Output-Based Standards in Animal Health – Prevention of the Spread of Tuberculosis as an Example

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ABSTRACT

National, regional and international standards are used in animal health to assist in disease control, including standards for recognition of a farm, zone or country as free from infection. Traditionally, these standards have been based on prescriptive descriptions of the amount of surveillance that is required (the input). The probability that a herd (or other grouping of animals) is infected is influenced by a range of factors including not only a particular surveillance activity, but the surveillance history (including multiple sources of surveillance data), and the risk of introduction of the infection into the herd. Farms that meet the same input-based standard may therefore have very different probabilities of being infected.

This paper discusses an approach whereby the standards define the output (the probability of infection) rather than the surveillance input. This approach allows greater flexibility in the design of surveillance, decreases the surveillance burden for low risk herds, and decreases the risk of spreading disease from high risk herds. Implementation requires both the definition of a standard probability of freedom from infection as well as a standardised approach to calculating that probability, taking relevant risk factors into account.

Keywords
Freedom from disease, trade, standards, tuberculosis, surveillance

INTRODUCTION

An important role of animal health authorities is the development of standards to help prevent the spread of infectious animal diseases. Examples of such standards include the World Organisation for Animal Health's (OIE) terrestrial and aquatic animal health codes, and the directives of the council of the European Economic Community (EEC). Three desirable characteristics of these standards are:

- practicality (they need to be able to be interpreted and applied in a clear and uniform fashion),
- efficacy (they should succeed in preventing the spread of disease), and
- fairness (they should not impose unnecessary restrictions when the risk of spread of disease is low enough to be acceptable).

Traditionally, these standards are based on inputs (such as the amount and method of surveillance required to demonstrate freedom) and are highly prescriptive. In the example of both OIE and EEC standards for bovine tuberculosis (TB), they specify the processes required to accept a herd as being free from infection including the number and type of animals to be tested, the test to be used, the number of times the test should be applied and the period between tests.

This level of detail makes application of the standards relatively simple (addressing some aspects of the practicality criterion). However, in some cases they are neither effective (infected animals have been moved despite meeting the requirements of the standards) nor fair (the requirements of the standards appear to be excessive for some low-risk groups). This is because the standards assume that the population to which they apply is homogenous in terms of the probabilities of infection and detection, and that the application of the same inputs in all cases will result in the same output. In the current example, the inputs are prescribed surveillance activities, while the output is the probability of freedom from tuberculosis.

In reality, populations vary significantly due to a wide range of factors. The probability that a herd is free from TB is related to:

- the history of introductions into the herd,
- the presence of wildlife vectors,
- biosecurity measures to prevent contact with vectors, and

- the history and results of all forms of surveillance (tuberculin tests, meat inspection etc) that may detect the presence of TB, amongst other factors.

Depending on the specific combinations of these factors, application of the input-based standards may be ineffective (too little surveillance) or unfair (too much surveillance).

An alternative approach is the use of output-based standards. Instead of defining inputs (the surveillance required), standard setting organisations may set a standard output (the probability that a herd is free from infection).

STANDARD FOR FREEDOM FROM DISEASE OR INFECTION

Due to imperfect tests, it is very difficult to provide absolute proof that a herd is free from infection. Instead, claims of freedom must usually be expressed in terms of probability. The quality of surveillance to demonstrate freedom has often been described in terms of 'confidence' or more strictly speaking, the sensitivity of the surveillance (the probability that, if disease were present at or above a specified level, the surveillance would be able to detect at least one infected animal). Animal health standards sometimes specify the sensitivity required of a surveillance activity (usually 95%). This represents a form of output-based standard.

However, from a disease control point of view, the objective is to prevent the movement of infected animals. The quality of surveillance, as measured by sensitivity, only provides part of the picture. The history of previous surveillance results, the pressure for introduction of new infection and the level of biosecurity also play important roles.

Instead of surveillance sensitivity, a better measure of whether it is safe to move animals from a herd is the probability that the herd is free from infection. This is both more intuitively understandable and captures other factors such as surveillance history and the risk of introduction of infection.

The selection of an acceptable standard for probability of freedom is likely to depend on the nature of the disease and the consequences of failing to prevent spread. The common standard for surveillance sensitivity (95%) is often applied to herds that already have a high probability of being free which means that the achieved probability of freedom is significantly higher than the sensitivity. Appropriate standards for probability of freedom are likely to be in the range of 99% to 99.9%

Calculation of the probability of freedom

Once a standard has been set, it is necessary to be able to evaluate individual herds against this standard. A framework for the calculation of the probability of freedom from infection has been described (Martin, 2008; Martin *et al*, 2007a; Martin *et al*, 2007b). This approach is able to take multiple surveillance activities, the history of surveillance, the level of biosecurity and the risk of introduction of infection into account.

For each surveillance activity, the sensitivity is estimated using scenario-tree modelling, which is able to account for risk-based or biased sampling. The combined sensitivity of all different surveillance activities is then calculated, taking overlap between activities into account (examination of the same animals in two or more activities). A Bayesian approach is then used to progressively incorporate evidence of freedom from historical surveillance, adjusting for the risk of introduction of infection. The result of this calculation is the estimated probability of freedom from infection which can be compared to the standard.

Practical implementation

If a standard output is to be applied, there must also be a standard way to determine if a herd meets the required probability of freedom or not. The analysis described can be challenging on a herd-by-herd basis. Instead, a single model can be created, capturing the main factors influencing the probability of freedom. Inputs to the model include:

- Types of surveillance undertaken
- Factors influencing the sensitivity of surveillance (targeting, bias)
- Numbers of animals processed
- The dates of past surveillance activities
- Tests used
- Risk factors for introduction of infection

A farm questionnaire can then be used to assess the surveillance undertaken and determine the risk factors applying to that particular farm, to generate an estimate of the probability of freedom.

CONCLUSIONS

There are many different possible approaches to doing surveillance. For tuberculosis, whole herd skin tests are commonly used, but abattoir meat inspection and routine post mortem examination of sick animals may also detect the presence of the disease. Output-based standards provide producers with the flexibility to undertake surveillance in a way that best fits with their own situation. For instance, one farm may choose to establish freedom rapidly through regular whole herd tests, while another may use less sensitive (and less expensive) approaches such as meat inspection over a much longer period. Farms exposed to the risk of introduction of infection through wildlife need to conduct ongoing surveillance, while farms in areas with no wildlife infection and that do not introduce animals may be able to maintain a high probability of freedom with minimal surveillance.

The use of output-based standards allows for a high degree of flexibility in the implementation of surveillance, decreases the burden on low risk farms, and provides increased assurance for high risk farms.

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