Brown F, Roth J (eds): Vaccines for OIE List A and Emerging Animal Diseases.
Dev Biol. Basel, Karger, 2003, vol 114, pp 281-289.

Factors to Consider When Using Vaccine to Control an Exotic Disease Outbreak

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Abstract: Recent global events have dramatically increased the attention given to veterinary medical regulatory authorities' responsibility of protecting their country's agricultural interests from the threat of exotic disease outbreaks. A vaccine can be a valuable tool to help curb the spread of an exotic disease epidemic and/or lessen its economic impact. However, the decision on whether or not to use a vaccine during an outbreak may be complex and have far-reaching impacts. The decision must be approached in a logical and orderly fashion, taking into account the scientific, economic, political, and practical considerations that are unique to each individual disease outbreak. A decision-making process for the use of a vaccine developed for foot-and-mouth disease and its potential application to help decide on the use of vaccines in other exotic disease outbreaks is discussed.

Introduction

The United States Department of Agriculture, Animal and Plant Health Inspection Service (USDA, APHIS) is charged with the responsibility of protecting U.S. agriculture from exotic diseases. Recent global events have dramatically increased the attention given to this responsibility, not only for USDA, APHIS, but for comparable veterinary medical regulatory authorities worldwide. Outbreaks of classical swine fever in the European community, the devastating foot-and-mouth disease epidemic in the United Kingdom, and the increased threat of deliberate introductions of animal diseases by terrorists, have caused veterinary medical regulatory authorities to re-visit and strengthen their emergency preparedness. Many response plans include the potential for using vaccines to help curb the spread of an epidemic and/or lessen its economic impact. The decision to use, or not to use, a vaccine in the face of an exotic disease outbreak can be complex and have far-reaching socio-economic consequences. Incorrect decisions or delays occurring during the actual outbreak can be costly. Every outbreak is unique, and it is not reasonable to prepare contingency plans for all possible scenarios; however, a well-structured, logical, and thorough decision-making process can, and should, be included as part of any emergency plan.

Such a process was developed and tested for a foot-and-mouth disease (FMD) response plan, as a result of tripartite exercises with Mexico, Canada, and the United States conducted in the autumn of 2000. Although this decision tree/matrix was developed specifically for FMD, little modification is required to adapt it to other exotic diseases.

Decision process

The process uses a decision tree flowchart (Fig. 1), combined with decision matrices, which consider multiple-related factors for individual decisions, which are arranged sequentially. The decision process starts from the top left (Decision Box 1) and proceeds to Decision Box 5 in the bottom right of the figure.

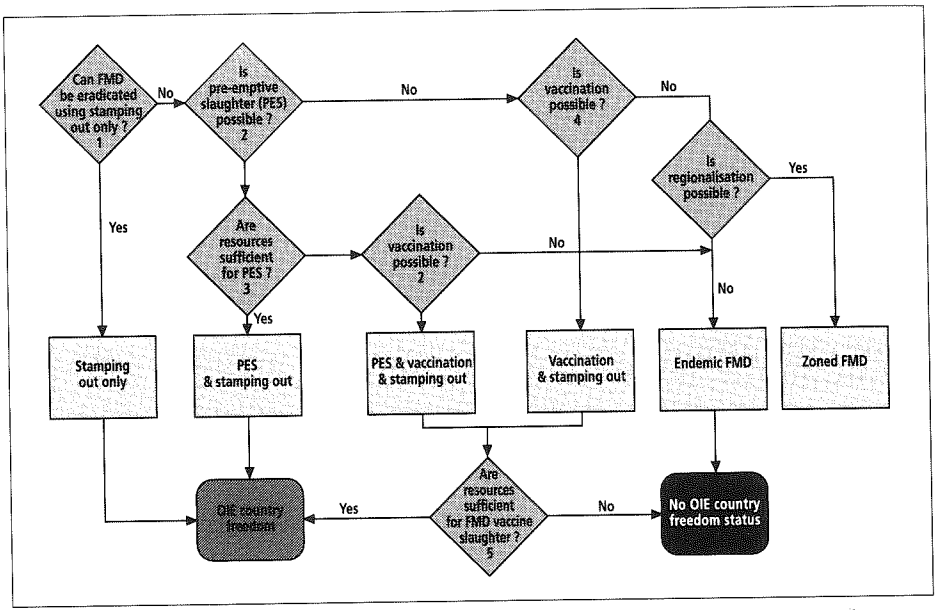

Fig. 1: Decision tree for FMD vaccine use.

Each decision box is supported by a decision matrix, where appropriate factors are listed for consideration. The factors have been grouped into four pivotal factors that characterise the nature of the epidemic (Outbreak Factors) and four pivotal factors that describe mitigation measures for the outbreak (Mitigation Factors). Each pivotal factor has numerous subfactors described below:

Outbreak Factors are:

Contact Rate
Host or Species Affected/Species at Risk
Status of Outbreak
Environmental

Mitigation Factors include:

Physical Resources
Human Resources
Sociopolitical Factors
Economic Considerations

Nearly all of these factors are common to all outbreaks of exotic diseases, so the process can be modified to fit many other exotic diseases. The following describes factors that must be considered when deciding specifically whether to vaccinate during a disease outbreak (corresponding to Decision Boxes 1, 4, and 5 in Figure 1):

Can the disease be eradicated using stamping out only?

In this decision box, all outbreak factors and mitigation factors must be considered. For FMD, this is the point of departure from the preferred, traditional policy of stamping out.

Contact rate

Contact rate is a critical factor for modeling a disease outbreak. The contact rate will vary considerably, depending on the methods of disease spread. However, contact rate factors include:

Kind of farms

For example, dairies and feedlots tend to have a higher rate of movement in and out, as opposed to other types of operations (e.g., a back yard producer). So, if the affected area has a lot of dairies and/or feedlots, the weight given to this factor should be increased.

Direct and indirect movement

The movement of animals (direct), people or equipment (indirect), or other possible vectors, such as wildlife, must be considered. The frequency of movement of animals from infected farms is more important than equipment or people. Indirect movement includes fomites, such as equipment, contamination of supply delivery vehicles, veterinarians, and farm workers; it also includes marketing of animal products and by-products. Distance of movements is also important for the spread of the outbreak. This factor should also include an estimate of illegal movements in the outbreak area, as well as past movements.

Host

The species affected and species at risk must be considered. Modeling in the USA for FMD suggests that if more than two swine herds are involved at the time of detection, stamping out alone will not be sufficient.

Domestic livestock

For FMD, swine are crucial because of their ability to amplify the amount of virus that can be spread by airborne means. Sheep and goats tend to have sub-clinical disease and be less likely to spread virus by aerosol. These types of host-pathogen specific interactions must be considered in all exotic disease outbreaks.

Game farms, zoos, wildlife

This must include consideration of genetics or endangered species that must be maintained (animals cannot be slaughtered). Additional considerations include the effectiveness of quarantine or isolation methods and the special handling methods that must be used with exotic livestock and wildlife.

Pathogen tropism

The tropism of the pathogen may not be immediately known. Additional surveillance testing of non-target species will be required.

Status of outbreak

This is an estimation of the extent and duration of the epidemic. For FMD, modeling in the U.S.A. suggests that if five or more herds are affected, with two foci separated by 10 km, stamping out alone will not be successful. Sub-factors to be considered include:

Number of affected flocks/herds

The greater the number, the more likely it becomes that there are undiscovered, or incubating, flocks or herds. A large initial number also could indicate biological terrorism, as would detection of more than a single serotype in an outbreak.

Number of foci

One focus of infection would be less likely to spread before stamping out could contain the outbreak. Two or more foci, separated by 10 km or more, would indicate that the outbreak has already spread.

Rate of spread

Rapid spread would be reflected in an increasing number of cases per day or week. Rate of spread estimates, based on epidemiological data, may be used. During the initial phases of any disease outbreak, it is important to differentiate the true rate of spread from the increased detection of pre-existing, but undiscovered, cases as surveillance mechanisms are implemented.

Environment

This factor includes cultural and physical geography, as well as climate.

Livestock and farm density and distribution

This evaluates the number of herds/animals per square unit of area. The likelihood of spread increases as the density of animals increases and the area densely populated with animals increases.

Livestock management

This factor considers whether the majority of affected producers are large corporations/owners on private land, communes, small producers, or back yard subsistence producers, as the predominant management practices are likely to have an impact on the outbreak.

Casual access

This factor considers the network of transportation corridors in the outbreak area and its simultaneous use by casual human and vehicle traffic.

Physical barriers

This factor considers whether the outbreak occurs in a naturally isolated area (i.e., desert, island/isthmus, rivers, mountains).

Climate

Prevailing winds, temperature, and humidity conditions that favour airborne spread (if possible) must be considered.

Physical resources

Slaughter capacity

Facilities must be adequate to handle the slaughter of all infected and suspect animals. On-farm slaughter may be necessary.

Transportation capacity

If conditions prohibit on-farm disposal, there must be bio-secure methods of transportation available for carcasses and all other exposed materials.

Disposal capacity

If on-farm disposal is required and available, there must be sufficient heavy equipment for burial or incineration. If off-farm disposal is required, there must be adequate rendering facilities, burn sites, or burial sites.

Human resources

Emergency response system/movement control

There must be sufficient trained staff (and administrative support) for stamping out and to enforce movement restrictions to limit spread. The level and quality of surveillance must be sufficient to enforce movement controls.

Epidemic projections

Region-, species-, or cost-specific projections may aid in decision-making.

Social-political

Legislation available

Legislation may be necessary for mandatory depopulation efforts.

Public opinion/legislative will/appearance of government

The current welfare/animal rights climate, including public perception of affected animal destruction, should be considered. Regulatory officials must maintain the trust and confidence of the general public through direct, timely, and constant lines of communication. Public opinion must be considered in the decision-making process.

Industry acceptance

The producer organizations should concur with the decision to stamp out the outbreak, so the information on which tracebacks are based is more likely to be credible and fully disclosed. The opinion of non-affected livestock industry sectors should also be considered if the agricultural economy in general is affected by international restrictions.

Socio-economic status of producers' region

The sophistication, as well as the socio-political influence, of the producers in the affected region should be considered. Care must be taken to ensure equal treatment regardless of status and keep the implementation of control efforts consistent.

Economic

Compensation

There must be sufficient funding for indemnity payments for the potential number of animals that will be eliminated by stamping out. Differential payments for commercial versus pure-bred herds should be considered, as should compensation for lost production and animal products and by-products.

Value of exports

The value of the disease-free status of the country in the export market should be considered and compared to the cost of the eradication effort.

Regionalization

The ability to regionalize the affected area, so that animals outside the infected region may retain their international acceptance, should be explored.

Is vaccination possible?

Physical resources

Vaccine availability

Efficacious vaccine(s) against the correct disease strains must be available.

Vaccine doses available

A sufficient amount of the vaccine must be available.

Vaccine logistics

It must be possible to distribute the vaccine to the field in a timely manner and to store the vaccine under suitable conditions in the field setting. Facilities must be adequate to administer the vaccine to the animals, and record-keeping practices must be suitable for identifying and tracking vaccinated animals.

Laboratory capacity

Ideally, it should be possible to distinguish vaccinates from infected animals. If such a vaccine is used, one must consider whether cooperating laboratories have the diagnostic capability and capacity to analyse suspect and surveillance samples during, and after, an outbreak.

Human resources

Emergency response system/movement control

There must be sufficient trained staff to vaccinate animals and to enforce subsequent movement restrictions.

Risk of disease spread

Provisions must be made to prevent vaccination teams from spreading the disease as they move from farm to farm.

Epidemic projections

The possibility of additional outbreaks due to an increased risk of carrier animals or inadequate vaccine coverage must be considered.

Social-political

Legislation available

Legislation may be required for mandatory vaccination.

Public opinion/appearance of government

The current welfare/animal rights climate must be considered, as must the potential for public perception that vaccination leads to an inferior product or trade restrictions. Regulatory officials must maintain the trust and confidence of the general public through direct, timely, and constant lines of communication. Public opinion must be considered in the decision-making process.

Industry acceptance

The producer organizations should concur with the vaccination decision, to increase the chances that all susceptible animals will be presented for vaccination.

Consideration must be given as to whether the industry would rather avoid vaccination and be compensated at market value or vaccinate their animals and have the livestock market value reduced.

Socio-economic status of producers'region

As above (p. 286).

Economic

Cost of vaccination

The cost of vaccination must be considered.

Value of exports

It should be determined whether vaccination will reduce exportation from the country in general. The cost/benefit ratio of the additional time to attain country-free status after vaccination should be considered.

Regionalization

The possibility of regionalizing the affected area should be considered, so that international acceptance of exports from outside the affected region can be maintained despite vaccination.

Are resources sufficient for a vaccination-slaughter programme?

The disposition of vaccinates is a separate consideration from the decision to vaccinate, but it may be necessary to regain "free" status for international trade. For FMD, the OIE standard for "FMD free without vaccination" status is achieved three months after the slaughter of the last vaccinate, whereas "FMD free with vaccination" status is achieved 12 months after the last FMD case.

For previously FMD-free countries choosing to vaccinate in an outbreak and not slaughter all vaccinates, a six-month period after the last case is required provided that a serological survey based on the detection of antibodies to non-structural proteins of FMDV demonstrates the absence of infection in the remaining vaccinated population. There are international markets whose standards exceed those of OIE. Thus, this is primarily an economic consideration, but other mitigation factors also play a role. Resource, disposal, and compensation factors, similar to those considered in the decision to vaccinate, should be considered before implementing a programme to slaughter vaccinated animals.

Discussion

Each disease outbreak is unique, and each disease has unique epidemiological factors. Regardless of the disease, however, the decision to use vaccine in control and eradication efforts must be based on the same scientific, economic, political,

and societal factors. Many times the decisions made for control and/or eradication efforts cannot be entirely science-based. For example, a vaccination programme may be very effective in eliminating clinical disease, yet cripple a country economically because of the huge losses in exports. Similarly, a genetically-engineered vaccine may be highly effective in eliminating a disease, but if the public will not consume meat from vaccinated animals, the vaccine may have limited value. The ultimate goal of any control procedure should be not only to eliminate the disease, but also to eliminate negative economic impacts of the disease.

Even though a decision whether or not to use vaccine to control an exotic disease outbreak cannot be pre-determined, a decision-making process can be established ahead of time. Knowing what inputs will be required for such decisions, efforts can be focused now on preparedness. Basic disease research can aid in the development of new, or improved, vaccines and diagnostics. Education programmes can prepare livestock owners, consumers, and the general public for what to expect in the event of an outbreak. Legislation can be passed to establish appropriate emergency authorities. Regulators can implement and practise plans for mobilizing quickly and efficiently. Livestock and wildlife population density maps can be established and made readily available. Vaccine sources can be identified and evaluated for capacity and speed of product delivery. Disposal sites and slaughter facilities can be located and mapped for quick access. The required staffing sources can be identified, trained, and tested for their respective roles during an outbreak. These efforts will increase the probability that fast, appropriate decisions will be made in the face of a disease outbreak and that responses will be coordinated and timely.

Acknowledgements

Many thanks to Dorothy W Geale, John B Belfrage, and MVZ Susana Arellano and MVZ Cesar Villarreal for developing the decision tree/matrix for foot-and-mouth disease. Thanks also to Paul Hauer, for assistance with the preparation of this manuscript.

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