FOOT-AND-MOUTH DISEASE CONTROL IN ENDEMIC SETTINGS: COMBINING EPIDEMIOLOGY, RISK ASSESSMENT AND VALUE CHAINS ANALYSIS TO IDENTIFY RISK CONTROL POINTS

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ABSTRACT

Foot-and-mouth disease control in endemic settings poses a number of challenges, particularly the extreme contagiousness of the infection, host range, the diversity of production sectors at risk, and the optimum use of the limited financial and human resources available to veterinary services. Targeting of these resources and regulatory controls to interrupt or reduce transmission at critical points in FMD transmission cycles could achieve significant advantages over programs that do not discriminate between risk groups, as occurs in most national mass vaccination programs which developing countries could hardly sustain. Traditional FMD surveillance is focused on the density and distribution of livestock population without taking into account the level of risk of different ecosystems, production systems and market chains. Risk based disease surveillance using analysis of livestock markets, livestock and animal product circuits must be a guiding element in the analysis of FMD risks and decision-making for control interventions addressing those risks. This paper will provide examples from FAO programs of how these critical control points can be identified, and will outline ideas for expanding the use of the methods in endemic countries as part of national FMD control strategy development. In particular, it will:

1) Illustrate how a risk factor/ production and marketing chain approach can be used to develop consensus on risk and critical control points within a livestock marketing (value) chain, using examples on ongoing FAO activities in Ecuador, Venezuela (GTFS/RLA/172/ITA) and Vietnam;
2) Illustrate how a combination of outbreak investigation, marketing chain analysis, and serological surveys at markets and slaughterhouses has been used to identify critical control-points in FMD control in Turkey;
3) Illustrate how a serological (NSP antibody) survey approach can be used to identify how FMD exposure is related to production/marketing chains, species and age, using examples from the multi-country FMD surveillance program in five Central Asian countries (GTFS/INT/907/ITA);
4) Outline how the use of the methods could be expanded to assist other endemic countries to identify strategies for reducing FMD risk.

2. CASE STUDY N°1

Foot-and-mouth disease risk assessment in endemic settings of Viet Nam, Ecuador and Venezuela using value chain analysis

2.1. Background

Often, the focus of disease control in response to outbreaks or prevention in response to perceived threat is on spatial or geographical, so-called ‘local’ means of disease spread, plus sometimes spread through air currents. This leads to such disease control and prevention measures as quarantine areas (‘protection zones’), local area culling, ring vaccination and buffer-zone vaccination. However, these measures fail to take into account the fact that animal disease is often spread through the actions of people involved in the production and marketing of animals and their products. Thus, infected animals can be rapidly trucked across vaccinated buffer zones, traders carrying virus on their vehicles, can move from farms within ring vaccinated zones to farms outside and pigs can be infected with swine fever as a result of feeding waste feed (swill) with origins outside a country. In this way, disease can be seen to spread by direct animal to animal contact or indirect contact (by carriage of infectious virus on people, vehicles, equipment etc.) over variable
distances and along routes that are determined by patterns of production and trade, rather than
disease spreading between contiguous animal populations as a result of proximity (local or
contiguous spread).

A better understanding of the dynamics of livestock production and marketing chains in FMD
endemic settings could improve the understanding of transference of risks within chains. Value
chain analysis in combination with risk assessment could be used as a tool to identify critical risk
points within the different livestock chains and therefore risk based control interventions used to
tackle disease risks.

By definition a value chain ‘describes the full range of activities which are required to bring a
product or service from conception, through the different phases of production (involving a
combination of physical transformation and the input of various producer services), delivery to final
consumer, and final disposal after use’ (Kaplinski et al., NK). Value chains can be described
pictorially, orally and in some cases quantitatively. Such structures provide a good starting point
and can create good discussions particularly to identify hazards and risk issues. The first result of
value chain studies is often one or several diagrammatic value chain ‘maps’ consisting of boxes
representing different actors and/or production/marketing sites in the chain and lines or arrows
indicating flows of poultry and products between these boxes.

2.2 Methodology

This project has been divided in three main phases:

- The first phase started with an initial desk based data collection of disease information and
characteristics of production systems in each country and ended with one workshop in each of
the countries selected.
- Based on the data gathered, the second phase concentrated on the development of detailed
value chains for different production systems and products in each country.
- The third and last phase is the identification of risk control points and their assessment.

For every workshop participants represented main actors of livestock production systems and
marketing chain in livestock production, for example producers, representatives from
slaughterhouses and dairy plants, private veterinarians, representatives of national veterinary
services, traders and animal health services and representatives of wholesale, retail and trade.

Before the workshop a questionnaire with relevant questions was addressed to the participants to
in order to give a guideline on the information that needed to be collected during the workshop.

The risk assessment approach is based on gaining detailed understanding of the ‘value chains’
associated with production, trade, marketing, and consumption of meat and other products of the
relevant species (pigs, bovines, small ruminants). The following information relevant to FMD risk
assessment was collected during discussions with stakeholders:

- Overview of the FMD epidemiological situation;
- Overview of local farming systems;
- Data on production systems for susceptible species such as bovines, pigs and small ruminants;
  what are current and future trends?
- A detailed description of the different value chains identified by participants that varies between
countries.

Using three of the four basic principles of risk assessment described in the OIE Code (release,
exposure and consequences; the fourth being ‘risk estimation’), the risk factors which are likely to
affect the probability and amount of FMD occurring were identified throughout the description of
value or market chains derived from the workshops.

Risk factors were subdivided into those which have their main effects on FMD introduction,
exposure of local livestock or related to FMD spread. A qualitative assessment of the level of risk
was presented and each risk factor identified.

2.3. Preliminary results of the study

An initial draft value chain was mapped and described by participants for each of the three
workshops. Extensive production systems, beef chains, milk production chains, pig, sheep and goat
production and marketing chains were discussed and described by the participants in each of the
country of study.
Value chains are not uniform and static; for instance in Viet Nam, three different chains were described for pig production and there was a marked seasonality of pork supply identified, in particular from smallholder production systems which contribute to almost 80% of the pork production.

In Venezuela, for instance, large scale cattle production can be divided into four different production systems including extensive commercial cattle production, commercial milk production, beef fattening and dual purpose production (Figure 1).

Figure 1: Dairy value chain in Venezuela

During the workshop in Venezuela, two market chains were discussed by the stakeholders in the workshop:

- Dairy value chain and
- Beef cattle chain.

The second step is to complete the value chains and information is to include additional information on types of products, prices or volume of transactions, or added margins of profit along the chains. From the preliminary identification of risk control points by the stakeholders in the different value chains described during the workshops, most of the risk for FMD spread in all three endemic
countries studied comes from movement of live animals, contamination from poorly regulated slaughter facilities, swill feeding, feeding of animals with milk untreated by heat, use of manure or bedding as fertilizers, spread by fomites carried by traders and transporters of live animals and to a lesser extent fomites carried by other farm service providers.

Also communal grazing and sharing of breeding males in cattle or pig productions also contribute to risk of local spread. In the closing phase of this project, the value chains identified will be revisited in more detail to understand how these risks can be mitigated in a stakeholder-friendly way. Moreover, some risk mitigation measures will be proposed and evaluated with stakeholders in more detail with reference to the country-specific analyses already carried out (and supplementary information where needed) and assessed with respect to their potential impact on stakeholders within the value chains and costs associated for the final phase of this study.

3. CASE STUDY №2

Risk assessment of FMD in Central Asian countries

3.1 Background

FMD is known to be present in some of the Central Asian countries of the FAO GTFS/INT/907/ITA regional project, which encompasses Afghanistan, Pakistan, Tajikistan, Turkmenistan and Uzbekistan.

The common strategy usually adopted in order to control the spreading of the disease is through vaccination targeting specific areas. Mass vaccination programs could hardly be carried out both for financial and logistics constraints and the issue of identifying specific target populations to be vaccinated appear rather important in order to optimize the usually scarce resources available.

In this paper we assume that the overall risk of becoming infected with FMD virus is not evenly distributed among the different livestock productive systems that may be present in a given country and that, subsequently, it is possible to qualify and quantify such risks so that any control program could be targeted initially on the higher risk groups and thus make the biggest impact on the course to progressively reduce the load of FMD virus. The assumption is that geographical factors are not the only features that need to be taken into account in designing a disease control strategy for FMD.

In this regard a collaborative study has been carried out with the Danish Technical University in the Landhi Dairy Colony located in Bin Qasim, in the suburbs of Karachi, Pakistan during 2006-2007 is of relevance. The Dairy Colony is a particular productive system and Landhi is considered the world largest buffalo colony. It was first established in 1958 in order to move existing buffalo populations out of the residential areas of Karachi which were causing problems for the disposal of dung. Initially the colony extended over an area of 752 acres but today it extends over an area of approximately 1,600 acres (approximately 6.7 km²) and with an animal population of more than 300,000 head, 95% of which are buffaloes. Currently, there are about 2,000 dairy farms in the colony.

The dairy colony production system has some peculiar characteristics. The animals are kept on individual farms for milk production but only for the period of their lactation (230-300 days), so recently calved and near-calving animals are purchased and brought onto the colony farms. The calves are generally not kept with and only high-yielding milking animals are maintained in this production system. This system is dominated by the buffaloes as buffalo milk contains higher butterfat and is preferred by the customers. In order to fulfil the market demand the production level of the farm is maintained at almost constant level through an intense turn-over of animals. On average 10 to 12 per cent of animals in dairy colonies are replaced monthly. The animals are brought from livestock rich districts of Punjab and Sindh Provinces. The dairy farmers of the colonies directly purchase the animals from villages (20 to 30 %), livestock markets (55 to 65 %) and from ‘buffalo hotels’ or ‘piri’ (10 to 15 %) established in Karachi where livestock traders bring the animals for sale. There is no grazing in this production system and all animals are stall-fed using green fodder and high concentrates. Breeding activity varies from farm to farm but generally is minimal. The current trend of increase in prices of animals has resulted in enhancing the animal breeding activities at the dairy colonies (Afzal M, 2003).

The study focused on the detection of FMD virus or viral RNA both from clinically and non-clinically affected animals and in the same study, a serological investigation was carried out with 180 serum samples collected between April 2006 to April 2007 from slaughtered animals that had spent at
least one lactation period into the Landhi Colony. Out of 180 samples collected 176 (98%) had detectable levels of NSP antibodies (Klein J, et al 2007, 2008). This finding was consistent with animals, sampled at any given point in time (slaughter) that had the common experience of having spent into the colony at least one lactation period (230-300 days) in Landhi.

Presently no data are available on the level of NSP antibodies that may be present on the population entering for the first time the colony. Undoubtedly the level of exposure to FMDV seems to be relevant and it is assumed that transiting into the colony would increase the risk of exposure to FMD virus to a certain extent which should be reflected in the different level of antibodies between pre and post-exposure.

The study carried out in the Dairy Colony has provided a good indication of how the level of exposure to FMD virus may be strictly linked with a specific productive system. It is in fact suggested (Klein J, et al 2008) that this peculiar system could be targeted for a vaccination program which in turn should contribute to reducing the overall load of the FMD virus. While for Pakistan, the Dairy Colony may be considered an important "hot spot" for FMD virus, there is the possibility that other production systems with equivalent or significant level of risk that should be identified and addressed in order to progressively reduce the overall load of FMD virus. For this purpose a surveillance program has been designed and in the present paper it is presented the serological component of such plan.

3.2 METHODOLOGY

In an attempt to quantify how the risk of becoming infected with FMD virus may be distributed into different productive systems the following ones have been identified in the participating countries of GTFS/INT/907/ITA: (i) households animals; (ii) commercial sector - dairy; (iii) commercial sector - beef; (iv) genetic centers (usually government farms); (v) dairy colonies (only in Pakistan); (vi) animals seasonally moved to pastures; (vii) animals at slaughterhouses. The level of exposure to FMD virus will be measured through the detection of NSP antibodies and the target species for the survey will be cattle and buffaloes, which are considered equivalently susceptible to infection. The sample design and criteria adopted to conduct the study are a combination of what could be practically achieved while measuring the statistical robustness of the estimates. The approach is the one of a cross-sectional study with a blood-sampling scheme where the criteria of eligibility for individuals to be included in the sample are category and age (Cannon R, et al 1982; Fleiss J, 1981). The epidemiological unit of concern may vary according to the particular category. This may be the village itself (in the case of household animals) or the farm for animals into commercial units such as dairy, beef etc.) or directly the individual animals in the case of a pre and post exposure assessment (transhumant/pastoral and dairy colony animals). The sample size required for each one of the combination age/categories identified above will not differ substantially from any survey that has to reach a certain level of statistical significance. In this particular study the proposed approach is, usually, through a multistage sampling scheme with the first stage identified with the epidemiological unit and the second stage with individuals into the unit distributed into three different age categories (0-1 yr; 1-2 yrs and more than 2 yrs). The general criteria established for estimating the sample size aimed at: (i) maintaining the standard error of the estimated proportion at an acceptable level (maximum tolerable error 11% at 95% confidence level); (ii) to be able to detect (at 95% confidence level) the presence of at least one NSP antibodies positive animal if the proportion (in each age category) of positive is equal or more than 20% (with no adjustment for test sensitivity and specificity); (iii) to be able to detect a prevalence risk ratio not exceeding 3.2 between two independent proportions with a type I and type II error of 0.05 and 0.1 respectively.

In considering the criteria above, the outcome for the sample size estimation in different epidemiological units and categories is shown in table 1:

<table>
<thead>
<tr>
<th>Category</th>
<th>Household (with epi-unit being the village)</th>
<th>Dairy</th>
<th>Beef</th>
<th>Genetic centers</th>
<th>Transhumant/Pastoralists</th>
<th>Slaughtered</th>
<th>Colonies</th>
</tr>
</thead>
</table>

Table 1: Minimum sample size in different categories in each country
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<table>
<thead>
<tr>
<th>N. units to be sampled</th>
<th>60</th>
<th>5</th>
<th>5</th>
<th>n.a.</th>
<th>n.a.</th>
<th>n.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. Individual Samples</td>
<td>2880</td>
<td>240</td>
<td>240</td>
<td>240</td>
<td>300 (two rounds of 150 each)</td>
<td>300 (two rounds of 150 each)</td>
</tr>
<tr>
<td>Max SE (95%)**</td>
<td>3.2%</td>
<td>11%</td>
<td>11%</td>
<td>11%</td>
<td>8.2%</td>
<td>5.8%</td>
</tr>
<tr>
<td>Range of Min. detectable PRR**</td>
<td>1.36 2.7</td>
<td>1.52 3.2</td>
<td>1.52 3.2</td>
<td>1.38 2.5</td>
<td>1.22 1.7</td>
<td>1.38 2.5</td>
</tr>
</tbody>
</table>

Note:
* Maximum tolerable standard error at 95% confidence level
** Range of the Minimum Prevalence Risk Ratio (PRR) detectable with any given lowest group for prevalence ranging from 0.1 to 0.5 (Type I error 0.05; Type II error 0.1). Only for the categories "Transhumants" and "Colonies" the range for PRR has been estimated within group.

Two additional issues are to be considered: (i) most of the large ruminants present are at the household level, thus this category is the most represented in the sampling scheme; (ii) commercial farms are rare to find in the GTFS/INT/907/ITA beneficiary countries. Live animal markets are not included into the present blood-sampling scheme. Reasons for this are that usually owners at the live markets are not keen to have their animals sampled. In order to target this system a concurrent activity which foresees clinical inspections and swabs/tissue sampling from both clinically (if any) and not-clinically affected animals will be implemented.

4. BIBLIOGRAPHY