Risk-based surveillance in animal health

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by

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Abstract

Animal health surveillance is an important part of animal health care, particularly in countries dependent on livestock for food production and international trade. There are two major issues related to the provision of effective surveillance activities. Firstly, for good information to become available, the design and conduct of data collection activities should be carried out following sound statistical principles. In reality, constraints such as imperfect tests and unavoidably-biased sampling strategies hinder straightforward analysis and interpretation of survey results. Risk-based surveillance is used to target high-risk sub-populations to increase efficiency of disease detection; however, biased datasets are generated.

This thesis develops methodologies to design risk-based surveillance systems and allow statistically valid analysis of the inherently biased data they generate. The first example describes the development of a method to analyse surveillance data gathered for bovine spongiform encephalopathy (BSE). The data are collected from four different surveillance streams of animals tested for BSE, with each stream containing unavoidable biases and limitations. In the BSurvE model, these data are combined with demographic information for each birth cohort to estimate the proportion of each birth cohort infected with BSE. The prevalence of BSE in a national herd can then be estimated using the method of moments, whereby the observed number of infected animals is equated with the expected number. The upper 95% confidence limit for the prevalence is estimated both for infected countries and for those where no BSE has previously been detected.

A similar approach to that used in BSurvE is then applied to surveillance data for trichinellosis, for which risk-based post-mortem testing is also performed. Negative results from multiple species using different, imperfect tests are combined to give an estimate of the upper 95% confidence limit of the national prevalence of trichinellosis in a reference population. This method is used to provide support for freedom from trichinellosis in Great Britain.

A different approach to risk-based surveillance is explored as the surveillance strategy for detection of exotic causes of abortion in sheep and goats in New Zealand is examined. Using a geographic information system (GIS) maps of disease risk factors were overlain to produce a risk landscape for the lower North Island. This was used to demonstrate how areas of high- and low-risk of disease occurrence can be identified and used to guide the design of a risk-based surveillance programme.

Secondly, within one surveillance objective there may be many ways in which the available funds or human resources could be distributed. This thesis develops a method to assess BSE surveillance programmes, and provides tools to facilitate BSE detection on the basis of infection risk and to increase the efficiency of surveillance strategies.

A novel approach to allocation of resources is developed, where portfolio theory concepts from finance are applied to animal health surveillance. The example of surveillance for exotic causes of sheep and goat abortion is expanded upon. Risk of disease occurrence is assessed for a population over different time periods and geographical areas within a country, and portfolio theory used to allocate the number of tests to be carried out within each of these boundaries. This method is shown to be more likely to detect disease in a population when compared to proportional allocation of the available resources.

The studies presented here show new approaches that allow better utilisation of imperfect data and more efficient use of available resources. They allow development of surveillance programmes containing an appropriate balance of scanning and targeted surveillance activities. Application of these methods will enhance the implementation and value of surveillance in animal health.

Publications

Peer-reviewed papers

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Lewis Carroll

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