;10(10):1250–4. https://doi.org/10.14202/vetworld.2017.1250-1254
12. Cochran WG. Sampling techniques. 3rd ed. New York: John Wiley & Sons; 1977
13. Kusumastuti TA, Kobayashi I, Juwari A, Antari LD. Determinants and Control Strategies of FMD in Japan and Indonesia. Am J Anim Vet Sci. 2024;19(1):86–100. https://doi.org/10.3844/ajavsp.2024.86.100
14. Chumsang P, Singhla T, Punyapornwithaya V, Chaisowwong W. Foot-and-mouth disease knowledge and attitude as determinants of preventative behaviors among dairy farmers in a Thai

297 endemic setting based on structural equation modelling. Vet Integr Sci. 2024;23(2):ID058.
298 https://doi.org/10.12982/VIS.2025.058
299 15. Seifu K, Muluneh A, Getachew Y, Jibril Y, Negussie H. Epidemiological study and dairy farmers'
300 knowledge, attitudes, and practices on foot and mouth disease in central Ethiopia. Heliyon.
301 2023;9(5):e15771. https://doi.org/10.1016/j.heliyon.2023.e15771
302 16. Chowdhury T, Ahmed J, Hossain MT, Roy MC, Ashik-Uz-Zaman M, Uddin MN, et al. Knowledge,
303 attitudes and biosecurity practices among the small-scale dairy farmers in Sylhet district,
304 Bangladesh. Vet Med Sci. 2023;9(5):2221–9. https://doi.org/10.1002/vms3.1199
305 17. Sieng S, Patrick IW, Windsor PA, Walkden-Brown SW, Sar C, Smith RGB, et al. Knowledge,
306 attitudes and practices of smallholder farmers on foot and mouth disease control in two Cambodian
307 provinces. Transbound Emerg Dis. 2022;69(4):1983–98. https://doi.org/10.1111/tbed.14182
308 18. Khan S, Addoddon D, Prapapanpong J, Suwannaboon M, Arjkumpa O, Na-Lampang K, et al. Path
309 analysis of farmer knowledge, attitudes, and practices toward lumpy skin disease in beef cattle. Anim
310 Dis. 2025;5:3. doi:10.1186/s44149-025-00155-0.
311 19. Athambawa MJ, Kubota S, Kono H. Knowledge affecting foot-and-mouth disease vaccination
312 behavior: traditional dairy farmers in the dry zone of Sri Lanka. Trop Anim Health Prod.
313 2021;53(1):88. https://doi.org/10.1007/s11250-020-02501-5
314 20. Lestari VS, Rahardja DP, Sirajuddin SN. The contribution of men and women in biosecurity
315 practices on traditional cattle farms in Bone Regency, South Sulawesi. AIP Conf Proc.
316 2023;2628(1):130003. doi:10.1063/5.0144005