Limiting the Impacts of Foot and Mouth Disease in Large Ruminants in Northern Lao People’s Democratic Republic by Vaccination: A Case Study

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Introduction

Asia and the Pacific accounts for more than 60% of the world’s undernourished people (FAO, 2009). Although there has been dramatic progress in addressing poverty in recent years, southern Asia has the highest prevalence of underweight in the developing world, with 46% of all children under five being underweight and the prevalence of underweight children in rural areas almost double that of children in urban areas (FAO, 2009). This region includes the Lao People’s Democratic Republic (Lao PDR) where the progress that has been made is considered insufficient to meet the target of halving mortality in under 5-year-old children (FAO, 2009). There have been considerable changes in dietary patterns in the region, with meat consumption more than doubling in the last 20 years (Pingali, 2007). This change in dietary preference has led to increased demand, rearing and movement of livestock, particularly large ruminants for meat consumption, increasing the risk of transmission of transboundary diseases, including foot and mouth disease (FMD).

Summary

Foot and mouth disease (FMD) is the most important global transboundary livestock disease and is endemic in Lao People’s Democratic Republic (Lao PDR) with outbreaks occurring regularly. Lao PDR shares borders with five countries and as a major thoroughfare for transboundary livestock movement, is vulnerable to the social and economic impacts of FMD. The FMD outbreak occurred in January 2009 in the Pek District, located in the north-eastern Lao PDR province of Xieng Khuang and involved all 111 villages in that district. In March 2009, we conducted a case study on the impacts of FMD in four villages in Pek District. In two villages cattle and buffalo were vaccinated for FMD recently and prior to the outbreak as part of an ongoing research project. In one of these villages, all cattle and buffalo were vaccinated and just over half the large ruminant population was vaccinated in the other village. The other two villages involved in the case study were located nearby but not part of the ongoing research project and no animals had been vaccinated. Data were collected from the four villages by interviewing the village animal health worker in each village using a standard questionnaire. Morbidity rates for the fully vaccinated village were 1% and 7.9% for the partially vaccinated village and were much lower compared with the two adjacent, unvaccinated villages where morbidity rates were 61% and 74.3% respectively. Estimates of the financial losses incurred were USD 1.7–1.9 per cow or buffalo for the fully vaccinated village, USD 6.9–8.1 for the partly vaccinated village and 52.4–70.8 USD in the unvaccinated villages, providing evidence that a large opportunity cost is incurred by failing to vaccinate in areas where the risk of FMD incursions is high.
FMD is the most important global transboundary livestock disease. It has major economic impacts on trade and food security, with ease of spread between countries compromising international trade in livestock and their products (Rweyemamu et al., 2008). The FMD also has major social impacts in developing countries, particularly in south-east Asia, with impacts at both village and national levels (Khounsy et al., 2008). At the village level, FMD negatively impacts by reducing the value of large ruminants, their draught power, local consumption of meat and their use as a store of wealth. At the national level, the impact of FMD is mainly through the loss of international trade or potential trade.

Foot and mouth disease is considered to be endemic in Lao PDR, where outbreaks occur regularly (Khounsy et al., 2008). Lao PDR is vulnerable to incursions of FMD as it is a major thoroughfare for transboundary livestock movement and trade, sharing borders with Cambodia, China, Myanmar, Thailand and Vietnam. Thus effective FMD control in Lao PDR requires regional international cooperation, as promoted by the Regional Coordination Unit of the OIE sub-commission for FMD in south-east Asia (SEAFMD) that has developed a roadmap for disease freedom with vaccination by 2020.

The capacity for in-country diagnosis of FMD in Lao PDR is now available using virus antigen typing enzyme-linked-immunosorbent serologic assay at the national veterinary laboratory in Vientiane (Khounsy et al., 2008). The sero-prevalence of antibodies to FMD in Lao PDR in samples from large ruminants collected between 1996 and 2005 ranged from 65.7% in Vientiane to 3% in Houaphan province, dominated by serotype O (Blacksell et al., 2008). However, this study had a disproportional number of samples from the Vientiane province with fewer submissions from other provinces because of difficulties in communication and transport.

Vaccination is the preferred FMD control option in Lao PDR as a ‘slaughter out’ policy is not currently socially desirable or economically feasible. However, the cost of broad scale nationally sponsored vaccination is prohibitive and strategic use of FMD vaccine is required. ‘Ring’ vaccination in a radius of 6 km around a recently infected village to create an immune buffer zone as well as vaccinating animals along movement routes has been advocated (Khounsy et al., 2008). Alternatively, increasing the value of large ruminants through productivity enhancements has been suggested as a means to increase the interest of farmers in disease risk management (Khounsy et al., 2008).

Although northern Lao PDR is one of the most poverty-stricken areas in Asia, the increased demand for red meat products in neighbouring countries including China, Thailand and Vietnam, provides an opportunity for Lao smallholder farmers to participate in this emerging market and increase their income through provision of fattened cattle and buffalo to these markets (Windsor, 2008). Increased investment into large ruminant production may result in increased investment in risk management including disease control and prevention by individual farmers and livestock authorities. The research project ‘Best Practice Health and Husbandry in Cattle and Buffalo, Lao PDR’ (Windsor, 2006) aims to identify those interventions that can best be utilized by farmers to improve productivity, including strategies to enhance animal health, nutrition, reproduction management and marketing. The project works with smallholder farmers in six villages in three northern provinces of Lao PDR including Xieng Khuang province, which is located in north-eastern Lao PDR bordering Vietnam and is an important source of live ruminants for trade to Vietnam. The large ruminant population in Lao PDR in 2008 was 1.398 million cattle and 1.155 million buffalo, of which 73 200 (5.2%) cattle and 53 123 (3.8%) buffalo were located in Xieng Khuang province (MAF, 2008). In January 2009 a major FMD outbreak was reported from this province. This case-study documents the investigations of this FMD outbreak and its impact in the four case-study villages.

Material and Methods

Study site and village selection

Four villages located within Pek District of Xieng Khuang province that were involved in the FMD outbreak in January 2009 were purposively selected for the case study. Two villages, Ban Nong and Ban Nadee were part of the research project ‘Best Practice Health and Husbandry in Cattle and Buffalo, Lao PDR’ (Windsor, 2006). These villages were originally selected for this research project based on selection criteria including: similarity of size, type of livestock enterprises and livestock numbers (as the research involves a 4-year longitudinal study in these villages and comparisons between villages are to be made), large ruminant populations exceeding 250 animals (to allow for some losses because of trade or deaths during the 4-year study period, and still maintaining a large enough sample size), willingness by households, village officials and local officials to participate, all year road access (to ensure research staff can access sites at least quarterly for data collection), evidence of forage growing for large ruminant supplementary feeding, and villages being more than 10 km apart (to avoid ‘spill over’ of interventions to be researched in individual villages). The other two case-study villages, Ban Pongvaen and Ban Ang, were non-research project sites, located within 3–4 km from the two research project villages Ban Nong and Ban Nadee.
Foot and mouth disease and haemorrhagic septicaemia vaccination

The research project vaccinated large ruminants older than 6 months in two project villages, Ban Nadee and Ban Nong located in Pek district of Xieng Khuang province, between 17–22 and 8–10 December 2008 respectively (Table 1) against FMD and Haemorrhagic Septicaemia (HS) as part of routine animal health interventions that are being researched. Vaccines used were trivalent-inactivated FMD vaccine containing type O, A and Asia1 antigens (AFTOVAX; Merial, France) and inactivated HS vaccine (Nongteng Vaccine Production Centre, Vientiane Lao PDR) and each animal presented in both villages was vaccinated on the same day with 2 ml of FMD and 3 ml of HS vaccine by subcutaneous administration proximal to the shoulder by trained Lao Department of Livestock and Fisheries animal health staff and in accordance with manufacturers recommendations.

Data collection

Local district staff from the Department of Livestock and Fisheries visited the four villages between February and March 2009 and collected information on the large ruminant populations, disease management and the recent FMD outbreak, using a semi-structured questionnaire including closed and open questions, developed in Lao by participants attending a workshop conducted by the ‘Best Practice Health and Husbandry in Cattle and Buffalo, Lao PDR’ research project team in Luang Prabang in mid-February 2009. Copies of the questionnaire are available in English and Lao from the author. The village veterinary worker (VVW; Local motivated villagers who have been selected and trained by the local district agriculture and forestry office in basic livestock diseases, prevention and control. They provide veterinary services and medication and vaccine for a fee to local village farmers. The VVW system was established to provide some access to veterinary services for remote village farmers. Active VVW have local knowledge on disease outbreaks.) of each village was interviewed and responses recorded in Lao and later translated into English by a translator.

Foot and mouth disease diagnosis

The diagnosis of FMD was based on clinical signs and history obtained by livestock officers trained by the research project team in disease recognition. Samples for isolation and sero-typing were collected from the outbreak but were considered unsuitable for processing on arrival at the veterinary laboratory in Vientiane because of poor quality. Regional information on current FMD and sero-typing at the regional FMD reference laboratory in Pakchong, Thailand from an outbreak in the same district about 60 km from the case-study villages during the same outbreak, was used to diagnose the FMD strain involved.

Financial analysis

Estimates of financial losses incurred during the outbreak were based on the following assumptions using local expertise:

1. The mean value of cattle or buffalo is USD 230 each, based on the value of adult female cattle of moderate body condition score (200 kg) and is a conservative estimate as male cattle and buffalo are of higher net value.

2. The mean value of calves is USD 58, based on the average value of cattle calves <12 months old and of moderate body condition score.

<table>
<thead>
<tr>
<th>Table 1. Large ruminant data during the foot and mouth disease outbreak of January 2009 in four case-study villages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ban Ang (95% CI)a</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Total no. cattle and buffalo</td>
</tr>
<tr>
<td>269 (452)</td>
</tr>
<tr>
<td>No.1 vaccinated</td>
</tr>
<tr>
<td>Vaccination rate</td>
</tr>
<tr>
<td>Vaccination date</td>
</tr>
<tr>
<td>Number ill</td>
</tr>
<tr>
<td>Attack rate</td>
</tr>
<tr>
<td>Mortality no.</td>
</tr>
<tr>
<td>Mortality rate</td>
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</tbody>
</table>

NA, not applicable.

aConfidence intervals (CI), calculated using a binominal proportion calculator from http://www.dimensionresearch.com.

bNumber refers to number of cattle or buffalo.
3 The costs of animal treatments including antibiotics and other treatments (e.g. application of astringents on FMD lesions for enhanced healing) and staff labour costs for therapy are estimated at USD 10 per animal.

4 Based on weighting a sample of affected animals in Ban Nong and Ban Nadee as part of regular data collection for the ongoing research project it is estimated that FMD-affected animals lose approximately 30% of their weight and decrease in condition score by at least 1 in a rating system of 1–5, reducing the value of the animal by 30% or an average loss of USD 69 per adult animal.

5 The cost of feeding an animal to pre-illness weight levels (200 kg) are estimated at 85 USD based on weight gain of 1 kg/day. This requires 45 kg grass per 1 kg weight gain or 2700 kg of grass to regain the 30% or 60 kg weight loss at a cost of USD 0.63/20 kg of grass.

6 The cost of vaccination is estimated at USD 0.89 per dose, consisting of USD 0.69 for the vaccine and USD 0.20 for administration and equipment.

Results

Disease outbreak history

The FMD outbreak was considered by local authorities to have involved all 111 villages in the Pek district of Xieng Khuang province. The outbreak started in early January 2009 and reports of clinical cases ceased by the end of February 2009. Clinical signs consistent with FMD, including lethargy, depression, excessive salivation, lameness, vesicular lesions on mouth and feet, in-appetence and some mortality mainly in calves were only reported in cattle and buffalo and other livestock species in the villages showed no clinical signs consistent with FMD.

Source of infection

The source of the FMD outbreak was considered by local animal health authorities to have originated from the return of cattle and buffalo recently transported from Xieng Khuang province to Vietnam. The FMD (O south-east Asia strain) had recently been diagnosed in Vietnam (unpublished data, Khounsy S) and Vietnamese authorities returned the livestock in transit to Xieng Khuang province. Exposure to FMD virus during transportation was suspected.

Transmission

The mode of transmission into and among the four villages described in this case study was uncertain. There were no reports of cattle or buffalo introductions into these villages for the months prior to the outbreak. People, vehicle and product movements were not investigated because of resource constraints. Communal grazing was practiced in three of the case-study villages (Ban Ang, Ban Pongvaen and Ban Nadee) but not in Ban Nong.

Index cases were reported as follows: Ban Nadee on 1 January 2009 involving a cow; Ban Nong and Ban Ang on 10 January 2009 in a buffalo and cow respectively and on 12 January 2009 in a cow in Ban Pongvaen.

Foot and mouth disease serotype

Type O south-east Asia strain, was suspected based on sero-typing of samples taken during the same outbreak located about 60 km from the case-study villages and processed at the Vientiane veterinary laboratory and at the regional FMD reference laboratory in Pakchong, Thailand.

Clinical features

Disease signs observed by farmers, VVW and government staff in the four villages in cattle and buffalo included: anorexia, lethargy, excessive salivation, vesicular lesions in the mouth and on the feet, lameness, and some deaths of calves.

Morbidity and mortality rates

Morbidity and mortality rates in large ruminants in the four case-study villages are tabulated (Table 1). Illness was recorded in animals aged 2 months to 7 years, but mostly adult animals were affected. Deaths were recorded in one adult animal and 23 calves.

Vaccination for foot and mouth disease

The number of animals presented and vaccinated in one of the research project villages (Ban Nong) was 100% compared with 54.19% of the total cattle and buffalo population in the other vaccinated village (Ban Nadee). Vaccination ceased in Ban Nadee on 22 December 2008, 9 days prior to the FMD index case being reported; compared with Ban Nong where vaccination ceased on 10 December 2008, 31 days prior to the FMD index case being reported.

Large ruminant grazing management

All cattle and buffalo grazed in communal areas during the day and were brought back to the house during the night, with exception of Ban Nong where ruminants were not grazed in communal areas but tethered around the village area for grazing during the day.
Disease treatment

In all four villages, farmers treated the sick animals by washing sores in the mouth and on the feet with salted water, lime juice or other local acid fruit juices or dishwashing detergent. In Ban Nadee, penicillin (Pendistrep L.A.; Phenix Pharmaceuticals, Antwerp, Belgium) at recommended dose rates was given to some affected animals and ill animals were regularly isolated from the healthy animals.

Financial analysis

Estimated total and per animal costs either assuming sale of affected animals or retaining and feeding affected animals were calculated and are tabulated (Tables 2 and 3).

Consideration of the mortality with loss of 22 animals (one adult and 21 calves) in the unvaccinated villages versus two calves in the partly vaccinated village, with adult animals valued at USD 230 each and calves valued at USD 58 each, indicates a comparative per animal cost of USD 0, 0.2, 0.5 and 4.5 in the fully, partly and two non-vaccinated villages respectively.

Consideration of the costs of morbidity, based on estimated treatment cost of USD 10 per animal and an estimate of around 95% of affected animals treated were USD 6.5 per animal in the unvaccinated villages with 50 affected animals compared with USD 0.4 per animal in the vaccinated villages with 50 affected animals.

If affected animals lost approximately 30% or 60 kg of their weight and decreased in value by an average USD 69, there was a comparative per animal cost of USD 51.3 in Ban Pongvaen, USD 51.8 for Ban Ang the two unvaccinated villages versus USD 6.7 for Ban Nadee the partly vaccinated village and USD 0.9 for Ban Nong the fully vaccinated village.

The total potential costs estimated are USD 40 698 for the unvaccinated villages (USD 56.4 per animal) and USD 4590 (USD 5.2 per head) for the vaccinated villages if sick animals are sold or USD 48 698 (USD 67.5 per head) for the unvaccinated villages and USD 5390 (USD 6.1 per head) for the vaccinated villages if the sick animals are retained and fed to pre-illness weight levels.

In contrast the cost of vaccination at USD 0.89 per dose in the two vaccinated research project villages was USD 287.5 or 0.5 per head in Ban Nadee the partly vaccinated village and USD 257.2 in Ban Nong the fully vaccinated village.

Discussion

Studies in Lao PDR on the financial benefit to farmers of FMD vaccination have not previously been reported. From the limited economic data available for this study, it was possible to conclude that the potential cost of not investing in vaccine in the unvaccinated villages was very high, estimated at USD 40 698 or 52.4–58.9 per animal (sick animals sold) to USD 48 698 or 62.1–70.8 per animal (sick animals retained and fed) versus USD 4592 or 1.7–6.9 per animal (sick animals sold) to USD 5390 or 1.9–8.1 per animal (sick animals retained and fed) in the vaccinated villages. These are crude estimates based on limited data and local expertise. Further research is required to enable more precise financial analyses; however, these estimates nevertheless indicate the potential large economic return that can be gained from investing in vaccination especially in high risk areas.

The mode of transmission especially between the case-study villages is uncertain. While all villages reported no livestock movements for the months prior to the FMD outbreak, it is possible that FMD was introduced by unreported livestock movements. Indirect transmission via people or fomite movements is likely to have occurred.

| Table 2. Estimated total and per animal costs in USD for the four case-study villages assuming all sick animals are sold, January 2009 |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                | Ban Ang (unvaccinated village) | Ban Pongvaen (unvaccinated village) | Ban Nadee (partly vaccinated village) | Ban Nong (fully vaccinated village) |
| Cost            | Total Per animal | Total Per animal | Total Per animal | Total Per animal |
| Mortality       | 1218 4.5          | 230 0.5           | 116 0.2           | 0 0              |
| Treatment       | 1560 5.8          | 3190 7.1          | 450 0.8           | 30 0.1           |
| Weight loss     | 11 316 42.1       | 23 184 51.3       | 3243 5.4          | 207 0.7          |
| Vaccination     | 0 0               | 287 0.5           | 257 0.9           | 494 1.7          |
| Total           | 14 094 52.4       | 26 604 58.9       | 40 963 6.9        | 494 1.7          |
but could not be investigated because of resource constraints and the large amount of such movements occurring in day-to-day village activity. Transmission within villages is likely to have occurred through direct and indirect transmission. In three of the case-study villages, communal grazing is practiced providing ample opportunity for direct transmission. We have recently identified that farmer knowledge of disease transmission and biosecurity measures is very low, as determined through farmer knowledge surveys conducted as part of the research project in Ban Nadee and Ban Nong (unpublished data, Nampanya S).

The practice of selling ill livestock is actively discouraged by local animal health professionals but often becomes a necessity for poor smallholder farmers who cannot afford the cost of treatment or the feed cost to return animals to their pre-illness weight and health. Fresh fodder is still a rare commodity in large parts of Lao PDR. Some farmers grow forages mainly for supplementary feeding of their own livestock and only small markets for fresh fodder currently exist in a few urban locations in Lao PDR. The economic analysis shows that selling affected animals rather than retaining and feeding them is a better economic option for farmers and may be another reason sale of ill livestock is practiced, increasing the risk of disease transmission amongst villages and districts. Protocols of disease declaration and movement restrictions exist in Lao but implementation and enforcement of these restrictions is difficult because of resource and capacity constraints of the Lao animal health system and remoteness of many villages.

Based on field reports of this FMD outbreak, there was apparently good protection provided against FMD infection by the recent vaccination programme in the two vaccinated project villages, despite the brief period between the administration of the vaccine and the presumed exposure of vaccines to infectious doses of the virus. Naturally acquired immunity to FMD is considered unlikely as the villages were selected as research project sites in July 2008 and have had continuous contact with Lao project staff and the last reported FMD outbreak in the villages was in early 2002.

The fully vaccinated village (Ban Nong) was vaccinated up to 2 weeks earlier than the partly vaccinated village (Ban Nadee). It is considered likely that both the strategy of vaccinating the whole population and the longer duration between vaccinating and exposure were important factors in enabling a more effective immune response to have been achieved prior to the onset of FMD infection in Ban Nong. The simultaneous use of inactivated FMD and HS vaccination was not considered of relevance as a previous study has established that this practice does not compromise the protection offered to both pathogens (Joseph and Hedger, 1986).

The financial analysis of this case study indicates that vaccinating the whole large ruminant population compared with only just over half the population reduced the losses because of FMD per animal by a factor of about four times. In Ban Nong with a 100% vaccination rate, estimated costs of only USD 494 or 1.7 per animal (sick animals sold) or USD 542 or 1.9 per animal (sick animals retained and fed) because of FMD were incurred, compared with estimated costs of USD 4096 or 6.9 per animal (sick animals sold) or USD 4848 or 8.1 per animal (sick animals retained) in Ban Nadee with a 54% vaccination rate.

The reduction of morbidity, mortality and hence financial losses in the village that was fully vaccinated about 1 month prior to the outbreak compared with the partly vaccinated village where vaccination occurred closer to the outbreak, indicates a higher level of protection and that regular vaccination of whole populations at risk is of benefit.

However, besides vaccination other strategies are required to control FMD in Lao PDR, including surveillance for early detection and reporting of the disease and rapid declaration of disease areas/ zones and movement restrictions which are enforced to enable rapid response. These strategies require a well-resourced animal health system, including experienced, competent and technically

<table>
<thead>
<tr>
<th>Cost</th>
<th>Ban Ang (unvaccinated village)</th>
<th>Ban Pongvaen (unvaccinated village)</th>
<th>Ban Nadee (partly vaccinated village)</th>
<th>Ban Nong (fully vaccinated village)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Per animal</td>
<td>Total</td>
<td>Per animal</td>
</tr>
<tr>
<td>Mortality</td>
<td>1218</td>
<td>4.5</td>
<td>230</td>
<td>0.5</td>
</tr>
<tr>
<td>Treatment</td>
<td>1560</td>
<td>5.8</td>
<td>3190</td>
<td>7.1</td>
</tr>
<tr>
<td>Nutrition</td>
<td>13 940</td>
<td>51.8</td>
<td>28 560</td>
<td>63.2</td>
</tr>
<tr>
<td>Vaccination</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total costs</td>
<td>16 718</td>
<td>62.1</td>
<td>31 980</td>
<td>70.8</td>
</tr>
</tbody>
</table>
skilled staff who are adequately resourced as well as ongoing commitment of the government and private livestock sector (Rweyemamu et al., 2008). For the success of a vaccination programme in the face of an FMD incursion, not only efficient surveillance and rapid disease reporting and response are required but also access to an emergency supply of vaccine stocks. It is suggested this take the form of a ‘vaccine bank’ containing the most likely serotypes required to manage an FMD outbreak. In Lao PDR the serotypes suggested as most needed for inclusion such a bank would be O, A and Asia 1. Further considerations as to whether the vaccine stocks could be transported to the outbreak region efficiently, particularly if the villages involved are remote, are required.

Conclusion

Comparison of the estimated financial losses incurred in the unvaccinated versus the fully and partly vaccinated villages, indicates a potentially significant opportunity cost of not routinely vaccinating large ruminants in areas where the risk of FMD incursion is high. The proximity of the vaccination programme to the onset of the FMD outbreak suggests further that vaccination in the face of an outbreak may be a cost effective approach to FMD control in an endemic region and minimizes the disease related costs to smallholder farmers in Lao PDR.

Acknowledgements

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