

Biosecurity in endemic foot and mouth disease settings: a case study of foot and mouth disease vaccination in South-East Asia

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Summary

Foot and mouth disease (FMD) is a highly contagious viral infection affecting cloven hooved animals including cattle, buffalo, sheep, goats and pigs. The disease is endemic in several parts of Asia, as well as most of Africa and the Middle East. In 1997, the World Organisation for Animal Health (OIE) established the South-East Asia Foot and Mouth Disease campaign with the aim of increasing livestock sector productivity and economic output through the control and eradication of FMD in South-East Asia. Large-scale vaccination of livestock against FMD has in the past led to the successful eradication (or control) of the disease, for example in the Philippines. However, despite the benefit associated with large-scale vaccination, biosecurity risks can be created by vaccination teams moving between locations. It is therefore recommended that biosecurity measures are used by vaccination teams to prevent inadvertent disease spread. The majority of existing guidelines are focused on high-risk situations such as exotic animal disease outbreaks in developed countries, or agents posing a risk to human health. This paper describes the development of novel biosecurity guidelines for vaccination teams in South-East Asia. To achieve this, available literature was scanned followed by in-country workshops and field-testing of draft materials. Entry and exit procedures are laid out within the context of five core rules following the biosecurity principles of situational awareness, segregation, cleaning and disinfection. Guidelines and accompanying fact sheets were translated into local languages and included in a comprehensive vaccination training programme for all vaccination teams undertaking cattle FMD vaccination programmes in the New Zealand OIE FMD control project target countries (Myanmar and Laos). The material developed has wide practical relevance to veterinarians, traditional healers and village or community animal health workers, who all pose a heightened risk of spreading infectious agents.

Keywords

Animal health worker – Biosecurity – Cleaning – Disease control – Disinfection – Foot and mouth disease – Segregation – South-East Asia.

Introduction

Foot and mouth disease (FMD) is endemic in several parts of Asia, as well as most of Africa and the Middle East (1). In 1997, the World Organisation for Animal Health (OIE) established the South-East Asia Foot and Mouth Disease (SEAFMD) campaign with the aim of increasing livestock sector productivity and economic output through the successive control and eradication of FMD in South-East Asia (2). The programme was extended in 2010 to include the People's Republic of China (China) and in 2016 to include Mongolia. When China joined the campaign, it was renamed the South-East Asia and China Foot and Mouth Disease (SEACFMD) campaign. Foot and mouth disease is a highly contagious viral vesicular infection affecting cloven hooved animals including cattle, buffalo, sheep, goats and pigs (1). The virus may be readily and inadvertently transmitted by personnel and equipment, including teams tasked with vaccinating animals in countries where the disease is endemic, or during vaccination of livestock in response to an incursion in a free country.

Large-scale vaccination of livestock against FMD has led to the successful eradication of the disease, for example in the Philippines (3). The concurrent implementation of adequate biosecurity measures has been recommended to embed good practice and mitigate disease spread associated with vaccination (4). Successful efforts have been made to improve local adoption of biosecurity measures by knowledge transfer through demonstrations and training in cattle production, health and biosecurity (5).

Ironically, large-scale vaccination programmes aimed at reducing disease can create additional biosecurity risks. For example, local animal health workers (AHWs), investigating veterinarians, traditional

healers and vaccinators can and do spread infectious agents by moving from farm to farm or between villages after close contact with animals (6). If proper hygiene procedures are not strictly followed, vaccine teams can carry virus from an infected farm to a clean farm, and this has previously been recognised as a risk to vaccination programmes following an incursion in previously disease-free countries (7). Further, the need for vaccination teams to be well trained and adequately equipped has been identified (8, 9), and the adoption of strict biosecurity measures by vaccination teams has been recommended (10).

The New Zealand government, in partnership with OIE–SEACFMD, is currently supporting a cooperative FMD control programme in Myanmar and Laos, under the ‘New Zealand OIE FMD Control Project’. The overall aim of the programme is to improve socioeconomic conditions for people in South-East Asia through improving existing surveillance, vaccination and control strategies for FMD. To support the implementation of risk-based vaccination, work was undertaken to develop culturally and context sensitive biosecurity recommendations. The primary objective was to minimise the inadvertent spread of FMD virus by personnel carrying out vaccination campaigns in endemic countries, while developing a foundation of skills and support material to help raise biosecurity awareness and educate the livestock sector, primarily farmers, veterinarians, animal health workers and other agricultural service personnel.

Materials and methods

A project development framework was designed to ensure delivery of appropriate biosecurity protocols within the time frames set by the planned vaccination programme in each target country. Following a literature review, a detailed stakeholder evaluation and implementation process was carried out to ensure the recommendations were practical, fit-for-purpose and achievable. The review included face-to-face workshops and field testing in each

country, while the implementation stage focused on translation of materials and a training programme to embed the approach.

Literature review

A literature review was undertaken, focused on gathering evidence on reported biosecurity measures to limit the transmission of FMD by vaccination teams and their immediate equipment. Personal decontamination has previously been identified as a key measure to reduce inadvertent disease spread. Decontamination can be defined as ‘removing any FMD virus or fomites (a fomite is any inanimate object or substance capable of carrying infectious organisms, such as manure, mud, protective clothing, vehicle tyres, animal handling equipment, etc.) from a person and their clothing, shoes and equipment’ (11). The review was focused on biosecurity measures of relevance to vaccination teams moving between villages in the Mekong region, and specifically Myanmar and Laos. In particular, the aim was to identify appropriate measures that were achievable and relevant within the context of the local climatic and cultural conditions, while taking into consideration the resources available.

Rapid evidence assessment (REA) methodology was used to search the available literature (published and grey), in order to establish an evidence base for the development of country (i.e. Laos and Myanmar) and task (i.e. village-level vaccination) specific biosecurity guidelines for FMD vaccination teams, including in particular recommendations regarding decontamination and appropriate protective equipment. Rapid evidence assessment is a form of knowledge synthesis in which components of the systematic review are simplified in order to obtain key information within shorter time frames (12); REAs are frequently used in the health sector to support rapid evidence-based decision making (13).

In a first step, the grey literature was investigated through a Google web search, using the core search terms ‘biosecurity’, ‘FMD’, ‘foot and mouth disease’, ‘vaccination’, ‘Laos’, ‘Myanmar’, ‘Mekong’, ‘Asia’ and ‘Latin America’. ‘Latin America’ was included as a search term because of the expected similarities in conditions experienced by

vaccination teams, e.g. similarities in climate. Documents identified that were relevant to the specified scope were retained and reviewed in full. In order to capture related information on biosecurity measures for vaccination teams working with diseases other than FMD, or outside the target regions, the Google search was repeated, omitting the FMD and region-specific search terms.

In a second step, a scanning search of the scientific literature databases PubMed and Scopus was undertaken, using the following Boolean search query: (biosecurity AND (Laos* OR Myanmar OR Mekong OR Asia OR South America OR Latin America) AND (FMD OR 'foot and mouth disease') AND vaccine*). The searches were limited to content in the article title, abstract and keywords. Following retrieval, the data from both searches were pooled and duplicate references were removed. A first-level screening of abstracts by the three principal authors was carried out to identify papers of likely relevance. The retained references were then reviewed in full.

As an additional step to identify relevant unpublished work, information was sought through a process of network cascading, beginning with approaching relevant personal contacts of the authors (i.e. those with expertise in the fields of biosecurity, vaccination and disease control in the South-East Asia region), and through them further government personnel and researchers with relevant local and practical experience.

In-country workshops

Draft procedures were introduced to key personnel and project counterparts for testing through classroom-based workshops in each target country. The workshops brought together approximately 15–20 government veterinarians and AHWs involved in the vaccination campaign at the central, regional and district levels in each target country. Materials were introduced through presentations on general biosecurity principles and the results from the literature review. Following this, the draft biosecurity procedures were introduced to the group by sequentially working through a presentation that described the actions involved in a vaccine team entering and exiting a village,

followed by the additional procedures appropriate for personnel carrying out an outbreak investigation. Each step in the entry and exit procedure served as a theme, which participants reviewed in smaller groups (of about five participants). Feedback related to each theme or step was brought back to the group for further discussion before agreed revisions were incorporated. Through this process of small group discussion and debate, all the steps, protocols and equipment requirements detailed in the draft guideline text were reviewed and amended.

Field testing

The office-based workshops were further supported by field exercises with the same mix of veterinary and animal health personnel to ensure the biosecurity protocols were tested for practical application in the field and were fit for purpose. Day-long field trials were carried out in both target countries with the procedures implemented in a simulation framework representing the arrival of a vaccination team ready to carry out vaccination of village cattle. The practical application of additional procedures required for personnel carrying out an outbreak investigation was also assessed. During the field work, photographs were taken to support the development of visual aids for the guidelines and associated training programme.

Implementation

Based on the findings from the literature review and in-country testing, a final set of biosecurity related material for the vaccination programme was developed. An important aspect was incorporating feedback on draft versions of the entry and exit protocol and supporting material, from both the workshops and field exercises. In addition, feedback was elicited to ensure the words and phrases chosen were appropriate and conveyed the required meaning. The biosecurity materials developed included an overview document for training purposes, the *Biosecurity Training Handbook* (14), and a two-page guide for field use, the *Quick Reference Guide* (15).

The English-language templates for the *Biosecurity Training Handbook* and *Quick Reference Guide* were translated into each target country's official language: Lao and Burmese. In addition, a biosecurity module was developed and incorporated into a training-of-trainers (ToT) programme developed for the vaccination teams working in each country. The ToT programme also required a pre- and post-impact assessment using a set of multiple-choice questions. As part of the ToT training, each vaccination team was assigned a 'biosecurity champion', a role separate from that of the team leader. The role of the biosecurity champion was to provide guidance and oversight of the team's daily activities, ensuring appropriate biosecurity protocols were followed. In addition, external monitors (provincial veterinary officers, project officers) visited vaccination teams throughout the vaccination campaigns to assess compliance with the biosecurity guidelines, along with other areas of importance such as vaccination technique and adherence to the cold chain. Retraining and re-evaluation of poorly performing teams was implemented on the spot.

Results

The initial Google search yielded seven documents of relevance to the project scope. No documents specifically dealing with measures for vaccination teams were found. The expanded Google search identified a further nine non-region or non-FMD specific sources of information regarding biosecurity measures for AHWs or vaccination teams dealing with contagious disease. The scientific database search yielded a total of 13 unique documents. Following the first-level screening of abstracts, a total of four documents were retained and reviewed in full. Of these, none aligned directly with routine vaccination carried out within the context of endemic FMD, although they provided useful generic guidance that could be adapted to the project context. Additionally, relevant documents received from personal contacts were reviewed in full and provided a valuable resource.

Most of the documents considered to be of potential relevance to the objectives of the review focused on emergency animal disease (EAD) outbreak situations (as opposed to an endemic state) and provided recommendations for personnel in developed countries. For example, the Australian Veterinary Association (AVA) provides guidelines on veterinary personal biosecurity, with a specific focus on measures to reduce the risk of zoonotic infections (16). An FMD-specific protocol for putting on and removing protective clothing is available (17). The New Zealand government has, further, published a comprehensive disinfection operational plan (18), which provides detailed guidance on the principles of cleaning and disinfection, as well as decontamination and use of personal protective equipment during an FMD outbreak. In a second New Zealand document, the vaccination operational plan is documented (19). It contains instructions regarding farm vaccination visits. Mandatory cleaning and disinfection routines are specified and supported by a cleaning and disinfection fact sheet (20). An online repository ('Biosecurity Response Knowledge Base') provides detailed technical information (e.g. on mixing disinfectants), as well as an overview of processes, policies, procedures and tools (21). Furthermore, the United States Department of Agriculture (USDA) publishes, under their Foreign Animal Disease Preparedness and Response Plan, standard operating procedures for disinfection (22) and biosecurity procedures (23). Both documents detail cleaning and disinfection procedures, the biosecurity procedures being specific to FMD.

The overall goal of personnel cleaning and disinfection is to remove any contamination on the body or clothing (18). Decontamination procedures for personnel were highly prominent in the documents retrieved, because they facilitate the safe movement of response staff from property to property during an emergency disease response (18, 24, 25). For countries in which FMD is exotic, there are often standard operating procedures relating to personal protective equipment and disinfection points for entering/exiting suspected FMD-infected premises, and for use when vaccinating livestock (19, 26). Relevant to FMD endemic countries, some personnel decontamination guidelines have previously been compiled (11) for situations where people have

contact with an FMD-infected animal. Basic pictorial biosecurity guidelines focused on developing countries were identified (27), linking with the core biosecurity principles of segregation, cleaning and disinfection (28, 29, 30).

Segregation in the context of people visiting farms is described as: ‘set aside – prevent contact between what is dirty and what is clean’ (29). Segregation guidelines previously published to prevent disease spread in the case of equine influenza went as far as compartmentalising vehicles into clean and dirty sections (31). In general, requirements related to segregation appeared to be less of a focus than procedures related to personnel cleaning and disinfection (27, 28, 29, 30).

Cleaning of at-risk materials and the use of disinfectants are dominant in the materials retrieved and are described in detail by the authors of available materials. Commonly, a rationale as to why specific steps are required is provided, for example regarding cleaning of at-risk materials: ‘removing organic material such as manure from items or equipment, clothing, shoes and people’s hands is very important prior to and after contact with animals. Once items are scrubbed clean they should be disinfected or dried thoroughly or both’ (9).

It was frequently reiterated that disinfection should only take place after thorough cleaning, because many disinfectants are inactivated in the presence of organic material such as manure (9). In addition, the contact time of disinfectants is also very important. The required contact time will vary with the disinfectant chosen, the agent and other factors such as ambient temperature.

Geographically relevant material included guidance on livestock biosecurity measures for traders of cattle and buffalo (32), and basic biosecurity measures for village AHWs in Cambodia (33), as well as national biosecurity guidelines for pig and poultry farms in Vietnam (34, 35). None of the information provided was specific to vaccination teams but included general biosecurity guidance, which reiterated the importance of standard biosecurity principles such as disinfection. However, it has been highlighted that general principles should be applied using veterinary judgement and leadership (36).

Guidelines have been developed for the decontamination of premises where animals are infected with an EAD (37), and although not specific to the South-East Asian context, key principles were relevant. Biosecurity guidelines for FMD-endemic situations have been collated (30) and highlight the importance of biosecurity ‘because many diseases (infections) are not only transmitted by infected livestock but also by persons (dirty boots, coats, hands) and people taking materials onto farms’.

Interestingly, most of the material retrieved was visually supported, either by photos or graphical illustrations, in most documents (11, 27, 38), presumably to embed approaches and to support engagement and uptake.

Workshops and field testing

Following the workshop and field simulation exercise, a half-day classroom-based debrief ensured that feedback from the participants was understood and adequately incorporated into the guidelines. Amendments were made to the procedures to ensure that they were clear and practical, while remaining culturally appropriate and sensitive to climatic conditions. The draft guidelines were largely fit for purpose but required changes to words and phrases that were either not used or had a different meaning in the target countries. Products to be used for disinfection were rationalised and amended depending on availability in-country. The field exercise was critical to clarify implementation of the guidelines, the order of activities on entry and exit, practical aspects such as the appropriate size and use of the biosecurity mat and apron, and additional measures required for outbreak investigation personnel.

Implementation

The final biosecurity training material for vaccination teams comprised the detailed 12-page explanatory booklet, the *Biosecurity Training Handbook* (14), and the two-page *Quick Reference Guide* (15; Figs 1, 2 and 3). The explanatory booklet gave detailed background and technical information on the biosecurity procedures

and concepts underpinning the entry and exit protocol. The booklet was designed to assist knowledge transfer, classroom learning and uptake of the biosecurity method, and covered equipment required, village entry and exit, the key rules/principles and additional steps to include as part of outbreak investigation.



Getting it right
Now let us walk you through this in detail...

What you will need – the specific equipment you will use

- Apron**
In some instances it may be appropriate to cover your clothes e.g. in wet and muddy conditions. If it warrants it, use an apron to avoid obvious contamination of clothing. If you use an apron, it should be designed to cover underlying clothing as much as possible; with a style that fits with your culture and is practical to use. Ensure the apron is made from material that can be cleaned effectively.
- Clothing**
Ensure you have enough clothing so that a fresh set is worn for each village you vaccinate.
- Footwear**
Rubber footwear for ease of cleaning. Note: appropriate footwear may be open e.g. sandals or closed such as gumboots (better for protection of your feet).
- Tarpaulin**
Use a tarpaulin (approximately 3m x 2m; keep it small for ease of cleaning) at the station so you have somewhere clean and mud free to carry out cleaning and disinfection.

Vaccination equipment
Ice box, needles and syringes.

Animal restraint equipment

Cleaning equipment
2 buckets (one for cleaning, one for disinfecting) and 2 long-handle scrubbing brushes. The buckets and brushes should be colour coded to separate between equipment used for the detergent and disinfection wash.

Detergent
Liquid soap.

Disinfectant
Citric acid, or other approved disinfectant.

Storage equipment
Sharps container (for example a plastic bottle, could simply be a used drinking bottle), plastic bags.

Image 6: A man in a blue polo shirt and green apron holding a clipboard, standing next to a red bucket.

Image 7: A man in a blue polo shirt and brown wrap holding a clipboard and a red sharps container.

Fig. 1

Equipment for set up of biosecurity station, from the *Biosecurity training handbook* (12 pp), produced to implement biosecurity procedures as part of a foot and mouth disease control programme in South-East Asia (14)

Main rules

Apply these FIVE main rules at all times.

1. Have a plan

Don't ignore what is going on around you or else you might end up not vaccinating all animals in the village or vaccinating sick animals. Some planning may need to occur prior to the visit, but a reassessment of the plan will need to occur on the day of arrival in case something has changed.

Do talk with the village head and village animal health worker to get the information you need and have a vaccination plan, including a place where you are going to set up your cleaning and disinfection stations.

Which animals should you vaccinate?

Vaccination is about stopping spread. To be effective the team should aim to vaccinate all healthy animals in the village. Vaccination of sick animals will not make them get better. By vaccinating them you could end up spreading sickness to other unaffected animals in the village.



3

2. Lead by example

Don't ignore your own responsibilities e.g. don't tell others to clean their footwear and walk around in dirty ones yourself.

Do be a role model and take your work seriously e.g. share knowledge with others in the village.









3. Bring the right things

Don't arrive on village unprepared e.g. without a suitable disinfectant or with clothing that has been worn whilst handling livestock at another village.

Do take pride in bringing the right things to get the job done e.g. rubber footwear and a brush for cleaning.

How can a good leader make a difference?

A good vaccination team leader will check that all vaccination staff have clothing washed and cleaned after any previous village vaccination visit and that staff have appropriate footwear and aprons (as required). They will also make sure that they do the same themselves.

Why do I need to plan where I clean and disinfect?

Planning ensures you won't forget anything, you will be efficient and you will maximise the benefit of vaccination. Your cleaning and disinfection station sets up a barrier that you must pass through before leaving the village. Meaning you will be less likely to spread animal disease to another village.

4

Fig. 2

The main biosecurity rules, from the *Biosecurity Training Handbook* (12 pp), produced to implement biosecurity procedures as part of a foot and mouth disease control programme in South-East Asia (14)

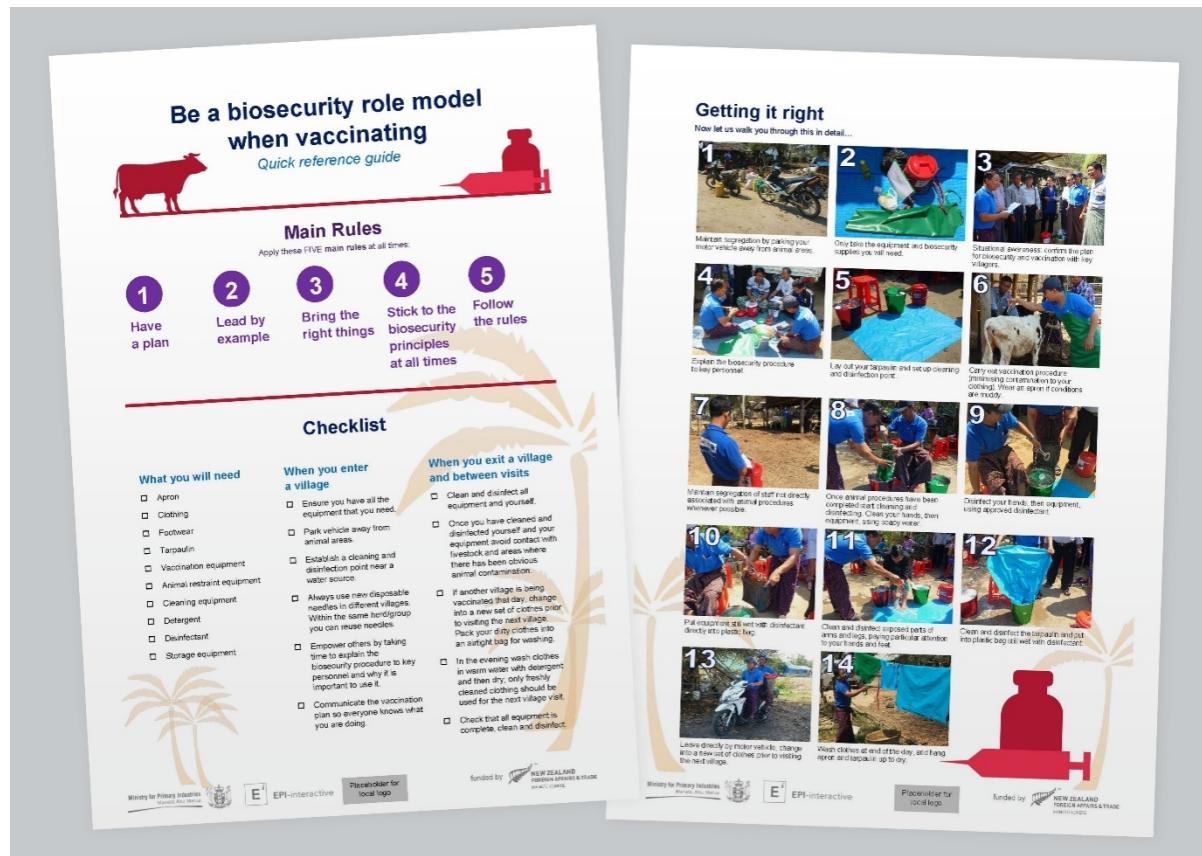


Fig. 3

Step-by-step field guide detailing biosecurity equipment and entry and exit protocols, from the *Quick Reference Guide* (2 pp), produced to implement biosecurity procedures as part of a foot and mouth disease control programme in South-East Asia (15)

In the guidance documentation, the equipment requirements (Fig. 1) and stepwise exit and entry procedures (Fig. 3) were set within the context of five core rules (have a plan, take the lead, bring the right things, stick to the biosecurity principles [situational awareness, segregation, cleaning, followed by disinfection; Fig. 4], do it the right way [Fig. 2]) which guide implementation within the wider context of leadership, skills transfer and situational awareness (Fig. 3).



Fig. 4

The core principles of biosecurity: situational awareness, segregation, cleaning followed by disinfection

The minimum equipment advocated as part of the entry procedures was an apron designed to fit within cultural norms, two sets of clothing, to be changed between villages, rubber footwear, vaccination equipment (hard shell cool box, needles and syringes, clipboard, documentation and ear-tagging equipment), animal restraint equipment, cleaning equipment (two buckets, two long-handled scrubbing brushes), detergent (soap), disinfectant (e.g. citric acid) and storage equipment (sharps container e.g. plastic bottle; plastic bags) (Fig. 1). Although an apron was included as core equipment, given the hot climate its use was considered optional because it would only be appropriate at certain times of the year (e.g. in wet and muddy conditions). The procedure thus advocates that changing clothing

between village visits was a core part of the protocol. Whilst apron use was considered to be voluntary under normal circumstances, the procedure indicated that its use, along with disposable gloves for animal handling and sampling, was compulsory for field visits during outbreak investigations.

Personnel were advised to park their vehicles away from areas with livestock (segregation), then to meet with the village head to plan for vaccination. Part of situational awareness was to assess the risk associated with animal cohorts, with the lowest-risk groups prioritised for vaccination ahead of higher-risk groups (e.g. animals purchased from markets in the preceding seven days). A biosecurity control (cleaning and disinfection) point was chosen based on its proximity to a water source. The biosecurity station set-up included a tarpaulin ($\sim 2 \times 3$ metres) to prevent mud contamination while cleaning, and buckets (one containing detergent, the other disinfectant) allowing a logical flow from cleaning to disinfection (Fig. 3). Other logistical issues were covered such as changing disposable needles between groups of animals. During an outbreak investigation, the biosecurity control point is set up at an appropriate entrance to the village.

The exit procedures covered the logistics of cleaning and disinfection and gave broad outlines of the dilution rate and contact time required for citric acid (0.2% = four level teaspoons citric acid powder per five litres of water) or other approved disinfectants. It was stressed that personnel must return to their vehicle only after cleaning and disinfection had been completed. An additional procedure to be carried out during outbreak investigation was cleaning and disinfection of vehicles (e.g. motorcycles).

A particular focus of the procedures and training support material was to empower and upskill others through clear and comprehensive explanations, and to foster role models of biosecurity behaviours. The *Quick Reference Guide* was created to provide a step-by-step visual prompt aimed at trained personnel, or those working under the supervision of trained personnel. The village entry and exit procedures were provided in a simplified, easy to use, two-page format with a

series of photographs provided to act as a visual prompt to the key steps in the procedure. The two-page *Quick Reference Guide* was designed to be laminated to allow decontamination after field use.

The finalised materials were used to familiarise vaccination team leaders with the required biosecurity procedures and equipment through ToT workshops carried out prior to each of the vaccination campaigns associated with the FMD control project. The purpose of the workshops was to introduce all vaccination team leaders to biosecurity theory, provide an overview of all the materials developed, and demonstrate how the procedures could be implemented during mass FMD vaccination campaigns. The key objective was to ensure that there was full awareness of the procedures, and that team leaders had appropriate understanding to allow them to train team members to implement the procedures in a practical and field-relevant format. The training included a classroom-based briefing followed by a half-day practical exercise in which participants completed specific biosecurity exercises that simulated a vaccination team entering and exiting a village during the campaign. Pre-training evaluation, using an anonymised multiple-choice test (ten questions) covering important aspects of the biosecurity and vaccination training, was conducted in some areas. Those participating in the test (108 personnel) achieved a mean of 55% (range: 10–90%) of answers correct. A mean of 79% (range: 50–100%) correct answers was achieved in the post-evaluation test using a comparable, but different, set of ten questions.

Approximately 750 personnel, forming part of around 100 vaccination teams in each target country, were trained in the practical application of core biosecurity principles including situational awareness, segregation, and cleaning and disinfection (Fig. 4). During the vaccination campaigns, monitoring and evaluation were carried out randomly by provincial livestock officers and OIE project staff, with on-the-spot retraining and subsequent re-evaluation of poorly performing teams. Unfortunately, no formal data are available from the field monitoring component, although observations were noted. The biosecurity equipment was easily transported by motorcycle, and segregation at the village level was generally well implemented. The

external monitors (provincial veterinary officers, project officers) considered that there was good knowledge transfer to other team members and to local farmers. This is evidenced by the biosecurity protocols often acting as a catalyst for further discussion among team members and with farmers to explain the aetiology and transmission of FMD. Some inconsistencies noted in applying the guidelines at every village included needles sometimes being reused between villages, and teams not changing clothing after every village. Cleaning followed by disinfection was carried out to a high standard, although teams sometimes missed pieces of equipment and were occasionally observed replacing disinfectant (citric acid) with detergent when they ran out.

Discussion

An evidence base supporting scientifically robust biosecurity procedures and guidance documents for FMD vaccination teams, part of the OIE FMD control project in South-East Asia, was developed. The remit was subsequently expanded to include additional biosecurity protocols applicable to outbreak investigation in the target countries. Both grey and published literature was assessed in a systematic manner to meet this objective. While scientific evidence and standard operating procedures specific to the South-East Asian context, and particularly vaccination teams, were sparse, the review identified useful foundation documents from developed countries that described approaches and standard procedures adaptable to the endemic setting of the South-East Asian countries involved in the New Zealand OIE FMD control project.

A substantial amount of material has been prepared by developed countries to enable a high level of biosecurity against the threat of, or in response to, an FMD incursion or outbreak. Consequently, there is a focus on high-risk scenarios, for example FMD-free countries dealing with the investigation of FMD on suspect farms or ‘stamping out’ disease during an outbreak.

Implementation of sufficient biosecurity standards is also important to developing countries where the focus may be on minimising disease

impacts, rather than incursion response with the goal of eradication. A considerable gap was identified regarding information specific to endemic countries, and in particular biosecurity protocols relevant to disease management measures such as vaccination in an FMD endemic setting. Some materials existed as project outcomes but these appear to be hardly ever formally published. This realisation led to the production of this paper, designed to allow people to re-use and build on what has been already been developed.

No material was identified that was specifically focused on the main objective of the review, i.e. biosecurity guidelines for Mekong village FMD vaccination teams. Most material that could be identified was focused on personal protective equipment (PPE) with the aim of protecting AHWs, technicians and veterinarians against zoonotic disease, or alternatively provided general farmer-focused biosecurity advice linked to the three concepts of segregation, decontamination and disinfection. However, the methods for biosecurity entry and exit from a farm generally do not incorporate a situational aspect and assessments to account for variation in risk, the focus being on active emergency outbreak situations and/or zoonosis protection. The authors propose that a risk averse approach may be counterproductive within the setting of vaccination teams visiting livestock villages in South-East Asia. Where villages with no history of an active infectious disease are treated identically to those under investigation for active incursions, field teams may consider the biosecurity protocols poorly focused and unwieldy, resulting in poor adoption and at best only partial implementation.

Developed countries have operational procedures for segregation, decontamination and disinfection as part of their veterinary emergency planning. While these documents provide a wealth of details and can be used to create the highest level of biosecurity in developed country settings, their procedures are far from the operational realities of the South-East Asian context. Given the resource restraints faced by developing countries, the recommendations are also in many cases excessively expensive, making them unsustainable, for example the use of multiple pairs of gloves and single-use overalls (e.g. Tyvek).

There were, further, some notable omissions in the material reviewed with respect to country-specific equipment. For example, based on field experience in the region, the use of polystyrene boxes should be discouraged, because they can be difficult to decontaminate and hence pose a considerable risk of moving contaminants between villages.

The findings of this study also highlight the possibility that recommendations that clash with local cultures and climatic conditions might increase rather than reduce the risk of disease spread. For example, disposal of new equipment such as coveralls following single use could be considered wasteful, and workers might be inclined to use overalls on multiple farms. A ‘uniform’ may make workers feel acknowledged and linked to a larger initiative, which further compounds the sense of wastefulness when overalls are required to be discarded after a single use. In addition, workers may prefer not to wear overalls because they may be uncomfortable in a hot climate. Thus, without the correct background understanding and training, costly equipment such as Tyvek suits could in fact undermine biosecurity initiatives: ‘If I wear Tyvek I have now fulfilled my biosecurity obligations no matter how many properties I visit wearing the same pair’. Similar observations have been made with regard to raising village chickens in Myanmar, where vaccination against Newcastle disease was associated with an increase in risk behaviours such as buying in chickens from multiple sources (39). A parallel comparison in everyday life concerns people driving more recklessly when they wear seat belts (40).

It is important to recognise that, for many people in the project target countries, the concept of biosecurity may be new or at least poorly understood (particularly outside the scope of outbreak investigation) and, therefore, sustainable and effective uptake of the concepts requires targeted education and an evolution of change. Clearly, any guidelines for Myanmar and Laos need to strike a balance between achieving a high level of protection/biosecurity and high compliance with the recommendations made. The greater the change from baseline activity the harder it is to encourage uptake. It has previously been highlighted that the achievable level of biosecurity depends on

the circumstances (36). The best transition will be one that modifies current behaviour and activities rather than one that requires a complete turnaround from what was done to what is expected. Thus, a focus on the core factors of importance that promote biosecurity awareness and planning is required, rather than prescriptive recommendations and rigid procedures, for example advocating ‘footwear that can be washed and disinfected’ (i.e. made from rubber, such as rubber sandals, slippers or slip-shoes) as opposed to detailing the use of a specific type of footwear such as wellington boots (gumboots) which may be unsuited to the cultural or climatic setting.

Over and above the operational aspects of biosecurity (segregation, cleaning and disinfection), many published guidelines do not discuss aspects of situational awareness and how these may inform biosecurity practices in real-time. Five foundation-setting principles that set the context for appropriate engagement and uptake are detailed in this paper. There is a strong focus on situational awareness and risk assessment, such as understanding whether active infection and transmission of disease may be occurring in the village, or whether certain animal cohorts pose higher risk than others of harbouring disease. This context is used to inform appropriate action. Risk mitigation steps may include not vaccinating cohorts of affected animals, as well as heightened awareness of the risks of spread by vaccination teams, or education of people in that village of the risk sick animals pose to other animals. Situational awareness also implies that behaviour will be modified so as to reduce disease transmission within a village, e.g. by vaccination of low risk cohorts prior to high risk cohorts. Thus, the authors consider that any biosecurity protocol developed should move beyond process and include a component of situational awareness, with the ability to adapt process and procedures to match the situation presented at the village level.

Results from previous fieldwork have shown that a number of factors affect animal health communication, including the motivation to follow animal health messages and the existing level of technical skills (41, 42). Studies have identified that village AHWs can provide an important link for village-level control – an essential element of

successful national FMD control – and have recommended that AHWs receive targeted training in biosecurity and vaccination (43). Local AHWs have an influential role in animal health matters at the village level through strong and trusted relationships with livestock farmers. They have an important role in demonstrating the benefit of and embedding new practices. Recent studies in the northern hemisphere have demonstrated the economic benefit (through enhanced production) associated with the adoption of routine farm-level biosecurity measures such as quarantine of new arrivals (44). Such published studies will assist with communicating the benefits of adopting simple biosecurity measures. However, a multi-level approach is clearly required because other studies have identified that higher levels of biosecurity can be achieved where vaccination planning and delivery are performed by central government veterinary staff (42). Centralised oversight can, for example, ensure that good vaccination technique and an unbroken cold chain are achieved, as shown in Cambodia (45). The approach developed during this study has included a strong educational and social media marketing component (Facebook campaigns, community-level farmer meetings and workshops) where skills transfer and the taking up of responsibility were promoted at both central and grass-roots levels (farmers, traders and AHWs).

Conclusion

Biosecurity involves both practical and behavioural interventions that can reduce or eliminate the likelihood and impact of disease occurrence (9). A previous study on compliance with personal decontamination during an equine influenza outbreak in Australia identified a range (60–100%) of compliance with the required biosecurity exit procedures on quarantined farms (46). Given the likely extremely high awareness during this outbreak situation, much lower compliance rates could be expected in endemic situations, complicated by generally lower levels of training and biosecurity awareness. The authors suggest that any biosecurity guidelines focused on FMD endemic settings must account for communication preferences, be supported by sustained engagement and training at

both the central and local levels, and must incorporate the important drivers of compliance, such as cost, practicality, cultural acceptance and climatic fit.

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