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HOW TO IMPLEMENT FARM BIOSECURITY: THE ROLE OF GOVERNMENT AND PRIVATE SECTOR

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Summary: *Two surveys of biosecurity practices were successfully conducted in August and October of 2017, involving ten national SEACFMD coordinators (pilot survey conducted during the 20th SEACFMD National Coordinators Meeting, 16–18 August 2017, in Pakse, Laos), and 25 OIE Delegates or their nominees (OIE survey conducted by questionnaire for the 30th Conference of the OIE Regional Commission for Asia, the Far East and Oceania) respectively. The findings provide important information for leadership personnel responsible for addressing international and national expectations of collaborative transboundary animal diseases control programmes and foot and mouth disease (FMD) in particular. The following findings emerging from this work will be presented at the 30th Conference of the OIE Regional Commission for Asia, the Far East and Oceania, in Malaysia, 20–24 November 2017. As a larger dataset would enable more statistical support for these findings, the conference is an opportunity to encourage participation of the ten countries that have not completed the survey.*

Key findings from the surveys are as follows:

- *All countries advised they would like the OIE to work on developing a template for farm biosecurity plans and most requested biosecurity support training and access to expertise;*
- *Achieving border check-point compliance through closer collaboration should be a major biosecurity priority for countries in the SEACFMD Campaign;*
- *Communal grazing and sale of non-vaccinated animals in FMD-endemic countries are risk factors for the spread of FMD and local strategies to minimise these risks need to be developed;*
- *Trader engagement in FMD control is a challenging and a problematic area that needs further attention for achieving more effective biosecurity;*
- *Promotion of hygiene messages on biosecurity is required to improve practices and although challenging, it is of considerable importance in achieving more effective biosecurity;*
- *The modest responses to questions on improved feeding strategies, indicates that the importance of nutrition as a driver for improved health practices and livelihoods needs further recognition;*
- *The promotion of feeding* ***cooked*** *food scraps to pigs, the keeping of* ***accurate records*** *of animal health events, and ensuring wild birds do not have access to water used for commercial poultry (highly pathogenic avian influenza risk), needs promotion as these help prevent and manage biosecurity risks;*
- *The quarantine, isolation of and discouraging sale and movement of ill animals, plus trading of vaccinated animals and engaging with traders, needs more promotion at village and smallholder farm;*
- *The use of systemic antibiotics for FMD treatment is common and an issue deserving attention in the context of the emergence of global antimicrobial resistance;*

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development of an alternative business model for veterinary para-professionals based on 'disease prevention is preferred to treatment' is required;

- *Use of 'negative disease reporting' and developing coordinated emergency response teams (e.g. an FMD task force) is considered critical to improving effectiveness of surveillance, vaccination, public awareness and other biosecurity aspects in endemic FMD countries;*
- *Use of mobile applications, social media and e-mail appears to be emerging, with clarification of their use and efficacy required to confirm the likelihood that this has improved TAD surveillance over the more widespread use of paper and fax communication;*
- *As responses to some questions differed between the two surveys and even between personnel from the same country, such inconsistencies strengthen arguments for the role for OIE in supporting biosecurity development, including provision of templates for farm biosecurity plans, biosecurity support training and provision of access to expertise able to ensure strong technical leadership;*
- *The 'Five principles of biosecurity' can be aligned with the 'Five factors of change management' to provide a robust framework for improving biosecurity practices. This requires understanding of: motivations for change; resistance to change, knowledge management requirements; cultural dimensions and farming systems; plus effective leadership.*

Implementation of biosecurity interventions suitable for smallholders through to village-level practices, commercial operation initiatives, and national/international programmes, is a complex process of education aimed at empowering people to make better personal and collective decisions. Biosecurity interventions need alignment with the motivations of all involved in the supply change of livestock production, preferably offering clear short-term risk management benefits that elicit interest, investment and application. As the practices of the commercial sector demonstrate, and public–private partnerships offer, the linking of biosecurity and disease control with improved livestock productivity and financial outcomes is important as it provides opportunities for sustainable improvements in livelihoods and economic development and a more effective FMD and other transboundary animal diseases' control and eradication strategy.

INTRODUCTION

Control and eradication of highly infectious transboundary animal diseases (TADs) that are capable of severely limiting livestock productivity is essential if international, regional and local markets for livestock and their products are to be sufficiently enhanced to address the emerging issue of global food insecurity [1]. The recent eradication of rinderpest has driven optimism that other important diseases can be similarly addressed, particularly foot-and-mouth disease (FMD). Several other TADs are deserving of similar attention, including peste des petits ruminants (PPR), classical and African swine fever (ASF, CSF), potentially the zoonotic avian and porcine influenza viruses and importantly, Newcastle disease in poultry.

In the past few decades, FMD has successfully been eradicated from Indonesia, Europe, The Philippines and significant steps in FMD control have been achieved in South America [2,3]. With the exception of the 'stamping-out' strategy used in the United Kingdom, these achievements appear to have been frequently attributed to FMD vaccination, despite the use of numerous tools in the various campaigns. The success of FMD campaigns has led to the aspirational global effort to control and potentially eradicate FMD. Seven regional pools of FMD viruses have been identified and FAO/OIE-led coordinated campaigns are being conducted to control the disease by encouraging countries within virus pools to use the Progressive Control Pathway (PCP) and Performance of Veterinary Services Pathway (PVS) mechanisms, to help define and improve where necessary, individual country FMD status and capacity to respond to the task of FMD control and eradication, providing countries with enhanced capabilities to respond to TADs in general and address emerging global One Health issues.

The PCP for FMD encourages the development of national FMD control plans that support strategies and the use of the various tools that promote disease control, including: improved surveillance;

vaccination programs; public awareness campaigns; and in particular enhanced biosecurity through control of animal and product movements by quarantine, reduced mixing of different cohorts, improved hygiene and sanitation practices, particularly with animal examination and treatments plus handling of potentially contaminated food.

However, with increasing demand for livestock products and especially in emerging markets where developing countries have seen rapid development of their economies, the challenges of achieving FMD control and eradication appear to be increasingly complex. As evidence of newly emerging virus serotypes (and topotypes) that appear to have originated from other virus pools accumulates, concerns of 'virus matching' in provision of most appropriate vaccines has arisen, as have concerns on the limited understanding of how the movement of animals and their products has led to the rapid spread of new virus strains between and within countries and virus pools. This situation is indicative of a major flaw in international and national biosecurity systems [1].

Much of the attention in FMD research and control programmes has been directed at playing 'catch up' with viral vaccine dynamics. However, recent research has been emerging from socioeconomic studies of biosecurity *knowledge, attitudes and practices* (KAP) in both developed and developing countries, indicating that attention needs to be as focused on the people involved and impacted by the disease as much as the virus in managing TADs [4, 5 6, 7]. Research indicates that in most rural sectors, personnel generally have poor understanding of biosecurity, the exception being some intensive commercial operations (mainly pigs, poultry and ruminant feed lots) but this can be improved through appropriate training [8, 9]. This knowledge deficiency is just one of the five 'change management factors' that needs to be better understood and addressed if control and eradication programmes for FMD and other livestock diseases are to prove sustainable [10].

To better define this issue and identify ways biosecurity can be improved, information on current biosecurity programmes is required. At the request of OIE, a survey of biosecurity initiatives was developed and conducted as a prelude to a session entitled 'How to implement farm biosecurity: the role of government and the private sector' to be delivered at the 30th Conference of the OIE Regional Commission for Asia, the Far East and Oceania, in Putrajaya, Malaysia, 20–24 November 2017. The 36 OIE Delegates of the OIE Regional Commission for Asia, the Far East and Oceania were requested to complete a survey to enable the collation of information on what biosecurity extension programmes have been occurring or are planned in their respective countries, and what assistance can be provided by OIE. The survey was developed within the framework of the following five principles of biosecurity.

This report provides a summary of the findings and preliminary conclusions from the survey(s).

Principles of biosecurity

1) **Livestock quarantine and animal movements.** Manage the introduction and movement of livestock in a way that minimises the risk of introducing or spreading infectious disease.
2) **People, equipment and vehicle hygiene.** People, equipment and vehicles entering the village, enterprise or country are controlled to minimise the potential for property contamination.
3) **Food and water safety.** Quality of stock feed and water is fit for purpose, especially purchased feed that is free from contaminants, untreated swill and/or restricted animal material (i.e. feeds containing ruminant tissue cannot be fed to ruminants).
4) **Animal health management, surveillance and reporting.** Prevent and control animal disease by using appropriate vaccination programmes, regularly monitoring for disease and immediately reporting outbreaks of TADs.
5) **Public awareness.** All farmers, traders, agency staff and contractors, understand the importance of the biosecurity requirements for the village, enterprise or country in which they work and can implement the agreed practices for which they are responsible.

Fig. 1. Improved hygiene with washing of shoes on leaving farms is an important biosecurity intervention that is inadequately practiced on smallholder farms

METHODOLOGY

Information was sought on the targeted recipients of biosecurity information, the content and delivery mechanism for these initiatives, and a request on how OIE could assist the process of improving biosecurity initiatives. Of particular interest was how biosecurity education and extensions programmes have been planned and delivered in relation to vaccination programmes, especially for FMD. As biosecurity is delivered at different levels within the various livestock sectors, survey questions were designed to seek information on the four major levels of biosecurity principles and practice in each country:

1) Small farm biosecurity for smallholder livestock owners,

2) Village-level biosecurity for smallholder livestock,

3) Biosecurity for the commercial enterprise livestock sector,

4) National biosecurity programmes for safer regional trade of livestock and their products.

A draft pilot survey was designed and delivered using the Commcare survey e-programme on two hand held tablets, then delivered for completion by participants at the 20th SEACFMD National Coordinators Meeting[2], in Pakse, Laos, 16–18 August 2017, led by staff from the OIE Sub-Regional Representation for South East Asia in Bangkok. Feedback was sought on the suitability of the questions, the advantages of seeking further comments for most questions, and ease of use of the Commcare programme.

The pilot survey and preliminary conclusions were then used to develop the survey used for this Technical Item (OIE Delegate survey), following ongoing discussions with staff from OIE Headquarters.

2 SEACFMD: South-East Asia and China Foot and Mouth Disease Campaign

This led to some relatively minor adjustments of the questions used in the pilot survey, with inclusion of questions on the role of OIE in developing and progressing biosecurity initiatives. The OIE Delegates survey was then conducted electronically by e-mail in collaboration with staff from the OIE Headquarters who collated the responses and submitted them for assessment and analysis by the author, assisted by The University of Sydney MLR (Mekong Livestock Research) Project Officer Isabel MacPhillamy.

Descriptive data from both of the surveys is presented as results 1 and 2, respectively. Inclusion of the pilot survey data is considered important, particularly as:

(i) SEACFMD coordinators from several countries provided responses to the pilot survey (Indonesia, Republic of Korea, Thailand, Vietnam) but a response from these countries for the OIE Delegates survey was not received, and

(ii) a number of responses differed between the two cohorts surveyed.

Results of the OIE Delegate survey data were also examined using binomial logistical regression. Preliminary findings of the univariable analysis comparing 'Income-1' (high and upper middle income) versus 'Income-2' (lower middle and low income) countries, and 'OIE-1' (FMD-free or with zones free without vaccination) versus 'OIE-2' (FMD present or with free zones with vaccination) countries, are also provided when considered relevant.

RESULTS

1. SEACFMD Coordinators pilot survey

The pilot SEACFMD survey was conducted with 10 of the 12 SEACFMD coordinators in Pakse, achieving a mean response rate of 91%. Non-responses were excluded from summary statistics. Interviewees were staff from the following SEACFMD Campaign Member Countries: Cambodia, People's Republic of China (P.R. China), Indonesia, Laos, Myanmar, Malaysia, Philippines, Republic of Korea (Rep. of Korea), Thailand and Vietnam. Of the countries surveyed, two are classed as FMD-free *without* vaccination (Indonesia and the Philippines) and one as FMD-free *with* vaccination (Rep. of Korea). There were 7 male and 3 female respondents. The average length of employment was 17.7 years, with 80% working in policy or agricultural extension, and 60% of respondents working in both.

- **Principle 1. Livestock quarantine and animal movements**

  The response rate in this section was 95%. The majority of respondents reported that the quarantine of incoming animals susceptible to FMD was promoted at the smallholder (100%), village (87.5%), commercial farm (87.5%), and national/border (90%) levels. One country recommends the importation of animals only from OIE FMD-free countries, with another reporting that imported animals are quarantined for 30 days. One country reported that imported animals are checked for clinical signs, documents are examined and then animals are sent for a two-week quarantine on-farm. Clarification from those countries applying quarantine on importation of animals would be beneficial to confirm that animals are sent to an official quarantine station, or just recommended to be quarantined by livestock owners, on-farm.

  The sale and movement of sick or infected animals was actively discouraged by 100% of the respondents at the smallholder, commercial and national/border levels, and 90% of respondents at the village level. One country reported that they attempted using a participatory approach at smallholder level but it was very difficult to enforce. Another country reported that imported animals and animals for local transport are tested for certain prescribed diseases and must have negative laboratory results before they could be given quarantine release and shipping permits, respectively. Laos reported that with numerous borders with neighbouring countries and low compliance levels at check points (it is well known that animals are walked around border check points), it is difficult to control this 'informal' animal movement.

  ⇨ *This finding indicates that achieving border check-point compliance through closer collaboration should be a major biosecurity priority for countries involved in the SEACFMD Campaign.*

The isolation and quarantine of sick animals was promoted by 100% of respondents at the smallholder farm and national/border levels, and 90% of respondents at the commercial farm and village levels. The activity of communal grazing of livestock during TAD outbreaks were discouraged by 90% of respondents at the smallholder farm, commercial farm and national levels, and by 100% of respondents at the village level. One country reported again that they have tried the participatory approach for smallholders but had difficulties in compliance/enforcement. One country reported they only have communal grazing areas at the village level whereas another reported that nearly all of their animal systems are 'backyard' with free-range grazing of animals, so communal grazing is difficult to prevent.

⇨ *Communal grazing in FMD-endemic countries is well known and published risk factor for the spread of FMD and local strategies to minimise this risk need to be developed and promoted.*

The engagement of traders and promotion of trading in vaccinated animals only was lower, with 77% of respondents advising they promote this at the smallholder, village and commercial levels, with 80% promoting at the national/borders levels. One country reported that their national transport requirements insist there is vaccination of animals against certain prescribed diseases. Another country reported that they have had more success with haemorrhagic septicaemia than FMD vaccination due to the low local availability of FMD vaccine.

⇨ *As findings suggest that for most countries surveyed, trader engagement is considered challenging and a problematic area for achieving effective biosecurity, further work on this issue is required.*

On a scale of 1 (most effective) to 5 (least effective) for each of the above activities in these questions, the average value given was 3.

- **Principle 2. People, equipment and vehicle hygiene**

The response rate in this section was 95%, although the question pertaining to hygiene practices had a 96% response rate. Washing foot wear with soap, the use of personal protective equipment (PPE) and washing hands with soap was promoted by 100% of respondents, with 75% promoting the washing of foot wear with water only, and 80% promoted the washing of vehicles when entering the village. Indonesia reported that these practices are performed well in integrated and industrial farms, at moderate levels in small scale commercial farms, and poorly in backyard farms. One country reported that, at the level of smallholder farmers, footbaths are provided before entering both the farm and the individual animal houses, with most farms having a tire wheel-bath or use of disinfectant sprays for vehicles entering the farm. Another country reported that they promote these in principle but there is difficulty in enforcing to achieve compliance with these practices.

The separation of species was reportedly encouraged by 89% of respondents at the smallholder and village levels, 90% at the national level, and 100% at the commercial farming level. These responses indicate that most of the messages on biosecurity practices are recognized but there is difficulty in getting the various personnel involved to effectively adopt them.

⇨ *Increasing the adoption of messages on biosecurity to improve practices is challenging but is an opportunity of potential importance in achieving more effective biosecurity change management.*

- **Principle 3. Food and water safety**

The response rate for this section was 84%. Improved feeding techniques were promoted by 90% of respondents and 80% of respondents reported promoting this at all levels (Fig. 2).

⇨ *The modest responses to questions on improved feeding strategies, indicates that the importance of nutrition as a driver for improved health practices needs wider recognition.*

- **Principle 4. Animal health management, surveillance and reporting**

The response rate for this section was 83%. Vaccination for FMD of incoming animals had a response rate of 85%, with promotion at the national level by 77% of respondents, at the smallholder and commercial farm level by 87.5%, and by 88% of respondents at the village level. Understandably, the two countries free from FMD did not answer questions pertaining to treatment of FMD and one country only indicated that they recommend vaccination for the treatment of FMD (presumably as a disease control measure). Three out of 7 (43%) respondents recommended treating FMD with injectable antibiotics, and 4 out of 7 (57%) respondents recommended the use of astringents. Topical antibiotics were recommended by 4 of 6 respondents (66%), and feed and supportive care was recommended by all of the six who responded.

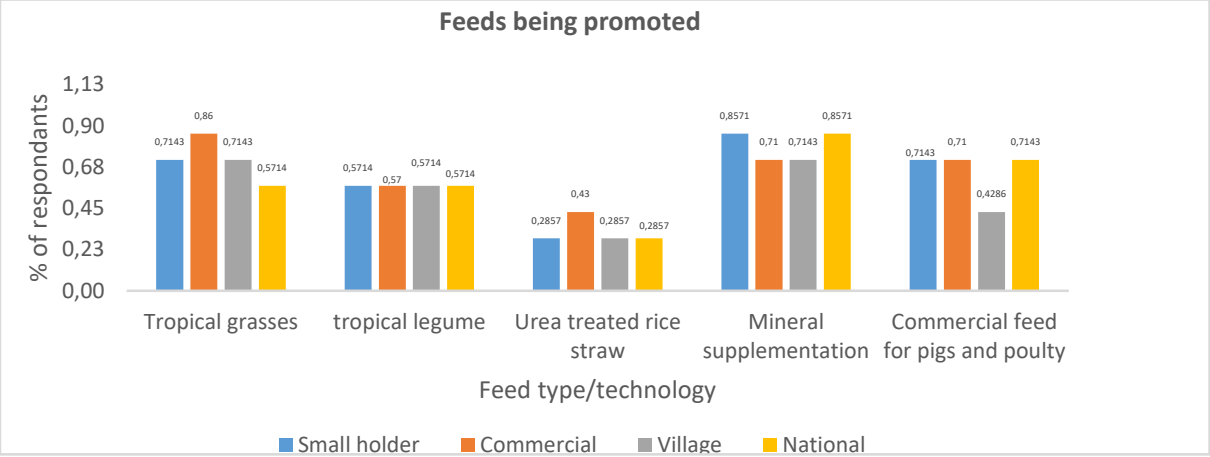

Fig. 2. Summary of the different technologies promoted at the different levels

Improved disease surveillance and reporting was advised by all respondents (Fig. 3). One country reported using an improved animal health information system and surveillance network; whereas another reported that they have legislation on a list of notifiable animal diseases and an online reporting system. One country reported that they mostly utilise passive surveillance and that reporting is often delayed and sometimes absent, although 'FMD negative reporting' is used in a current FMD vaccination zone of this country.

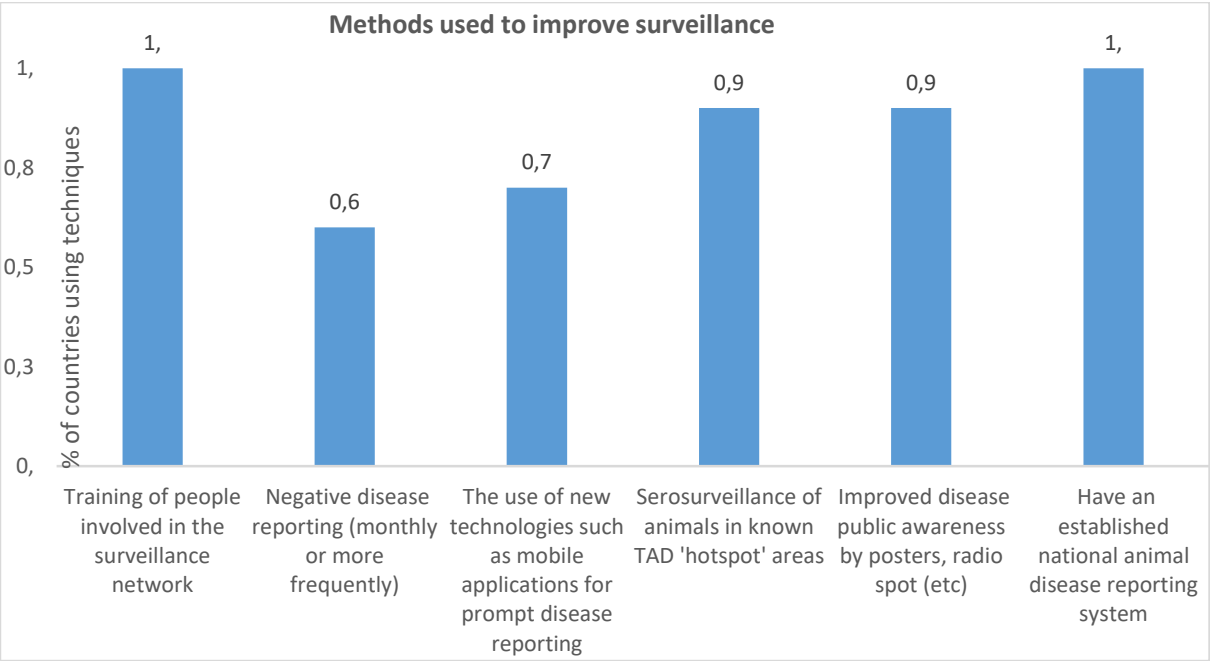

Fig. 3. Summary of proportion of countries utilising each method of improving surveillance

The village veterinary workers (VVW), district veterinary officers (DVO) and provincial veterinary officers (PVO) are all responsible for reporting in nine of the ten countries surveyed, with DVO and PVO levels responsible for reporting in Myanmar. Reporting frequency was answered by 73% of respondents, with 57%, 87% and 75% of VVW, DVO and PVO reporting in real time, respectively. Reporting methods include mainly post, fax and e-mail. One country reported that, in the event of outbreaks, the VVW will report by phone call or SMS and then report weekly, with monthly reporting generally conducted by the VVW, DVO and PVO at frequencies of 42%, 14% and 25%, respectively. One country advised that anybody can report when they find suspect or sick animals with another country advising that the system of reporting is from the grassroots (village level) to the municipal to the provincial to the regional then to the national level. Finally, one country advised that laboratory staff, farmers, traders and slaughterhouse personnel can report.

With 'negative reporting', one country did not provide information and of the remaining countries, all but one reported doing this, with two countries doing so monthly. All but one country advised they report outbreaks to the OIE, with two countries also reporting to the FAO. One country reports to the international agencies monthly, quarterly and yearly, one reports quarterly, and a further country advised reporting only when outbreaks occur.

With laboratory diagnosis reporting, one country did not provide information, with the remaining nine countries all confirming they report laboratory diagnoses. Of these nine countries, one advised reporting immediately after the diagnosis is confirmed, with other respondents advising that the time between receiving the initial report and response was 24 hours, although one country advised their response was 'days'.

With collection of samples, in 88% of the countries the Central and District teams are responsible for this. With promotion of an emergency response, 88% of respondents advised they do this. One country has a regional quick response team, and another country reported that, during outbreaks, they provide biosecurity information, prohibit animal movements, dispose of dead animals, and promote the use of disinfectants, separation of sick animals and treatments along with ring vaccination for a buffer zone.

- ⇨ *In FMD-endemic countries, use of a coordinated emergency response team is critical to improving the effectiveness of surveillance, vaccination, public awareness and other biosecurity interventions.*

- **Principle 5. Public awareness**

  All respondents report utilising public awareness campaigns. All use posters, 10% use newspapers, 40% use TV, 20% use radio/or 'school of the air', and 50% use social media. The percentage of countries promoting key messages is illustrated (Fig. 4).

  ⇨ *As no country reported the promotion of feeding **cooked** food scraps to pigs, or the keeping of **accurate records** of animal health events, these biosecurity risks need more awareness.*

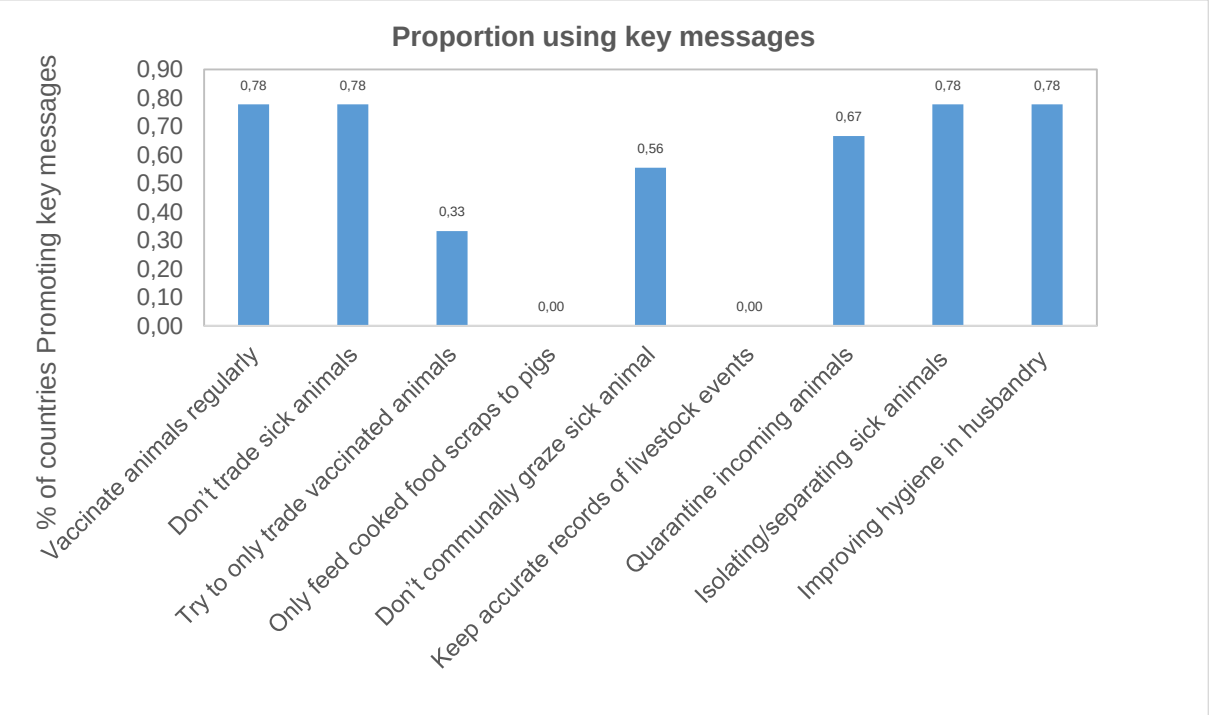

Fig. 4. Proportions of respondents using key public awareness messages

2. OIE Delegates survey

The OIE Delegates survey achieved 25 responses from the 36 Member Countries of the OIE Regional Commission for Asia, the Far East and Oceania invited to complete the survey, giving a mean response rate of 69.4%[3]. Non-responses were excluded from summary statistics.

Of the 25 OIE Member Countries from Asia, Far East and Oceania regions that responded (Fig. 5), their FMD classification was:

a) FMD-free *without* vaccination (7)
b) FMD-free zones with or without vaccination (3)
c) FMD present or not classified according to the OIE list of countries (15).

These countries included high-income, upper-middle-income, lower-middle-income and low-income categories.

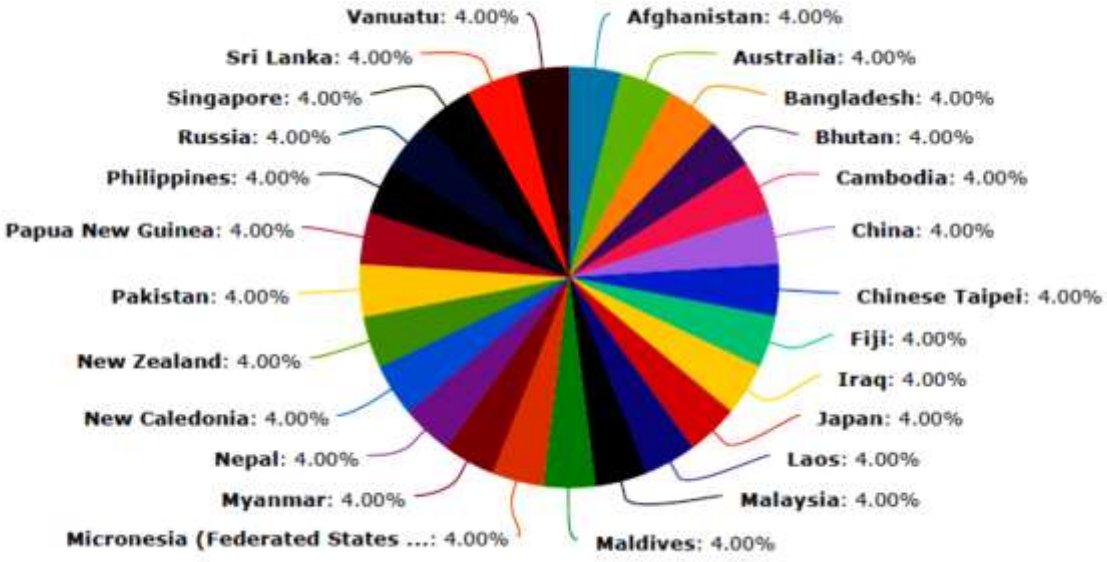

Fig. 5. The survey respondent countries

Of the respondents 96% work in agriculture/biosecurity policy and 88% work in agricultural and biosecurity extension, although only seven of the respondents were OIE Delegates. All 25 respondents provided feedback regarding the roles of government and private sector in the implementation of biosecurity. The level of detail in the responses was highly variable as was the sophistication of the role of government, presumably reflecting the variations in availability of resources, including veterinary services, plus priorities of livestock agriculture to the economies and social fabric of individual countries. As expected, the role of the private sector in livestock biosecurity occurred more in the developed nations and those with a large intensive pig and/or poultry industries.

Public–private partnerships (PPP) for on-farm biosecurity were reported from 62.5% of the countries surveyed (one country did not respond to this question). Countries with large pig and poultry industries indicated that these large farms generally have a private veterinarian on staff to assist with herd health and biosecurity. Private veterinarians may fill the role of government veterinary officials if required and private veterinarian groups are involved in public awareness and training campaigns.

3 Note that a survey from one country was received after the closing date and has been excluded from this report but will be included in an anticipated final scientific publication of this work

An example of the high level of sophistication in the shared roles of government and the private sector and the role of PPP, is that in one developed FMD-free country, each of the livestock industries has one or more organisations that represent their political and policy interests plus deliver research and extension services to their various stakeholders. In this country, these national peak industry bodies have to develop and maintain biosecurity manuals of minimum biosecurity standards for farms, in order to be signatories on an Emergency Animal Disease Response Arrangement (EADRA) that has been developed to fund a coordinated emergency disease response to an outbreak of a TAD. Although the national government is responsible for border biosecurity, the 'lead combat agency' for an emergency response to a TAD such as FMD, is the state government where the disease is diagnosed. To ensure all the various stakeholders (i.e. federal, state/territory governments and major livestock industry agencies) can be effective in provision of biosecurity and TAD response through EADRA, a national coordinating company was also developed. This has proven to be a successful mechanism to ensure that the various industry and government stakeholder members can collaboratively manage the EADRA, plus coordinate a national 'Farm Biosecurity Program' to create greater biosecurity awareness, provide tools for implementing and managing farm biosecurity, plus support research and extension projects associated with reducing diseases risks facing all livestock production industries and local and international consumers of livestock products.

This contrasts with a developing FMD-endemic country where the various livestock industries are yet to form national organisations. Nor the veterinary profession is sufficiently developed to form a national professional organisation. Here, there role of the government is currently in the implementation of farm biosecurity through provision of legislation, communication, extension and education, plus inspection services. This centralised government system is mainly involved in coordination and capacity building of a national surveillance network that supports communication from smallholder farmers through para-veterinary professionals to the district then provincial agricultural office service providers, to the national agency. PPP for farm biosecurity is currently confined to the developing commercial enterprise private livestock sector (mainly pigs and poultry and although cattle feedlot enterprises are emerging). In these sectors, implementation of biosecurity is supported by private sector veterinarians that largely work independently of government. Development of biosecurity initiatives to improve TAD preparedness and responses in this country (and other developing countries) has received research and development programme support through foreign aid funding from various developed countries and the initiatives of international agencies, particularly FAO and OIE.

A majority of the Member Countries (71%) surveyed indicated they were satisfied with the current OIE involvement in on-farm biosecurity; 71% indicated they would like OIE to develop new guidelines on biosecurity at the farm level, 71% would like to see the establishment of an OIE Collaborating Centre for on-farm biosecurity, and 86% would like the OIE to identify relevant experts that could be made available when Member Countries require (a few countries also made further requests).

All respondents indicated they would like the OIE to work on developing a template for farm biosecurity plans (Table I).

⇨ *There is high level of interest in having OIE to work on developing a template for farm biosecurity plans, plus support training and provision of access to biosecurity expertise.*

Table I. Requests of OIE for biosecurity support

Assist the Member Countries with poor infrastructure and technical capacity and link them to other countries.
Provision of experts for intervention / training for farmers and vets in interested countries.
Concise field guide covering just 7–10 TADs with images from TAD atlas, but minimal text targeted at promoting interest and awareness of farmers and veterinary para-professionals. It should come in laminated form to protect from weather etc.
The OIE as the global agency for animal health should support Member Countries in strengthening farm biosecurity especially in the developing countries where backyard farming still constitutes significant percentage of the total livestock farming activities. Inputs in training and facilitating projects to support farm biosecurity will be useful.
Developing needed public awareness material for smallholder farm and village levels for the smallholder livestock sector.

- **Principle 1. Livestock quarantine and animal movements**

Responses to questions on quarantine and animal movements at the different levels are displayed (Fig. 6). High levels of positive responses at the commercial farm and national level occurred for all questions, with variable responses for smallholder and village levels, presumably also reflecting the varying levels of smallholder farmer/village structure in the countries surveyed. The trends observed were similar to those of the pilot survey with lower levels of all risks promoted at smallholder and village levels. There was a significant difference between Income-1 and Income-2 countries (means 1/SD0 and 0.61/SD0.51, respectively, $p<0.009$) to the question of promotion of the isolation and quarantine of sick animals at the smallholder level, although this likely reflects that higher income countries have better facilities and therefore compliance at this level. A difference was noted with the washing of vehicles, with high-level promotion of this in OIE-2 countries compared to OIE-1 (means 1/SD0 and 0.73/SD0.47, respectively, $p<0.023$).

⇨ *Promotion of quarantine, isolation of and discouraging sale/movement of ill animals, plus trading of vaccinated animals and engaging with traders needs more promotion at village and smallholder farm levels.*

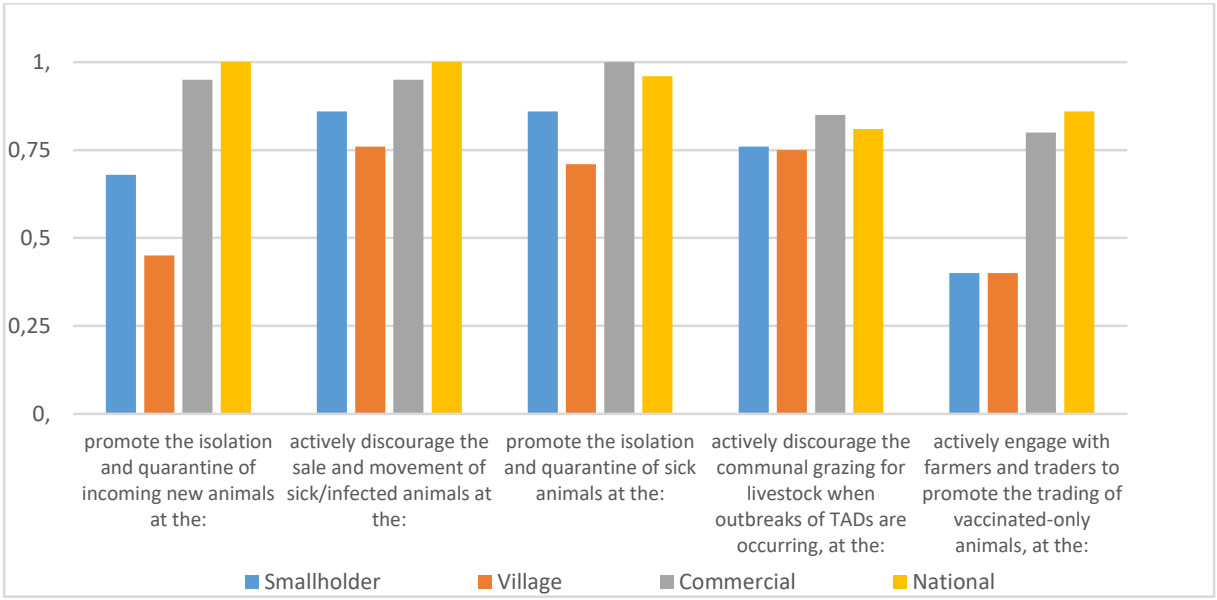

Fig. 6. Responses to questions on livestock quarantine and animal movements

- **Principle 2. People, equipment and vehicle hygiene**

Responses to questions on hygiene practices are displayed (Fig. 7). All respondents reported the use of personal protective equipment (PPE), with the washing of hands with soap after handling livestock is promoted at the farming, extension worker and trader levels. Animals sick and of differing species were advised to be separated to prevent transmission of disease by 68% of respondents at the smallholder and village level, 88% at the commercial level, and 83% at the national level.

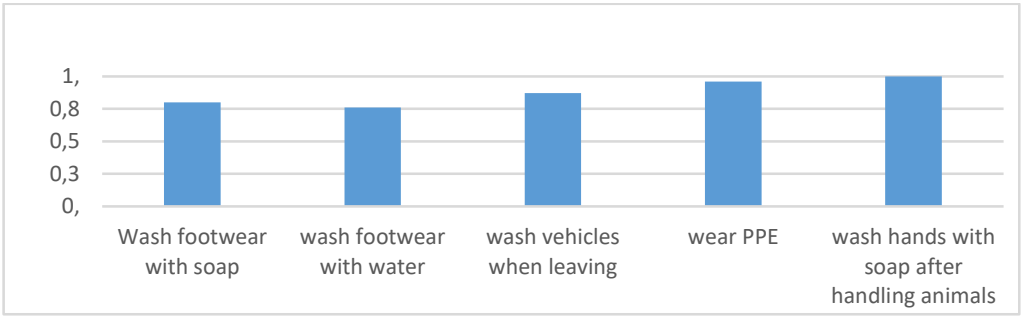

Fig. 7. Hygiene practices promoted to farm, extension, traders staff, etc.

- **Principle 3. Food and water safety**

All respondents reported promoting the use of better and safe livestock feeding and watering practices, at 100% at the national and commercial levels, 75% at the smallholder level and 69% at the village level. The feedstuffs promoted (Fig. 8) and the different safe feeding practices promoted (Fig. 9) are displayed, with trends similar to the pilot survey.

Interestingly, there were difference in responses by OIE-1 and OIE-2 countries to the two questions on access of wild birds to:

(i) feed in commercial poultry settings, and

(ii) water for poultry.

Although both categories provided relatively similar responses to question (i), there was a significant difference to question (ii) with lower level responses in OIE-2 countries to access of wild birds to poultry water and use of chlorination (means 1/SD0 and 0.69/SD0.48, respectively, $p<0.018$).

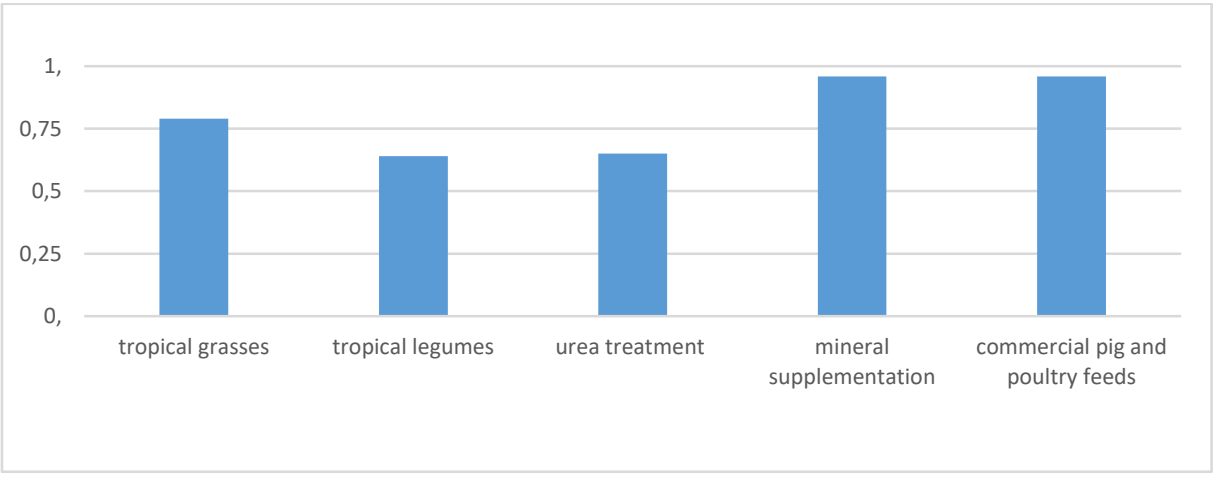

Fig. 8. The different feed stuffs promoted to farmers by responding countries

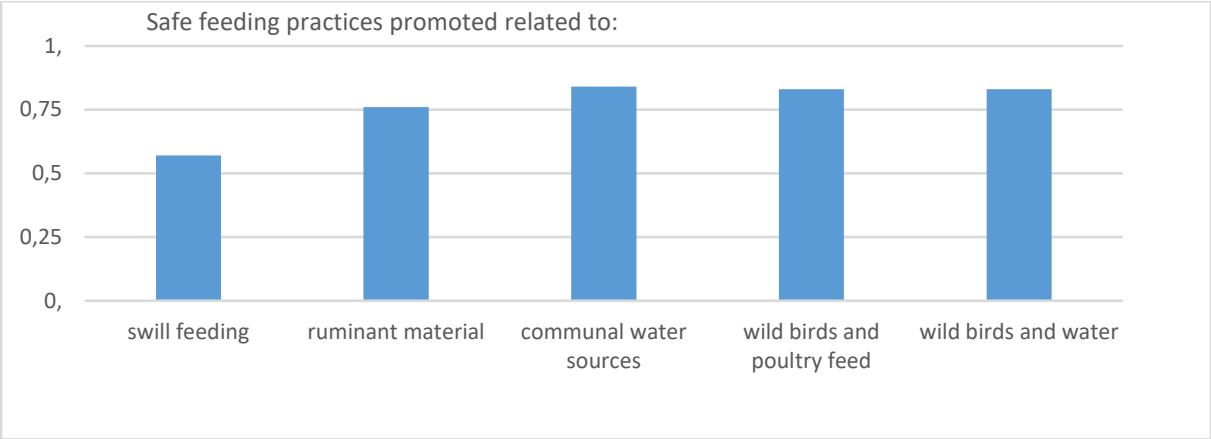

Fig. 9. Promotion of safe feeding practices to reduce risks

- **Principle 4. Animal health management, surveillance and reporting**

The promotion of vaccination for incoming animals against FMD and other TADs was relatively low across all levels, being highest in the commercial sector at 68%. The promotion of these practices was lowest at both smallholder and village levels at 56% and lower than reported in the pilot study (Table II). This difference between the surveys likely reflects the inclusion of FMD-free countries in the OIE Delegates survey, and confirmed as a statistically significant difference on comparison of OIE-1 versus OIE-2 countries, with means of 0.1 (SD0.31) versus 0.92 (SD0.3) respectively ($p<0.001$).

Table II. Summary statistics for pilot and OIE surveys on promotion of vaccination of incoming animals for FMD and other TADs

Level vaccination of FMD/TADs is promoted	Pilot (SEACFMD) (±SD; SE)	OIE (±SD; SE)
Smallholder	0.88 (±0.33; 0.13)	0.56 (±0.49; 0.10)
Village	0.88 (±0.33; 0.13)	0.56 (±0.49; 0.10)
Commercial	0.89 (±0.31; 0.11)	0.68 (±0.46; 0.09)
National	0.78 (±0.42; 0.15)	0.62 (±0.48; 0.10)

The treatments recommended for FMD are displayed (Fig. 10). This data also reflects that whilst 22-23/25 responses for each question were received, the low levels likely reflect that a number of countries are currently and historically FMD free. This was confirmed by the significant differences on comparison of both Income-1 versus Income-2 (means 0.1/SD0.32 and 0.67/SD0.49, respectively, $p<0.005$), and OIE-1 versus OIE-2 (means 0.11/SD0.33 and 0.61/SD0.5, respectively, $p<0.013$) countries on use of systemic antibiotics for FMD at the smallholder level. Further, significant differences between Income-1 versus Income-2 (means 0/SD0 and 0.53/SD0.51, respectively, $p<0.002$) and OIE-1 versus OIE-2 (means 0/SD0 and 0.45/SD0.52, respectively, $p<0.007$) countries were observed on use of astringents. Similar significant differences for supportive care treatments for FMD with country in income ($p<0.055$) and FMD status ($p<0.003$) respectively, were observed.

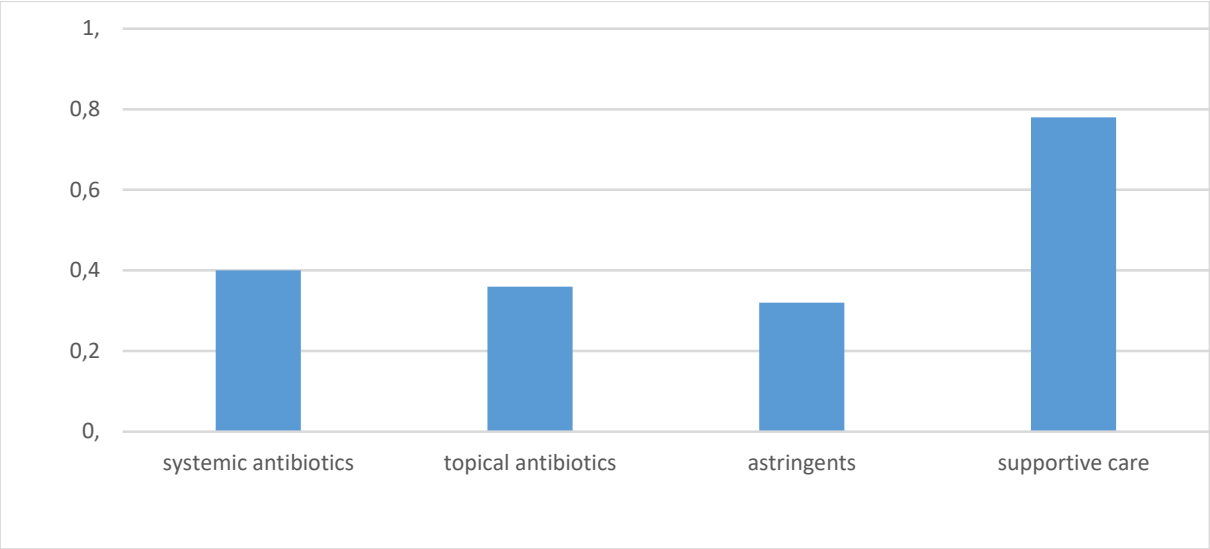

Fig. 10. Treatments recommended for FMD affected livestock

The observation that systemic antibiotics for FMD are still being recommended by some countries, including respondents from low-income countries (67%) and where FMD is present (61%) is an important finding, particularly with current emergence of global concerns on antimicrobial resistance (AMR) and evidence of the deleterious financial impact of this intervention on smallholder families. Of interest, was that, in the pilot survey, one country responded yes to systemic antibiotics being recommended and in this survey the response was no, with the reverse occurring in another country, suggesting likely confusion of national policies on this issue.

⇨ *The use systemic antibiotics for FMD treatment appears common and an issue deserving attention in the context of the emergence of global AMR, particularly with evidence these is inconsistency and likely confusion in national policies on this issue.*

The majority of countries (95%) promote improved surveillance and reporting, with the onus for these activities on farmers and/or veterinary authorities, depending on the country. All countries report training people involved in the surveillance network. Although this question did not have the same level of detail as the pilot survey, the option for respondents to expand further was provided. Respondents mentioned active and passive surveillance, testing of incoming animals and fines for producers not adhering to regulations. Reporting frequency was advised to occur in real time in the majority of cases (Fig. 11).

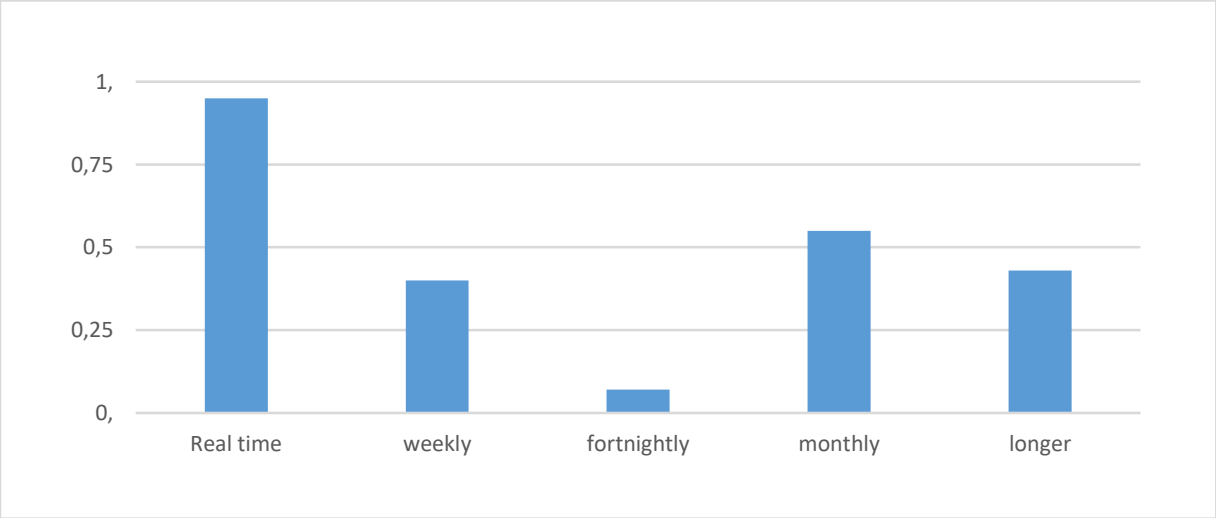

Fig. 11. Disease reporting frequency

The majority of countries reported using e-mail and verbal phone calls to report disease. Some countries (41%) report using mobile applications to report (Fig. 12).

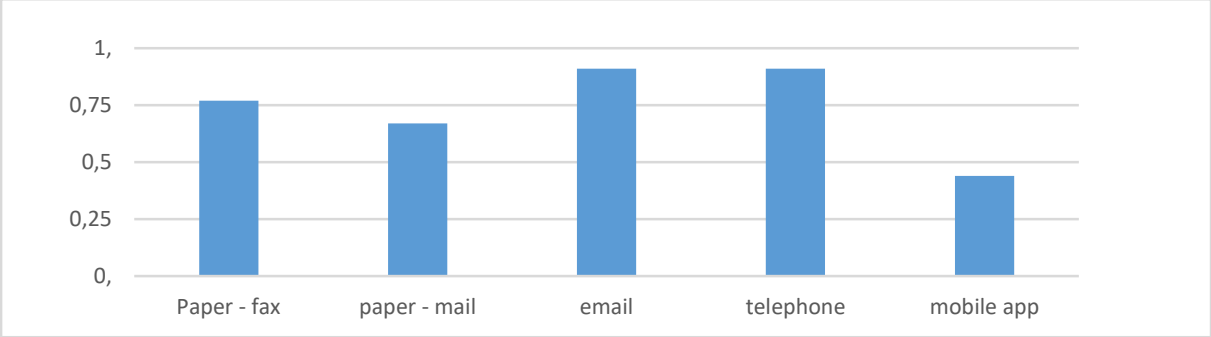

Fig. 12. Disease reporting methods

Additional information on the types and efficacy of using these 'apps' is required, including clarification of whether they are connected to an epidemiology database or if they are referring to a messaging 'app' (e.g. Telegram). For countries using e-mail, further information is required on the process, such as destination of the e-mail (i.e. are the directed to an individual person or is the information going to an epidemiology database). There appeared to be some confusion about the reporting questions, with some respondents uncertain of whether the question was targeted at in-country reporting systems or reporting to the OIE.

⇨ *The use of mobile applications appears to be an emerging strategy, with clarification of their use and efficacy required to confirm the likelihood that has improved surveillance systems.*

- **Principle 5. Public awareness**

Public awareness campaigns for biosecurity are utilised in 96% of the countries that responded to the survey. Posters were used by all, followed by newspaper and radio (both 86%), social media (80%) and television (68%). The main messages promoted in the public awareness campaigns are displayed (Fig. 13) and the comparative results of both surveys tabulated (Table III). On promotion of regular vaccination of animals, a significant difference was noted between OIE-1 and OIE-2 countries (means 0.54/SD0.52 and 1/SD0, respectively, $p<0.002$) although this likely reflects that as OIE countries are FMD free, vaccination is not or rarely practiced. A similar observation was observed on the message of trading of vaccinated livestock (means 0.8/SD0.42 and 1/SD0, respectively, $p<0.053$).

Table III. Public awareness messages promoted in both surveys

Public awareness message	Pilot (SEACFMD) (±SD; SE)	OIE (±SD; SE)
Vaccinate animals regularly	0.78 (±0.42; 0.15)	0.80 (±0.40; 0.08)
Don't trade sick animals	0.78 (±0.42; 0.15)	0.92 (±0.27; 0.06)
Only feed cooked food scraps to pigs	0	0.45 (±0.49; 0.11)
Don't communally graze livestock	0.56 (±0.5; 0.18)	0.73 (±0.44; 0.09)
Keep accurate records of livestock events	0	0.96 (±0.20; 0.04)

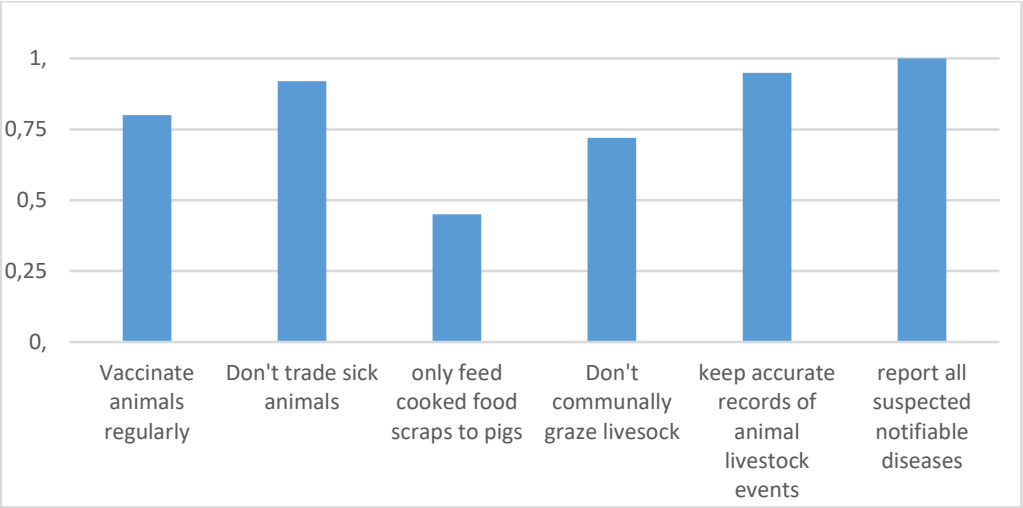

Fig. 13. Messages promoted in public awareness campaigns

The message of only feeding cooked swill to pigs appears to have been promoted by more countries in the OIE Delegates survey, although the numbers are still low. The keeping of accurate records was also promoted at a much higher level in the OIE Delegates survey and although this finding may appear to be attributable to inclusion of more developed countries, there were no significant differences found on comparison of the responses to this question between Income-1 and Income-2 or OIE-1 and OIE-2 categories. Interestingly, one country responded to this question in the OIE Delegates survey but not in the pilot survey, with differences to this question noted in the responses by two countries between the two surveys, reflecting the likelihood that different personnel view the practices in their country rather differently. Emergency disease responses during TAD outbreaks are promoted in 91% of the countries, with responses varying from promoting quarantine and hygiene practices to full scale outbreak management plans.

⇨ *Comparisons of responses to some questions between the pilot survey and the OIE Delegates survey, identified differences in responses between the two cohorts of interviewees, suggesting inconsistencies in understanding of questions or the practices and policies that could be addressed to ensure biosecurity programme leadership provides more consistent messaging.*

Fig. 14. Example of a trader biosecurity awareness poster from Laos

DISCUSSION

Two surveys of biosecurity practices in relation to the five principles of biosecurity, were successfully conducted in August and October of 2017 involving 10 national SEACFMD Coordinators and 25 OIE Delegates or their nominees, respectively. The data provides important insights into the current considerations of the leadership personnel responsible for addressing international and national expectations of collaborative TAD control programmes and FMD in particular. As a larger dataset would be preferred to establish more statistical support for the inferences emerging from this work and enable sharing through the scientific peer-reviewed publication process, it offers useful information for the 30th Conference of the OIE Regional Commission for Asia, the Far East and Oceania in Malaysia in November 2017.

A number of key findings from the surveys are as follows:

- All countries advised they would like the OIE to work on developing a template for farm biosecurity plans and most requested biosecurity support training and access to expertise;
- Achieving border check-point compliance through closer collaboration should be a major biosecurity priority for countries in the SEACFMD Campaign;
- Communal grazing and sale of non-vaccinated animals in FMD-endemic countries are risk factors for the spread of FMD and local strategies to minimise these risks need to be developed [1, 3, 10]
- Trader engagement in FMD control is a challenging and a problematic area that needs further attention for achieving more effective biosecurity [1, 10]
- Promotion of basic hygiene messages on biosecurity is required to improve practices and although challenging, it is of considerable importance in achieving more effective biosecurity [1, 3, 4, 10]
- The modest responses to questions on improved feeding strategies, indicates that the importance of nutrition as a driver for improved health practices and livelihoods needs further recognition [1, 12]
- The promotion of feeding cooked food scraps to pigs, the keeping of accurate records of animal health events, and ensuring wild birds do not have access to water used for commercial poultry (HPAI risk), needs promotion as these help prevent and manage biosecurity risks [1, 3]
- The quarantine, isolation of and discouraging sale and movement of ill animals, plus trading of vaccinated animals and engaging with traders, needs more promotion at village and smallholder farm [1, 3]
- The use of systemic antibiotics for FMD treatment is common and an issue deserving attention in the context of the emergence of global AMR; development of an alternative business model for veterinary para-professionals based on 'disease prevention is preferred to treatment' is required [11]
- Use of 'negative disease reporting' and developing coordinated emergency response teams (e.g. an FMD Task Force) is considered critical to improving effectiveness of surveillance, vaccination, public awareness and other biosecurity aspects in endemic FMD countries [1, 3]
- Use of mobile applications, social media and e-mail appears to be emerging, with clarification of their use and efficacy required to confirm the likelihood that this has improved TAD surveillance over the more widespread use of paper and fax communication.

An interesting observation in these surveys was that responses to some questions differed between the pilot and the OIE Delegates survey, even from the same country. This indicates the likelihood of inconsistencies in understanding of either the questions or the practices and policies to improve biosecurity programme leadership. This strengthens arguments for the role for OIE in supporting biosecurity development, including provision of templates for farm biosecurity plans, biosecurity support training and provision of access to expertise able to ensure strong technical leadership.

The 'Five principles of biosecurity' can be aligned with the 'Five factors of change management' to provide a robust framework for improving biosecurity practices, requiring exploration and understanding of: motivations for change; resistance to change, knowledge management requirements; cultural dimensions and farming systems; plus effective leadership [10, 12]. Implementation of biosecurity

interventions suitable for smallholders through to commercial operations is a complex process of education aimed at empowering people to make better personal decisions rather than necessarily adopting prescribed pre-defined interventions.

Biosecurity interventions need alignment with the motivations of all involved in the supply change of livestock production, preferably offering clear short-term risk management benefits that elicit interest, investment and application. As the practices of the commercial sector demonstrate, the linking of biosecurity and disease control with improved livestock productivity and financial outcomes is important as it provides opportunities for sustainable improvements in livelihoods and economic development and a more effective FMD control and eradication strategy.

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REFERENCES

1. Windsor P.A. (2011).– Review: perspectives on Australian animal health aid projects. Editor invited paper. *Transbound Emerg Dis.,* **58,** 375–386. doi:10.1111/j.1865-1682.2011.01216.x.
2. Rweyemamu M., Roeder P., Mackay D., Sumption K., Brownlie J., Leforban Y., Valarcher J.F., Knowles N.J. & Saraiva V. (2008).– Epidemiological patterns of foot-and-mouth disease worldwide. *Transbound Emerg Dis.,* **55,** 57–72. doi:10.1111/j.1865-1682.2007.01013.x.
3. Windsor P.A., Freeman P.G., Abila R., Benigno C., Nim V. & Cameron A. (2011). Foot-and-Mouth Disease Control and Eradication in the Bicol Surveillance Buffer Zone of the Philippines. *Transbound Emerg Dis.,* **58,** 421–433. doi:10.1111/j.1865-1682.2011.01225.x.
4. Windsor P.A., Khounsy S., Sothoeun S., Nampanya S., Stratton J., Rast L., Henry L. & Bush R. (2010).– Village-based approaches to biosecurity in the Mekong region. *In:* Adams L.B., Gray G.D. and Murray G. (eds.) 2012. Animal biosecurity in the Mekong: future directions for research and development. Proceedings of an international workshop held in Siem Reap, Cambodia, 10–13 August 2010. *ACIAR Proceedings*, **137**, 97–100.
5. Windsor P.A. & Young J. (2013).– Workshop summary. *In:* Young J.R., Rast L., Suon S. and Windsor P.A. (eds) 2013. Cattle health, production and trade in Cambodia. Proceedings from three ACIAR-funded projects presented at an international workshop held in Phnom Penh, Cambodia, 7–8 June 2011. *ACIAR Proceedings,* **138**, 11–12.
6. Young J.R., Sothoeun S., Andrews C.J., Henry L.A. & Windsor P.A. (2013).– Assessment of financial impact of foot and mouth disease on smallholder cattle farmers in southern Cambodia. *Transbound Emerg Dis.*, **60,** 166–174. doi:10.1111/j.1865-1682.2012.01330.x
7. Nampanya S., Khounsy S., Young J.R., Phonvisay A., Bush R.D. & Windsor P.A. (2013).– Financial impact of foot and mouth disease on large ruminant smallholder farmers in the Greater Mekong Subregion. *Transbound Emerg Dis.,* **62**, 555–564. doi:10.1111/tbed.12183.
8. Nampanya S., Rast L., Khounsy S. & Windsor P.A. (2010).– Assessment of farmer knowledge of large ruminant health and production in developing village-level biosecurity in northern Lao PDR. *Transbound Emerg Dis*. **57,** 420–429. doi:10.1111/j.1865-1682.2010.01168.x.
9. Nampanya S., Suon S., Rast L. & Windsor, P.A. (2011).– Improvement in smallholder farmer knowledge of cattle production, health and biosecurity in southern Cambodia between 2008 and 2010. *Transbound Emerg Dis.,* **59,** 117–127. doi:10.1111/j.1865-1682.2011.01247.x.
10. Young J.R., Evans-Kocinski S., Bush R.D. & Windsor P.A. (2013).– Improving smallholder farmer biosecurity in the Mekong region through change management. *Transbound Emerg Dis.*, **62**, 491–504. doi:10.1111/tbed.12181.
11. Stratton J., Toribio J.A., Suon S., Young J.R., Cowled B. & Windsor P.A.(2015).– Are Village Animal Health Workers able to assist in strengthening transboundary animal disease control in Cambodia? *Transbound Emerg Dis.*, **64**, 634-643. doi:10.1111/tbed.12432.
12. Young J.R., Suon S., Olmo L., Bun C., Hok C., Ashley K., Bush R.D. & Windsor P.A. (2017).– Investigation of smallholder farmer biosecurity and implications for sustainable foot-and-mouth disease control in Cambodia. *Transbound Emerg Dis.,* **64**, 2000–2012. doi:10.1111/tbed.12609.