EVALUATION

Systematic review of evaluations of animal and public health surveillance systems: Summary of main findings

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Abstract

A systematic review of literature describing evaluations of animal and public health surveillance systems was performed. Common themes, strengths and weaknesses of surveillance evaluations were identified. The output is being used to develop a generic surveillance evaluation framework which will help policy makers improve the efficiency of animal health surveillance.

Keywords: attributes, evaluation, policy, review, surveillance.

Introduction

Animal and public health surveillance programmes should be evaluated regularly to ensure they provide valuable information in an efficient manner. Evaluation of health surveillance programmes around the world is currently not standardised and therefore inconsistent. The aim of this systematic review was to review surveillance system attributes and the methods used for their assessment, together with the strengths and weaknesses of existing frameworks for evaluating surveillance in animal health, public health and allied disciplines.

Materials and methods

Systematic review of published and unpublished reports of evaluations conducted since 1995 on surveillance systems in the following areas: animal health/disease; public health; environmental health; bioterrorism; and public security. Three sources were searched: Web of Science, Google, and proceedings of two veterinary epidemiology society conferences. Information from 99 articles describing 101 surveillance systems was extracted and analysed.

Results

Most articles (73/99) described human health surveillance evaluations. Of papers evaluating animal health surveillance systems, the most common subject species was cattle (13/99). Influenza was the disease for which surveillance systems were most commonly evaluated (8 articles, of which 7 focused on the infection in humans and 1 in wild birds). Only one article integrated the evaluation of human and animal health surveillance, in a study of West Nile virus epidemiology [1].

The range and number of attributes assessed by different studies varied widely. In total, 23 different attributes of surveillance systems were assessed across the 99 articles (Figure 1). A variety of approaches, most of which were quantitative in nature, was used to evaluate these attributes (Table 1).

Figure 1: Surveillance system attributes assessed by the 99 studies included in this review. Attributes recommended for evaluation by CDC [2] are shaded in grey.

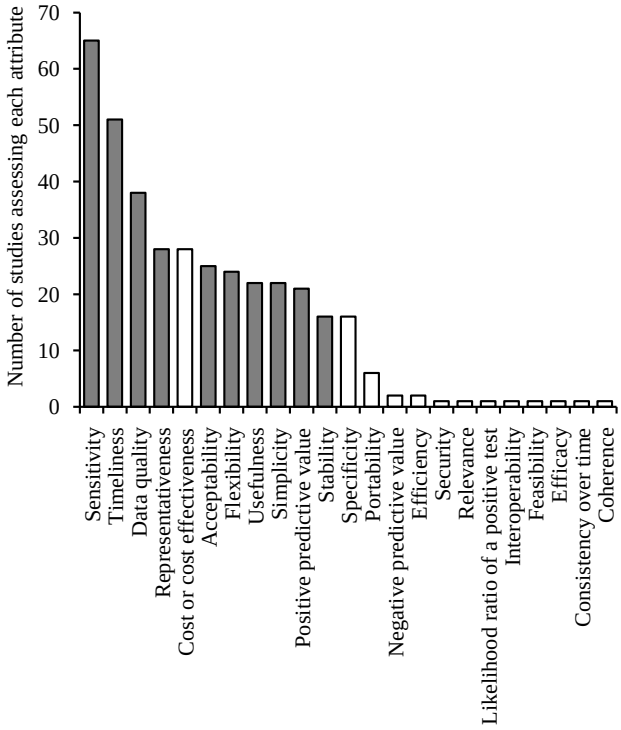

Table 1: Summary of methods used in the 99 articles in this review for evaluating surveillance systems.

Method of analysis	*Number of articles*[#]
Quantitative	**89**
Calculation of percentage of complete records	39
Comparison of one system with another	29
Simulation modelling or statistical algorithms	19
Scenario tree modelling	7
Cost-benefit analysis	6
Capture-recapture technique	5
Performance indicators	5
Odds ratios of disease detection probability	1
Measurement of effort applied	1
Qualitative	**26**
Subjective scoring system or expert opinion	23
Spatial mapping	2
Logic model	1

[#] Figures do not sum to 99 because several articles used more than one approach.

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Almost a quarter (23/99) of the articles specifically stated as an objective to assess one or more of the ten attributes recommended in the Centers for Disease Control and Prevention (CDC) guidelines for evaluating public health surveillance systems [2]. However, relationships between attributes were rarely investigated.

Discussion

A distinct lack of standardisation exists regarding the best approach for evaluating surveillance systems in order to facilitate decision making in the fields of animal or public health. At best, there is only moderate agreement on which attributes of a surveillance system should be assessed. This may be because the value of each attribute to decision makers varies depending on the purpose of the surveillance activity and the objectives of the evaluation.

The purpose of the surveillance activity was often not stated in the articles reviewed and so the reasons for choosing certain attributes for assessment were not always apparent. Evaluations of animal health surveillance systems should clarify the purpose of surveillance, identify clear objectives for the evaluation and be designed accordingly, rather than being dictated by convenience.

Only a minority of the articles in this review (27/99) performed a systematic assessment, by addressing five or more attributes to form a balanced evaluation of a surveillance system. Most of the evaluations carried out were based on the assessment of just one or two attributes, which would not provide a complete evaluation of a surveillance system and thus might be misleading and of limited use to policy makers.

It is surprising that economic evaluation is not an integral part of more surveillance evaluation programmes: only 28 out of the 99 articles in this review included some form of economic evaluation. The most commonly followed guidelines – those of CDC [2] – suggest that costs may be judged relative to benefits but do not explicitly advocate that this be an integral part of all surveillance evaluations nor indicate how this may be done. This seems a little surprising given the ever present need to justify resource use.

Focussing on the relationships between attributes is likely to improve the quality of surveillance evaluations by allowing identification of a limited number of 'core' characteristics which when all considered will allow for a holistic evaluation. A generic and comprehensive evaluation framework could then be developed consisting of a set of core elements whose priority is varied depending on the disease or range of diseases under surveillance. Economic evaluation should be an integral part of this evaluation process. This would provide a significant benefit to decision-makers who need to make choices based on ever-diminishing resources.

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Surveillance performance indicators for the control and eradication of bovine tuberculosis

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Abstract

The experiences of the TB subgroup (of the EU Task Force on disease eradication programmes) in the application of surveillance indicators in tuberculosis control programmes are discussed. Ten surveillance indicators relevant for the control and eradication of bovine tuberculosis were selected. Selected indicators include programme coverage, herd/animal prevalence and incidence, slaughterhouse submission rate, details on slaughtered animals and reactor animals and their herds, human cases and disease reproduction ratio. Potential misinterpretations, differences in reporting, and the usefulness of these indicators are addressed. The importance of relevant and well defined indicators is emphasized.

Keywords: tuberculosis, indicators, eradication, surveillance sensitivity.

Introduction

The zoonotic and multiple host species character of tuberculosis (TB) make it necessary to apply a systemic approach to the surveillance activities. Moreover, in countries where eradication efforts are on-going there is a need to follow up the results of eradication measures and the cost-effectiveness of such measures.

Every year the EU Commission provides financial contributions to national control programmes for certain animal diseases. The receiving Member States (MS) must provide certain indicators, to allow for follow-up and a cost-effective use of EU funds. The respective subgroups of the EU Task Force on Disease eradication programmes visit MS to assist and evaluate the progress of the programmes. The TB subgroup has recommended the use of several performance indicators (related to surveillance and eradication measures) for the TB control programmes. Surveillance indicators are regarded as particularly important for the success of the programmes. However, the use of such indicators is not always optimal and further discussion on these would be beneficial for the practical application of surveillance.

Basic indicators to be reported for the co-financed eradication programmes are provided in Commission Decision 2008/940/EC [1]. In the tables in the annexes of this decision, some performance indicators are specified that must be provided by the MS. Despite this, it is not always clear how the calculations of some indicators should be performed and various approaches may be argued. Moreover, for specific purposes in some countries, other indicators are needed and the veterinary administrations are not always familiar with how to obtain such indicators and how to make the most use of them for control purposes.

The experiences and recommendations of the TB subgroup are discussed in this paper, with the aim to increase awareness of how to apply surveillance indicators in practical situations for eradication purposes.

Selected indicators

Based on the required information to be reported for EU-financed control programmes for bovine tuberculosis and the reports of the TB subgroup [2], ten performance indicators were selected. Potential misinterpretations and differences in the reporting were identified. The selected indicators were evaluated in the context of the control of bovine tuberculosis.

The mandatory reports contain the following three surveillance indicators, on herd and animal level, respectively:

- Percentage coverage of the programme
- Prevalence
- Incidence

Moreover, the number of herds with different status (OTF/infected/not OTF) must be reported.

The TB subgroup has recommended additional indicators to monitor the progress of TB eradication, such as:

- Slaughterhouse submission rate;
- Number (and proportion) of herds detected by meat inspection with tuberculin reactors on follow-up tests;
- Number (and proportion) of tuberculin reactors with visible lesions at slaughter;
- Number (and proportion) of reactors that are confirmed as infected post-mortem;
- Number (and proportion) of positive herds with a history of positive reactors and/or inconclusive reactors;
- Number of human cases caused by *Mycobacterium bovis;*
- Reproduction ratio of the disease.

Some other issues related to surveillance indicators have also been mentioned in the reports of the subgroup.

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Discussion

Coverage: The figures for coverage are calculated as number of herds/animals tested divided by number of herds/animals under the programme. The number of herds/animals under the programme may be different from the total number of animals/herds in the population at risk. In such cases, this figure is less useful as a measure of how well the other indicators reflect the overall situation in the region.

In some areas, all herds are not submitted to yearly tuberculin testing, while some herds may be tested more frequently. Thus, the simple calculation for coverage may be misleading. If the frequency of testing is decreased to every 2, 3 or 4 years in some herds, this will affect the sensitivity of the surveillance and thereby the reliability of the prevalence and incidence figures.

Prevalence and incidence: Case definition is essential for prevalence and incidence figures. Some countries define positive reactors as cases, where others require the isolation of *M. bovis* from an animal before defining it as a case.

For TB, the difference between prevalence and incidence figures can be used to assess the efficiency of clearing the infected herds.

The prevalence figures in the EU reports are calculated as number of positive animals/herds divided by number of tested animals/herds. This apparently straightforward approach may however result in the figures in tables from different MS representing totally different things.

The number of tested herds usually includes herds subjected to routine tuberculin tests, whereas the number of positive herds may also include herds detected by post mortem inspection, pre-movement testing, epidemiological investigations and targeted surveys. Depending on surveillance efforts in addition to routine testing, prevalence figures may reflect a good surveillance or a less ambitious one, instead of being a comparative measure of disease occurrence.

The same is applicable for incidence figures where the number of new positive herds should be divided by the number of tested herds.

To avoid misinterpretations, especially when comparing regions or assessing the national situation, it may be necessary to use raw data instead of reported prevalence/incidence. This is especially important for countries/regions where only a sample of the population is tested every year.

For national purposes, *i.e.* to allow for a proper evaluation of the situation and make full use of all available information, data from screening should be calculated separately from risk based testing, and slaughterhouse monitoring results, as they will be used for different purposes and to allow for analyses of trends.

Monitoring of slaughterhouse submission rates is important to ensure the efficiency of this surveillance system. Even in the absence of tuberculosis, a certain number of visible lesions are to be expected due to *e.g.* parasitic infections and other bacterial infections.

Number of herds detected by meat inspection with further reactors: This figure will provide insight into the sensitivity of herd testing. If animals detected at slaughter have old lesions and no further positive animals are found in the herd, this does not give much cause for concern. On the contrary, if many reactors are detected on follow-up testing this indicates a failure to detect herds with active infection by tuberculin testing.

Number of reactors with visible lesions: If many reactors have visible lesions at post-mortem inspection, this indicates a lack of sensitivity of the tuberculin testing. This test should ideally identify animals before visible lesions appear, so that infected animals may be removed before they can spread the infection.

Number of reactors confirmed as positive: This figure is important for the confidence in the tuberculin test. However, when striving to achieve a high sensitivity of the testing, detected animals will be recently infected and difficult to confirm by post-mortem investigations. It is advisable not to rely too much on confirmatory testing if positive reactors are to be treated as positive cases. On the other hand, if only those reactor or lesion-positive animals that are confirmed as positive on the basis of laboratory tests are to be regarded as cases, then the low sensitivity of confirmatory tests must be taken into account (see discussion on prevalence). If a large proportion of reactors with visible lesions are not confirmed, the performance of laboratory tests may be questioned (if such tests are performed). The number of reactors without visible lesions but confirmed by bacteriology is also of importance as this indicates detection at an earlier stage of infection. However, in order to obtain this figure, resources must be allocated to bacteriological examination of all reactors and not just animals with visible lesions.

Number of positive herds with a history of reactors: Analyses of testing history in infected herds, especially herds detected at slaughter, will allow for follow-up of test performance, provide a basis for decisions on test interpretation in different situations and indicate the need for more strict eradication measures in some situations.

Human cases: Data on human cases of *M. bovis* infection may provide indications of undetected animal cases as well as a lack of biosecurity in infected herds. The interpretation of such data requires knowledge of the diagnostic methods and case definitions used in human medicine.

Reproduction ratio: In this context, this measure may be used for the number of new infected herds generated by each positive herd, or the number of reactors following the detection of each infected animal. The figure may be difficult to obtain, and requires proper follow-up of each infected herd and animal, with thorough epidemiological investigations to trace the infection. If reliable figures can be obtained, this is a very good indicator of whether infected herds are handled

efficiently and if control and eradication measures are working as intended.

In some situations indicators related to population demographics, such as the herd ratio of newborn calves per cow, or mortality vs. slaughter may be relevant. Such indicators may be used to validate population registers *e.g.* if the data quality or compliance with reporting is in doubt. Moreover, indicators related to the quality of test performance, such as testing results for each veterinarian, results of quality assurance monitoring, results of tuberculin potency testing, and test data related to different tuberculin sources could be useful. In areas where wildlife reservoirs present a problem, population data on wildlife are of importance, as well as data on investigations performed in wildlife.

To make the indicators meaningful, proper training of veterinarians and other staff involved in collecting the data, *e.g.* carrying out tuberculin tests, performing post mortem inspections or conducting epidemiological investigations is of utmost importance.

For this disease in particular, but also for many other diseases, a holistic approach to surveillance is needed. Low sensitivity of available tests, vague clinical signs, slow progress of the disease and broad host range all contribute to a complex epidemiology which must be matched by a combination of different surveillance components [3].

The use of appropriate indicators to evaluate the individual components of a disease control and eradication programme is necessary for a proper assessment of the management of the programme at regional/national level, with a view to identifying how different issues currently posing an obstacle for the eradication can be addressed. However, some of the more relevant indicators may require additional information to be recorded or analysed.

Easy access to data on all administrative levels, including all relevant information on the animal populations as well as general and specific surveillance activities is a prerequisite for an effective surveillance, control and eradication of tuberculosis.

Expertise in epidemiology is needed at national level to identify and provide the most appropriate indicators for each epidemiological situation, and to make international comparisons valid.

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Use of the OASIS tool for the assessment of exotic diseases surveillance systems in France, example of bovine Brucellosis surveillance

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Abstract

OASIS, an acronym for the French translation of "Analysis tool of health information systems" is a semi-quantitative tool to assess surveillance system in order to produce adequate recommendation for the improvement of these surveillance systems. This article presents an application of this assessment method to the French network of surveillance of the bovine brucellosis within the framework of priority exotic diseases surveillance assessment, and discusses the advantages and the limits of this method.

Keywords: surveillance, assessment, brucellosis, OASIS, France.

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Evaluation of factors influencing the quality of disease notifications in Switzerland

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Abstract

One of the major elements of disease surveillance in Switzerland is the notification and recording of disease outbreaks. All those who keep, look after or medicate animals are obligated to notify outbreaks or suspicion of 80 diseases to a veterinarian or to the regional veterinary office (RVO, cantonal veterinary office). Diagnostic laboratories report positive results to the RVO as well. All notifications are proofed by the RVO and then submitted to the Swiss Federal Veterinary Office (SFVO) where notifications are collected centrally and published. The project's aim was to identify which factors influence the recognition of diseases and which factors support or impede the notification itself, or its quality, on different levels of the notification process. By interviews and online surveys different factors identified at the level of RVO, veterinary practitioners, laboratories and farmers were assessed according to their value and relevance. The results indicate a high standard of disease surveillance, at least in the self-recognition of the involved persons. However, there is a potential to increase the notification process both with better legal and institutional framework as well by improvements in the relations of the involved parties and the realization of the notification process.

Keywords: disease notifications, passive surveillance, evaluation, questionnaire.

Introduction

The collection, analysis and timely publication of disease notifications is one of the major elements of disease surveillance and often basis for disease control. To get a case notified to the SFVO, actions along a chain of involved parties are necessary. Passive surveillance starts with the farmer and veterinarian recognizing clinical symptoms indicative of a certain disease. They take actions to have the suspicion clarified by laboratory diagnosis and eventually inform the RVO. If positive, the diagnostic laboratory informs the RVO, that then, if appropriate, takes measures for disease control and in any case forwards a notification to the FVO. In case of surveillance programmes, samples are also taken from unsuspicious animals, and if they are found positive, the case is also notified and further tests are conducted, eventually resulting in the detection of more cases. In Switzerland, 80 diseases are currently notifiable. Of these, 23 do not occur in Switzerland and for 28 of the remaining 56 diseases a notification is the only measure taken (monitored diseases).

Completeness, correctness and timeliness define the quality of disease notifications. This quality is influenced by various factors on different levels of the notification chain [1]. Under-reporting is the most common lack of official case notification systems [2]. It has been established by the SFVO, that the disease notifications vary in space and time in a way that cannot be explained by chance and the variation of the population at risk [3]. This project has the aim to identify and assess factors influencing the quality of reporting cases of clinical and sub-clinical disease. Particular attention is paid to the influence of disease awareness, the attitude towards diseases and organizational and financial constraints.

Given the study results, the ‚how' and ‚why' of the involved parties' actions can be better understood and the critical points in the institutional and legislative framework that have a negative influence on the quality of the notifications can be identified and remedied.

Farmers, veterinary practitioners, diagnostic laboratories and veterinary officers were identified as important parties in the notification chain. All of them were queried using a customized questionnaire. To develop the questionnaires, explorative interviews were conducted with two deputy veterinary officers, two representatives of the diagnostic laboratories, one veterinary practitioner and one farmer. These interviews were aimed at eliciting influencing factors in the notification chain and to evaluate these factors under practical aspects with the parties involved. It was the aim to cover a broad range of influencing factors from different environments: legal, economic, organizational, structural, disease specific, social and private. Then these factors were checked and quantified in online questionnaires. Showcase diseases were BSE, salmonellosis in cattle, enzootic pneumonia in swine, cryptosporidiosis in cattle and enzootic abortion of ewes (ovine chlamydiosis). In the questionnaires we surveyed relevance and value of the factors in general and for each showcase disease. The relevance scale stretched from ‚very impeditive' (-3) to ‚very supportive`(+3), with zero meaning ‚no relevance'; the values ranged from ‚not appropriate' to ‚fully appropriate' [1-6].

Invited for the survey were all RVOs (21), all accredited diagnostic laboratories (29) and almost all large animal practitioners in Switzerland (about 500). Additionally, 8,000 farmers were randomly chosen from the animal movement database and invited to participate in the survey.

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Results

The response rates in the different groups were: 76% for RVOs (17), 65% for laboratories (19), about 25% for practitioners (132) and 15% for farmers (1,177). The response rates for RVOs and laboratories are satisfyingly high, as is the response rate for the practitioners, especially as the questionnaire for practitioners was the most extensive one. For the farmers group, the feedback of over thousand participants is enough for a sound conclusion. However, given the low response rate, it must be assumed that there is a bias towards farmers who are interested over the average in animal diseases.

For this article, we focus on a sample of influencing factors that were given a high relevance in the notification chain, *e.g.* they were seen as most impeditive or supportive for the recognition and notification of disease cases and thus are likely to bias the statistics of notifications. These factors were given values of over +/- 1.4 on the relevance scale. We indicate the positive or negative tendency by a minus or plus.

Economic and legal factors

The knowledge and perception of laws, prescriptions and provisions, regional programmes and economic constraints influence the actions of involved parties.

Regional unequal practices in legal implementation (-): In Switzerland, RVOs often undertake own, regional programmes against certain animal diseases although they are not obligated by national law. Furthermore, assumption of costs, for example for veterinary advice, diagnostics or compensations for culled animals differ between RVOs. This regional variation in the incentive structure results in obscurity and incertitude.

Ambiguity of national laws and prescriptions (-): Primarily for the monitored diseases, veterinary practitioners and the RVOs quote ambiguity in national prescriptions. For example, these parties miss a clear regulation whether a laboratory diagnosis has to be established or not. Furthermore, over 40% of the veterinary practitioners are not aware that the questioned showcase monitored diseases were legally indeed to be monitored.

Financial incentives for veterinary practitioners and farmers (+): Financial incentives are important for the motivation of practitionerss and farmers towards disease notification. About 70% of the practitioners indicate to be more willing to clarify clinical cases by diagnostic testing if the costs are covered by the government. Half of the practitioners would be motivated to make disease notifications if they would be compensated for their time and effort. For farmers, the rate of those motivated by financial incentives is even higher, at 70%.

Disease specific factors

Major factors for disease detection are the conspicuousness of clinical symptoms and the knowledge of these symptoms by the farmers and practitioners.

The disease is difficult to recognize (-): Diseases with only common, unspecific symptoms (for example pathogens causing diarrhea) are often not recognized to be notifiable both by farmers and practitioners. Thus a large variation in the actions taken is quoted by the practitioners and farmers.

Deficient cognition of notifiable diseases by farmers (-): The table shows the deficient cognition of notifiable disease, in particular monitored diseases, by farmers.

	Never heard of	**Once heard of**	**Well informed**
BSE	5%	25%	70%
Salmonellosis	22%	54%	24%
Enzootic pneumonia	17%	48%	35%
Cryptosporidiosis	67%	23%	10%
Ovine chlamydiosis	52%	41%	7%

Social and private factors

Of increasing interest for the SFVO are individual and social factors driving the individual's attitude towards disease notifications and other official measures. Of special concern is the farmer and his relation to other parties.

Perceived importance of animal health (+): For the majority of farmers animal health topics are as important or even more important as feeding or animal breeding.

Increased disease awareness (+): Farmers and practitioners rate their awareness for infectious diseases as high. Over 80% of the practitioners and over 60% of the farmers indicate that infectious diseases are important topics and therefore they were aware about clinical signs.

Lacking education and expert knowledge (-): About half of the farmers assess their own education in infectious diseases as poor or moderate. About half of the queried farmers and practitioners estimate their expert knowledge in infectious diseases as moderate or incomplete.

Mutual trust between parties (+): Practitioners make the link between farmers and the authority. They are obliged to notify the occurrence of disease cases to the authority, but they also make a living form consulting and instructing their customers, the farmers. Most of the farmers have a high confidence in their veterinarian and they expect transparency when measures of the authority have to be followed. However, almost half of the farmers are rather sceptical towards the authority.

Negative emotions and consequences associated with diseases (-): The majority of farmers take the experience of a disease case as bad. This attitude is independent of the kind of the disease. They also estimate the consequences, such as loss of animals or stand still, as similar and heavy for every suspicion or case, independent from the kind of the disease.

Organisational and structural factors

To enable a reliable disease notification in the RVO and the diagnostic laboratories, an effective and efficient management is a prerequisite. A good communication between involved parties and suitable tools for daily business are also of major importance.

Suitable documentation for the clarification of suspect cases is lacking (-): Practitioners and official veterinarians agree that suitable documents for the clarification process of suspect cases is lacking, especially for monitored diseases. For the majority of practitioners it is often dubious respectively it is not on their mind where samples have to be sent in. Practitioners would prefer simple checklists for the procedure in the most important diseases.

Doubts on cost absorption for diagnostic tests (-) (-): Practitioners and the diagnostic laboratories mention that the cost absorption for diagnostic tests is regulated ambiguous. The problem is accentuated in laboratories, which receive samples from several regions.

Incomplete forms and poor sample quality (-): The laboratories indicate that about 20% of forms are incomplete (*e.g.* no anamnesis, missing information on the farm or animal). Ten percent of the samples for the detection of contagious diseases are inadequate due to the wrong sample matrix. This leads to retardation and increases the administrative effort, when material of information has to be re-called. In the worst case, the correctness of the result may be compromised.

Well-organised and central data management (+): The RVOs have timelines for the screening and notification of disease cases and normally these timelines are followed. Actually different data management systems are used for the laboratory data, the investigation of suspect cases and the disease notification to the SFVO. This will be changed soon.

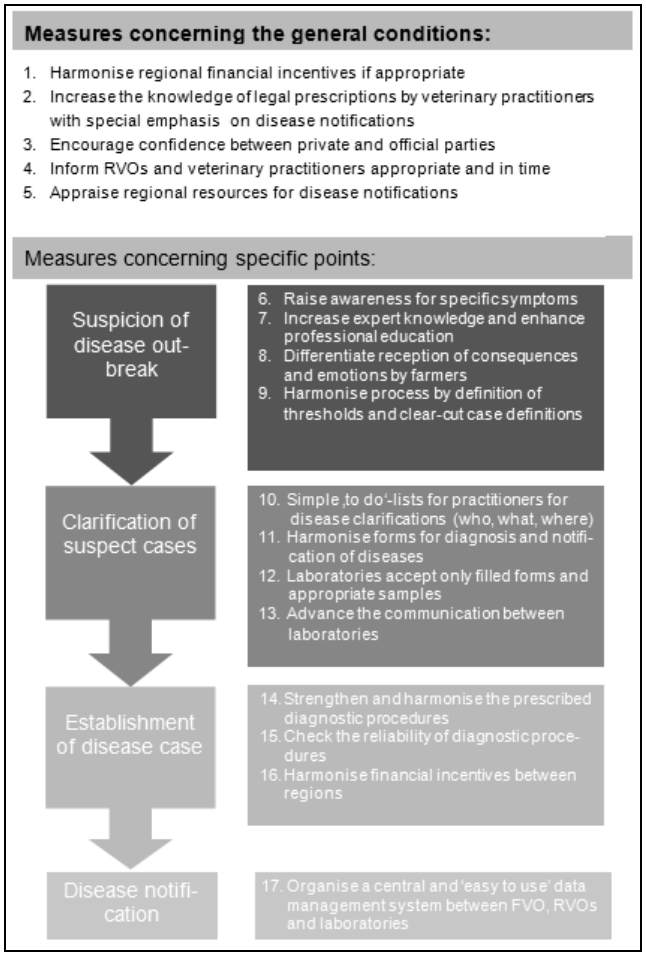
Sound information and communication by the authorities (+): Practitioners and laboratories assess the quality of the information and documentation released by regional and federal authorities as generally sound, but they see potential for optimisation. The frequent and comprehensive news and documentations on animal diseases should be more prioritised and harmonised. It is essential that the SFVO inform the RVO and the practitioners at an early stage.

Usefulness of disease notification for estimation of disease prevalence

The RVOs and laboratories were asked to estimate the correctness of the statistics of disease notifications for 'true' disease situation concerning the showcase diseases. They see the statistics as almost correct for BSE and EP, but as incorrect for the monitored diseases. For salmonellosis a large discrepancy between the estimates of the laboratories and the RVOs was observed.

Discussion

The results indicate a large influence of various factors, both impeding and supportive, on the notification of disease cases. Thus, optimization is possible on all steps of the notification chain. The graph show the optimisation measures identified within this project.



Evaluation of Laboratory Component of Highly Pathogenic Avian Influenza Surveillance in Nigeria, 2010

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Abstract

In February 2006, Nigeria reported Highly Pathogenic Avian Influenza (HPAI) in poultry. In January 2007, the first human case was detected linked to poultry from a Live Bird Market (LBM). The Regional Lab for Avian Influenza is responsible for investigating specimens from birds meeting the case definition of HPAI (passive surveillance). Specimens collected from LBMs and high risk areas in the framework of active HPAI surveillance were analyzed. We evaluated the laboratory component of the surveillance systems to determine whether it meets their objectives.

Methods: We used CDC's updated guidelines for evaluating public health surveillance systems, conducted six key informant interviews, reviewed lab reports and analyzed HPAI surveillance data from 2006-2009.

Results: Laboratory results were available within 48 hours and positive predictive value was 99.9%.The system has been adapted for surveillance of Newcastle Disease diagnosis. Of 25,763 samples analyzed for both systems, 300 (1.2%) were confirmed for HPAI from January 2006 to December 2007. LBM surveillance in 26 States with reported outbreaks yielded 12 positive cases while surveillance in 11 States with no previous outbreaks yielded two positive cases for HPAI in 2008.

Conclusions: The laboratory component of the HPAI surveillance is useful, acceptable, stable, timely, flexible and performing well. It is meeting its objectives, however, no information on timeliness of specimen was available.

Keywords: Laboratory, Avian Influenza, Surveillance, Evaluation.

Introduction

Avian Influenza is caused by type A influenza virus in the family Orthomyxoviridae [1]. All subtypes have been identified in birds and infections by the virus has been reported in a variety of domestic and wild birds though subclinical while it causes clinical disease in domestic poultry. Although this is a viral disease of birds, it has been shown that it can be transmitted to humans. It is a disease of public health importance because it raises the concern that it could recombine with seasonal human influenza virus and create a new and potentially pandemic human flu strain similar to the "Spanish" Influenza pandemic of 1918 [1].

In February 2006, Nigeria reported its first case of Highly Pathogenic Avian Influenza (HPAI) in poultry. Investigation on the source of the outbreak was inconclusive. By April 2006 more than 325,000 chickens from over 300 farms were positive for H5N1 virus of which most died of the infection and the rest were humanely decapitated as a control measure. These outbreaks occurred in backyard poultry and large commercial poultry farms. The first human case was reported in January 2007 and was linked to poultry from a Live Bird Market (LBM) in Lagos [2].

Surveillance of major Trans-boundary Animal Diseases (TADs) is carried out in Nigeria by the Federal Department of Livestock (FDL), through the National Animal Disease Information System (NADIS). The TADs under surveillance include HPAI, Foot and Mouth Disease (FMD), Contagious Bovine Pleuropneumonia (CBPP), African Swine Fever (ASF), Pestes de Petit Ruminants (PPR), Newcastle Disease and Rinderpest [1].

HPAI surveillance was carried out throughout the country and this was a collaborative effort of all the stakeholders. This was coordinated by NADIS which provided a more flexible information entry system allowing for the entry of additional diseases, attachment of GIS locations as well as poultry diseases. NADIS provides the data base platform on which HPAI surveillance data in Nigeria are being accumulated in accordance with the National Avian Influenza Control and Eradication Policy [1].

The laboratory aspect of the surveillance has a network of six (6) laboratories namely: FAO Regional Laboratory (Western and Central Africa) for Avian Influenza and Trans-boundary Animal Diseases (TADs) situated at the National Veterinary Research Institute (NVRI), Vom being the National Veterinary Reference Laboratory.

Five (5) regional laboratories domicile at the Veterinary Teaching Hospitals in Ibadan, Zaria, Sokoto, Nsukka and Maiduguri.

This evaluation focuses on the laboratory aspect of the surveillance handled by NVRI, Vom. The first stage of the surveillance was carried out in 2005 prior to HPAI outbreak in 2006, targeted at migratory wild birds and was done at the wetlands and bird sanctuary in the country.

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The second stage of the surveillance was a nationwide surveillance in selected geo-referenced surveillance points in the country. Passive surveillance was a continuous component that was running parallel to all other organized surveillance and involved routine diagnostic tissue samples submitted to the Central Diagnostic Laboratory by farmers and surveillance agents between February 2006 and December 2007. The third stage was active surveillance of HPAI in States that had confirmed cases of HPAI in Nigeria and was targeted at LBMs between October and December 2007. The fourth stage involved active surveillance of HPAI in States without confirmed outbreaks and was targeted at LBMs between May and July 2008. The fifth stage of the surveillance was targeted at resident wild birds in eight States that had confirmed cases of HPAI between July and November 2008. The sixth stage of the surveillance post outbreak period began in 2009, targeted at LBMs and control posts all over the country. It involved sampling of water fowls, sick birds and new batches of birds arriving the markets.

Clinical Case Definition of HPAI in Poultry: Surveillance is done at flock level rather than individual level. A flock with one or more of the following symptoms would be classified as exposed or infected with HPAI:

1. Production of soft-shelled or shell-less eggs/ decrease in egg production;
2. Respiratory signs such as rales, laboured breathing and dyspnea;
3. Neurological signs such as staggering gait or in coordination;
4. Reduction in feed and/or water consumption;
5. Swollen and bluish colouration of combs, wattles
6. Swollen head;
7. Subcutaneous hemorrhage/ reddish colouration of shanks;
8. Profuse watery diarrhea.

With or without the symptoms listed above, an unusual high mortality (>50% in two days) would also classify a flock as exposed or infected with HPAI [1].

All suspicious tissue samples for HPAI from the field are sent to the Central Diagnostic Laboratory where postmortem is done and visceral organs are harvested and sent to the Avian Influenza Laboratory (AI Lab). Other specimens like serum, cloacal and tracheal swabs are sent directly to the AI lab were virus isolation is done by egg culture and subtype by Heamagglutination Inhibition test to confirm the H5. The allantoic fluid containing the virus is further sent to the biochemistry and applied molecular biology lab where reverse transcriptase polymerase chain reaction (RT - PCR) is done to detect M-gene and if positive, a further test is done to detect the H5 gene. This is a second confirmatory test for H5N1.

Once a case is confirmed at the AI lab, batches of isolates are sent to the OIE/FAO Reference Lab for Avian Influenza and Newcastle Disease in Padova, Italy. At the AI lab, analysis is completed within 24 - 48hrs and result of positive specimens are sent to Director, Federal Department of Livestock/NADIS, AI desk officer, field surveillance agents that submitted the specimen and finally to the farmer concerned.

The objectives of this HPAI Surveillance was early detection of HPAI in poultry for early response as well as the role of LBMs in the spread of the HPAI virus.

Data Generated from the Surveillance will be used as follows;

1. To generate epidemiological data;
2. To monitor the pattern of spread among susceptible species and healthy carriers;
3. To provide a report to the World Organization for Animal Health (OIE);
4. To document introduction of a new clade of HPAI into Nigeria;
5. To trace the source of index outbreak and document live bird markets as portals of entry of virus into commercial farms;
6. For making policies to implement control and eradication of HPAI in Nigeria.

Data is collected using two forms administered by the surveillance agents. A more detailed form for epidemiology and a laboratory form. The laboratory form accompanies the specimen or samples to the lab at the time of submission while the more detailed surveillance forms are sent to NADIS for data collation. Data collected during the passive surveillance is domicile at the epidemiology unit of the Central Diagnostic Lab where they are collated and analyzed. Only data from active surveillance is sent to NADIS for collation and analyses.

Objectives of the evaluation:

1. To assess the operations of the system;
2. To evaluate the key attributes of the laboratory component;
3. To see if the system is meeting it's set objectives;
4. To provide recommendations on areas that need improvement.

Performance indicators for the laboratory component:

1. Stock pile of reagents and kits before outbreaks are reported;
2. All suspicious specimen correctly collected, labeled and sent to the laboratory (100%);
3. All suspicious samples correctly analyzed within 24- 48 hrs (100%);
4. Feedback of all the results to the field agents, farmers and NADIS within 24-48hrs;
5. 80% of staff are adequately trained.

Materials and Methods

The study period was from January 2006 – December 2009. We used Center for Disease Control and Prevention guidelines for Evaluating Public Health Surveillance Systems (MMWR, 2001) [3]. We evaluated key system attributes such as simplicity, flexibility, timeliness, stability *etc*. and conducted key Informant Interviews of some key stakeholders. Surveillance data and reports from January 2006 – December 2009 were reviewed.

Results and Discussion

Evaluation of the Surveillance System highlighted the following System Attributes;

1. *Usefulness:* The surveillance was useful in the control of HPAI in Nigeria.
2. *Simplicity:* Key stake holders rated the system as very simple because the case definition is simple. The forms used were easy to fill out and questions were straightforward.
3. *Positive Predictive Value*: System is sensitive at detecting true positive cases because diagnostic test (RT-PCR) used has a positive predictive value of 99.9%.
4. *Timeliness:* System is timely because specimen can be analyzed within 24-48hrs and results are communicated on time.
5. *Flexibility:* System is flexible because it has been adapted for surveillance of other Transboundary Animal Diseases.
6. *Acceptability:* The system was considered acceptable because of the integration of other laboratories in prompt diagnosis of HPAI. Stakeholders accepted the system and are willing to continue with it.
7. *Representativeness:* Tested samples from poultry population at risk analyzed by the system cut across the 36 states plus FCT.
8. *Stability:* The system is rated very stable since it has a very good operational structure. It can collect, manage and provide data without failure when needed. It has trained and dedicated personnel. It is donor driven.
9. *Data Management:* This is rated fair since the epidemiology unit of the central diagnostic lab which should serve as the data bank of the system does not have all the data for both active and passive surveillance. Questionnaires were filled out by and analyzed by trained epidemiologists.

Review of records from January 2006 – December 2007 revealed that a total of 1,205 suspected routine diagnostic samples, 8638 cloacal swabs, 7976 trachea swabs, 7328 serum samples and 616 carcasses were received. Of 25,763 samples analyzed for both systems, 300 (1.2%) were confirmed for HPAI from January 2006 to December 2007

For the targeted LBM Surveillance in 2007 covering 25 infected states and FCT, a total of 13,597 samples were analyzed out of which 12 were found to be positive and confirmed for HPAI.

Of the 1,874 samples analyzed from the LBM Surveillance in 11 States with no previous HPAI outbreak in 2008, only two were confirmed to be positive for HPAI. No positive case was detected in 2009.

HPAI Surveillance has been integrated with the Surveillance of other Trans-boundary Animal Diseases (TADs). The five regional Laboratories at the Veterinary Teaching Hospitals are not functioning due to lack of equipments.

Figure 1: Distribution of HPAI (H5N1) positive cases during the surveillance from January 2006 – December 2008

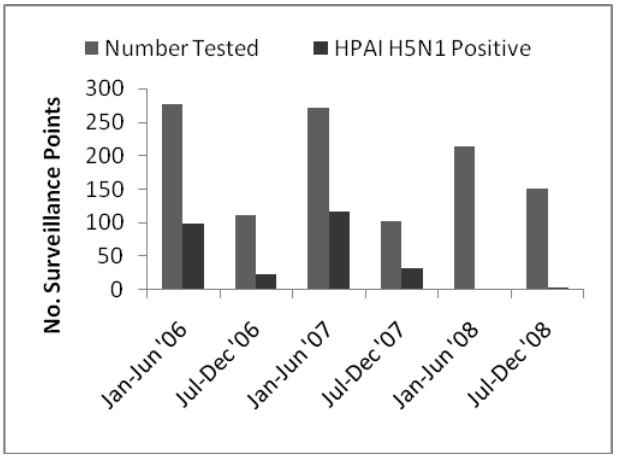
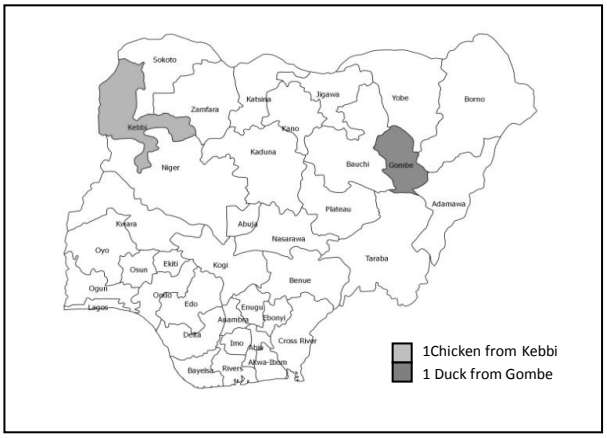


Figure 2: Distribution of States with no previous outbreaks which were Positive for H5N1 in LBM Surveillance in Nigeria, 2008



The Avian Influenza Lab in NVRI has adequately trained manpower with the capacity to receive and analyze specimens for HPAI diagnosis from any part of Nigeria within 24hrs. Private Veterinarians are not adequately integrated into the system.

As a result of the surveillance, the following public health actions were undertaken; Quarantine, depopulation and decontamination of affected farms; Payment of compensation to affected farmers; Health education on the HPAI risks, control and prevention; Building of new standard LBMs; Introduction of Biosecurity to LBMs and training of live bird marketers on best practices.

Limitations of this evaluation were that the sensitivity of the surveillance system could not be calculated because of unavailability of the denominator and also no information on timeliness from detection of sick birds to arrival of specimen at the laboratory was available.

In conclusion, the HPAI laboratory surveillance is useful, acceptable, stable, timely, representative, has good data quality and is performing very well. It appears to be meeting its objectives, however data

management and networking with the other regional laboratories has remained defective.

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A review of a regional animal disease investigation surveillance system

M.C. Ball[1*], K.A. Finlayson[2] and P.G. Freeman[3]

Abstract

Animal health policy makers need to be given adequate information about the nature of the animal disease monitoring and surveillance system of their regions. Such information can be used to make decisions regarding resource allocation and appropriate organisational structure. Government, private industry or a combination of both can fund veterinary services and laboratory testing. Finding an appropriate balance of funding is critical for achieving the desired type of surveillance.

In 2010, a review of the general livestock health surveillance activities occurring in the North Coast region of New South Wales (NSW) was conducted. This paper highlights the key features of an industry and Government shared funding mechanism for general disease surveillance and summarises the component of that review related to ruminants. On the North Coast of NSW there are approximately 408,000 ruminants on 7553 properties. Between July to December 2010 there were over 3000 ruminant disease investigations.

The review did not include other local surveillance activities such as sentinel herds, targeted surveys and abattoir monitoring. Other aspects of the review related to geographic location and diagnoses of disease investigations are beyond the scope of this paper.

Challenges of undertaking livestock health surveillance in a region where notifiable[4] diseases are typically absent and where traditional farms are being increasingly subdivided are discussed. Recommendations include to develop key performance indices for the general surveillance system and to enhance the planning of surveillance and associated extension activities.

Keywords: Surveillance, livestock, disease investigation.

Introduction

In 2009 the 47 former NSW Rural Lands Protection Boards (RLPB) underwent a significant restructure with the creation of 14 Livestock Health and Pest Authorities (LHPA)[5]. These Authorities are legislated to collect rates from the occupiers of all farm holdings greater than 10 hectares in size. Income from these rates is used to employ staff and deliver services. The LHPA delivers legislated livestock health functions in association with the NSW Government Department of Industry and Investment (I & I NSW). A Memorandum of Understanding (MOU) is in place between the two agencies.

The North Coast Livestock Health and Pest Authority (NCLHPA) operational area includes 1,454,653 hectares of land. It has approximately 15,000 ratepayers. In addition the region has a large number of farm holdings that are less than 10 hectares and whose owners do not pay rates. The North Coast is a popular subtropical region of Australia and traditional farms are increasingly being subdivided into small holdings. Land prices are high and many landowners are new to the region, work off farm and lack experience in livestock production. An increasing percentage of land is being used for environmental conservation or horticulture purposes.

The NCLHPA employs three veterinarians and six para- veterinary officers (Rangers), to carry out a range of livestock health functions as specified in the NSW Rural Lands Protection Act 1998. This Act outlines that Authorities are required to provide resources for conducting animal disease surveillance programs and are to collect, collate, interpret and report animal disease surveillance information. The NCLHPA provides a disease investigation service. Phone advice is available to the public. NCLHPA ratepayers are entitled to property visits to investigate any herd health problem. If the reported syndrome could be consistent with a notifiable disease, then non-ratepayers are also entitled to a property visit. Routine individual animal problems are referred to a private veterinarian.

I & I NSW maintain a State Diagnostic Laboratory and cover the cost of laboratory testing to exclude notifiable diseases. Producers generally must pay for all other laboratory tests. However, both I & I NSW and the NCLHPA each provide $AUS9000 per annum to pay laboratory fees for selected cases.

Monthly reports on surveillance activities undertaken in the region are provided by the NCLHPA to producers, private veterinarians and the NSW Government. I & I NSW employ a Regional Veterinary Officer (RVO) to assist in the planning, funding and reporting of surveillance activity for the NCLHPA and two other LHPA's in the north east region. NSW is divided into 5 regions overall: north east, north west, south east, south west and western.

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4 A disease with legislated reporting requirements in the state of NSW.
5 Administrative areas, within the state of NSW, that have prescribed roles in regard to animal health, feral and pest animal control and livestock identification.

Private veterinarians carry out the majority of ruminant disease investigations. These veterinarians report any suspected notifiable diseases to the NCLHPA and submit some of their laboratory samples to the State Diagnostic Laboratory. Other samples are sent to private laboratories. The NCLHPA is provided with a copy of all results from the State Diagnostic Laboratory but not from the private laboratories. Private veterinarians undertaking disease investigations occasionally request financial assistance from LHPA or I&I NSW for laboratory testing. These requests are assessed on a case by case basis evaluating the community benefit that may accrue by undertaking the additional testing.

The objectives of this study were to review: i) the ruminant population demographics in the NCLHPA area; ii) NCLHPA ruminant disease investigations between July and December 2010; and iii) additional disease investigations conducted by private veterinarians during this period.

Materials and methods

A disease investigation was defined to be an incident where a veterinarian made a diagnosis of a reported disease sign in cattle, sheep or goats. To obtain a diagnosis the veterinarian may have done one or more of: history collection on phone, history collection on farm, digital photo examination, clinical examination, necropsy and/or laboratory test interpretation.

Data on stock and farm numbers was collected from FARMS[6]. NCLHPA veterinarian reports and field diaries from July to December 2010 were collated and analysed for information relating to disease investigations and surveillance reporting activities. A phone call was made to each private veterinary practice in the region. Practices undertaking any ruminant activities were identified. A phone survey, consisting of 5 questions, was undertaken of a veterinarian in each of these practices. The survey asked for the number of veterinarians who worked with ruminants and the estimated number of ruminant disease investigations, necropsies and property visits between July and December 2010. The questionnaire was not piloted.

Results

The region has approximately 370,000 beef cattle, 26,000 dairy cattle, 8,000 sheep and 4,000 goats on over 7553 ruminant farms. Most of these livestock are spread out as small groups on many properties. 723 farms have dairy cattle, with only 87 of those farms having more than 100 cows. There are 6295 farms with beef cattle and these farms have an average herd size of only 60 animals. Fifteen of the beef herds have more than 1000 animals. Sheep are spread out across 335 farms with 20 farms having more than 50 sheep. A total of 200 farms have goats with 12 having more than 50 goats and 2 having over 400 goats.

Between July and December 2010 NCLHPA veterinarians carried out 549 ruminant disease investigations. 429 (78%) of these disease investigations involved a property visit. 135 (24%) of the investigations involved a necropsy. The results by species are shown in Table 1.

Table 1: NCLHPA investigations by ruminant species

Species	% of NCLHPA ruminant investigations	% total ruminants in region*
Bovine	91.58	97.34
Ovine	4.36	1.68
Caprine	4.06	0.98

Approximately 370 (5%) of the region's 7553 ruminant farms were visited by the NCLHPA during the six months. A further 2% received a diagnostic service by phone, counter or email. This figure is likely to be an underestimate as data may be lacking for all phone or email investigations where a diagnosis was not recorded.

Thirty-six private veterinarians were identified that undertook ruminant livestock health activities on the North Coast. These veterinarians were from 22 veterinary practices. Every ruminant farm on the North Coast is included in the service area of a private veterinarian.

Based on the survey it was estimated that approximately 3000 ruminant disease investigations were carried out by private veterinarians. 84.34% of these investigations were with cattle. Private veterinarians undertook necropsies in 102 (4%) of their ruminant investigations. It was not possible to determine the percentage of ruminant holdings that private veterinarians serviced. This would require extensive analysis of practice records. It is likely that private veterinarians substantially increase the percentage of holdings reached.

When the private veterinarian disease investigations are added to those carried out by the NCLHPA approximately 3500 disease investigations were carried out in the six months. The rate of return to the same property could not be accurately calculated for either the NCLHPA or the private veterinarians but is estimated to be 15% for the NCLHPA and higher for the private veterinarians.

Discussion

Traditional farms on the North Coast have been increasingly subdivided creating an increase in the number of landholders. There are still a significant number of ruminants in the region.

On the North Coast of NSW the combined resources of private veterinarians, NCLHPA and I & I NSW creates a busy general disease surveillance system. The differing activities of the three stakeholders complement each other and enhance the system. The majority of the surveillance is funded by industry including both fees collected by private veterinarians and rates collected by the NCLHPA.

[6] An electronic database maintained by the LHPA to store property and livestock information for farm holdings in the Authority area

Private veterinarians perform the majority of livestock health work. The 36 private veterinarians carried out 84% of the ruminant disease investigations during the six-month period. The NCLHPA only carried out 16% of the ruminant investigations but carried out 60% of the necropsies. Necropsies are time consuming and many farmers may be reluctant to pay the commercial hourly rate for them to be undertaken by a private veterinarian.

There are significant differences between private veterinarians' activities and the legislated activities of the NCLHPA. The latter has a 100% focus on herd livestock disease diagnosis with no resources allocated for treatments. NCLHPA veterinarians have easier access to laboratory test subsidies and the flexibility to spend longer time on a single investigation.

The ongoing division of traditional farms into smaller units creates challenges for a general surveillance system. Not only are there more farms to contact but many property owners work off farm and lack experience in livestock production. Other challenges have been created by the successful eradication of significant bovine notifiable diseases. Historically, ruminant farm contacts by veterinarians were higher when they were involved in highly funded eradication programs, such as the brucellosis and tuberculosis eradication program (BTEC program).

Increasing the number of disease investigations done by the NCLHPA would be difficult due to limited resources. In addition, almost 1000 of the farms with sheep, cattle or goats are less than 10 hectares in size, do not pay rates to the NCLHPA and are not entitled to property visits for routine disease investigations. The NCLHPA already undertakes a variety of extension activities to help meet these needs. Externally funded, village level biosecurity and syndromic disease workshops would be ideal.

The NCLHPA has legislative obligations to interpret and report on livestock disease in the region. Resources are actively used to spread surveillance information beyond the individual producer. This reporting function is an integral component of any surveillance system. Each month between July and December the NCLHPA distributed surveillance newsletters to both private veterinarians and producers and summarised surveillance activities for I & I NSW. In addition, staff wrote 18 disease case studies and had 8 radio interviews and 6 newspaper articles related to the regions surveillance activities. During the time of the review the NCLHPA collated over 720 laboratory reports.

Instead of attempting to increase its disease investigation service it may be more effective for the surveillance system overall for the NCLHPA to strengthen its surveillance reporting. To do this adequately the NCLHPA would need access to more data than it is currently provided.

It is beyond the scope of this paper to assess the cost benefit of the North Coast's busy general surveillance system to NCLHPA ratepayers and the wider public. If this was to be attempted it would be necessary to consider the relationship between the level of general surveillance and improvements in disease prevention and control at farm, Authority, State and National levels. Other benefits to ratepayers and the role this surveillance model plays in protecting overseas markts compared to models used in other Australian states could also be considered.

Risk analysis is an ongoing process in Australian livestock health agencies. Hopefully the findings of this review could be helpful for any future risk analysis that looks at particular disease risks to the North Coast of NSW. Disease risk analysis may also indicate what components of the system should be strengthened.

NCLHPA surveillance planning and reporting may be improved if its surveillance activities were focused on methods to detect and report on diseases listed on an annual local "target list". This list could consider results of risk analysis, NSW notifiable diseases, changes in local disease patterns and comments from local farmer groups. Decisions could be made about the most appropriate resourcing and surveillance method for each disease. This may be passive data collection, sentinel herds or surveys. The process may enable the NCLHPA to seek additional funding for surveillance beyond the disease investigation service funded by its ratepayers.

Overall the general surveillance activities in the region give enough information to the NCLHPA livestock health manager to monitor disease over time and detect changes in disease patterns. Alone, these activities are not adequate to reliably ensure specific disease detection. It is also difficult to assess the effectiveness of the components of this general surveillance system. This is partially because policy makers have not set key performance indicators (KPIs) for surveillance. In order to assess the effectiveness of the general surveillance system the livestock health manager should assist with the development of state wide KPIs that are related to geographical, enterprise and other risks rather than indicators of activity levels. The relevance of targets related to the number of disease investigations in proportion to farm holdings and to the number of various surveillance reports generated should be considered.

Reviewing data relating to disease investigation activities can provide livestock health managers with useful information to begin assessing the effectiveness of their general surveillance system. The development of general surveillance KPIs, enhanced surveillance reporting, and undertaking of continued risk analysis techniques are considered to be priorities.

Validity assessment of the cattle health surveillance system in the Netherlands

C.J.M. Bartels[1], G. van Schaik[1*] and P. Kock[1]

Abstract

In this paper, we give a qualitative validity assessment of the Dutch Animal Health Surveillance System (AHSS). The AHSS is characterized as an integrated surveillance system with multiple surveillance objectives and subsequently various surveillance components. We apply scenario-tree approach for the cattle part of AHSS; the cattle health surveillance system (CHSS). This approach is primarily used to initiate a discussion on how to validate complex surveillance systems and may be followed by a quantified validity assessment. For detecting (re)emerging disease, the most critical step in the passive surveillance component is keeping farmers and local practitioners motivated to inform the CHSS about non-understood health problems. This is achieved through a free telephone helpdesk with direct response to any questions on animal health. For providing information on trends and changes in cattle health, the most critical step in the active surveillance system is the availability of health-related data and the definition of cut-off values that indicate a breach in trends. This requires close interaction between epidemiologists working on the census data with cattle-health specialists working for the passive surveillance component.

Keywords: validity, assessment, surveillance system, scenario-tree analysis, cattle.

Introduction

In line with the SPS agreement of the WTO, a surveillance system has to satisfy the demands of its initiators, trading partners or government authorities. Therefore it is essential to assess if the information delivered by the surveillance system is of sufficient quality [Stark, 2003; Hoinville *et al*., 2010]. Stochastic scenario-tree modelling was developed to provide a quantitative probability estimate to support claims of freedom from disease [Cameron and Baldock, 1998a, b]. Recently a number of studies have been published on additional applications of stochastic scenario-tree modelling such as the modelling of a passive surveillance system in a disease-free and an endemic situation [Hadorn *et al*., 2008].

For the assessment of a general surveillance system such as the CHSS, there are additional difficulties as there is more than one primary objective and these objectives are not about specific diseases. In this paper, we assess the validity of the CHSS using the concept of scenario-tree modelling in a qualitative way. This is done with the focus on the evidence provided by the CHSS and thus deals with the usefulness of the information collected. We try to qualify the extent to which the signals, generated through the different components of the CHSSS, are reflecting real changes in cattle health.

Materials and methods

An overall quantitative assessment of the CHSS has not been done and would require extensive adaptation of the model to cover for its general surveillance objectives. For example, the probability of infected animals to show clinical signs and the disease awareness of farmers and veterinarians will depend on the nature of the infection and therefore will be different for various emerging diseases. However, we have taken the concept of scenario-tree modelling to assess the evidence provided in a qualitative way. The various steps in the pathway for both the passive and active surveillance components are defined separately and will be discussed step by step.

Results

For an emerging infection to be detected, there need to be clinical effects (Figure 1). Clinical signs depend on the virulence of the particular infection and the immune status of the cattle (Figure 1, step 1). Observation of these signs by a farmer or private veterinarian depends on the severity of signs as well as on the number of cattle affected. Severe clinical effects in many animals are observed more easily than minor clinical effects in one or only a few animals. However, the farmer's or private veterinarian's capacity to record something unusual is essential (step 2). This may very much depend on the person's interest in managing cattle and is influenced by communication, training and education.

Step 3, contacting the Livestock Watch, requires both knowledge about its existence and motivation of contacting it. The latter will highly depend on the perceived gain by doing so. It requires that the farmer or private veterinarian believes that calling Livestock Watch will help him tackling the situation without overdue conditions set to his farm or work.

An investigation between 2004 and 2008, showed that of 323 veterinary practices serving the ±40.000 Dutch cattle herds, 206 had been in yearly contact with the Livestock Watch. Only 12 veterinary practices had not contacted the Livestock Watch during this period and these veterinary practices provided services to 1 to 3 cattle herds each. It clearly indicated that the Livestock Watch has a high coverage, representing the cattle farm (beef and dairy) industry.

This paper builds further on a paper about the animal health surveillance system in the Netherlands [Van Schaik *et al*., submitted to ICAHS]. For details on the different surveillance objectives and components, one is referred to this paper.

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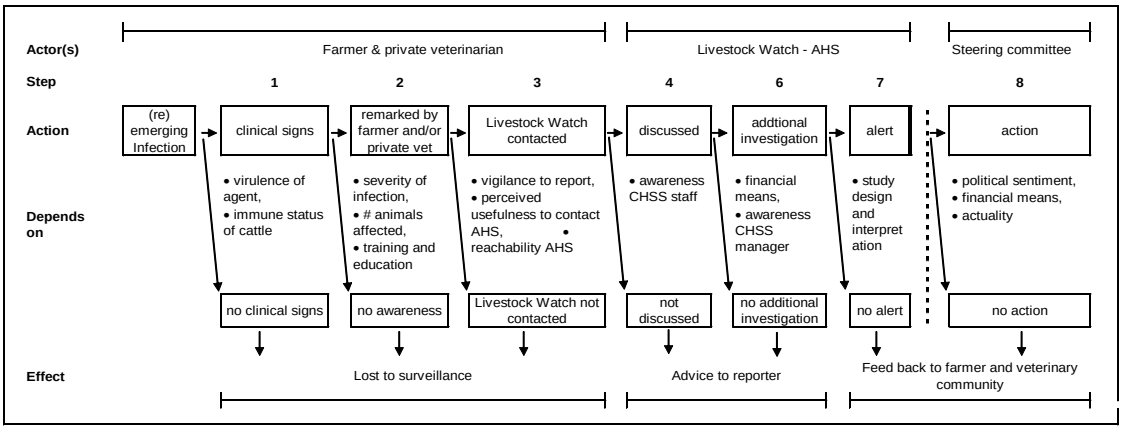
Figure 1: Scénario tree for passive surveillance on cattle



Once a call has been received at the Livestock Watch telephone desk, the seriousness of a reported health problem is first assessed by the person at the telephone (step 4). If he/she regards the health problem in line with the surveillance objective of the Livestock Watch, it will be discussed in the weekly meeting of the cattle-health specialists working for the Livestock Watch. When it is decided that there is reason for further investigation, a farm visit is conducted or pilot project is initiated (step 5). This decision is based on the combined experience, knowledge and vigilance of the cattle-health specialist and may be supported by additional and/or similar cases received. In case of a farm visit, it may become clear that the reported health problem is not indicative for an emerging disorder as it may be caused by a known endemic infection such as BVD. In that case, the signal will no longer be followed up. However, additional advice is relevant to the herd owner and its private veterinarian as they are consulted on how to deal with the health problem encountered. In case of a pilot study, more information is collected from similar herds or from literature. When additional investigation leads to an alert (step 6), the steering committee of the CHSS is informed instantly, otherwise the steering committee is informed at the quarterly meetings. Concluding that additional investigation supports an alert depends on interpretation of the acquired results. For this step to be relevant, the study design of an additional study is important and this is safeguarded by an independent research committee, evaluating study design for each additional pilot.

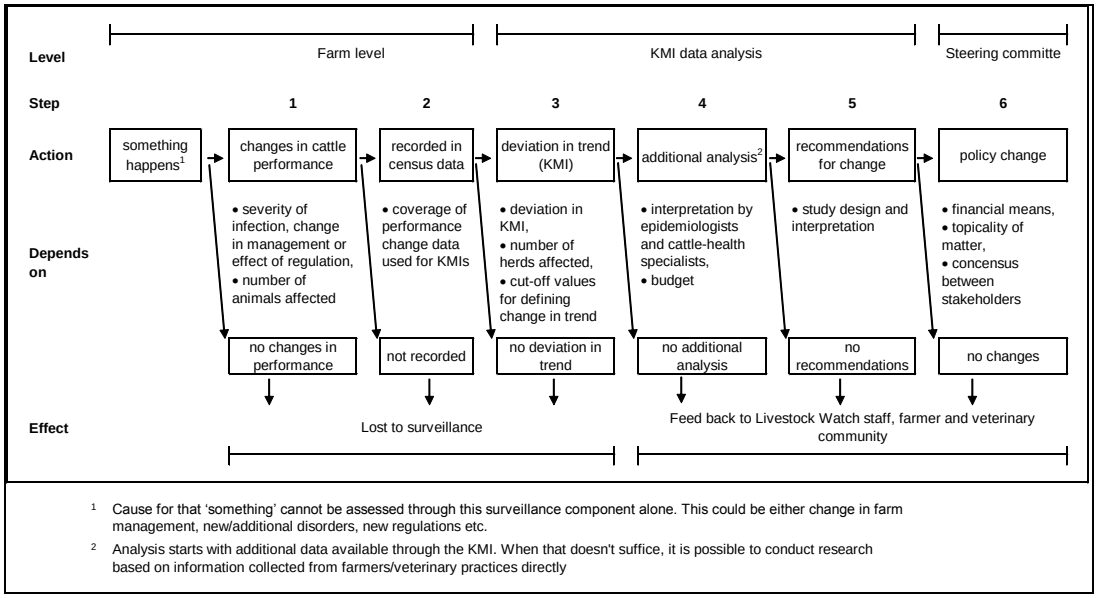
Overall, it is our observation that the most critical step in this pathway is the vigilance of farmers and private veterinarians to contact Livestock Watch. To motivate farmers and private veterinarians, different means such as newsletters, email messages, magazines, study group meetings. Post-graduate training, informative meetings and the GD-AHS website (www.gddeventer.com) are used.

The possibility of an emerging disease not being detected through the Livestock Watch component is considered small. This may be different for emerging diseases with minor pathology or with signs very similar to endemic diseases. In such case, the emerging disease may go undetected for some time.

Contrary to the passive surveillance, the objective for the active components is to provide reference information and to describe trends and changes in cattle health. Information is generated combining census data of 5 nationally-operating organisations into key monitoring indicators (KMI) by farm per quarter of year. There are however, multiple reasons for changes in KMI and these entail changes in farm management (fast growth of herd size due to high milk price), new regulations (EU regulations considering off-farm movement of sick cattle) or new / emerging disorders. These reasons may or may not influence performance in cattle (Figure 2, step 1). Next, performance changes may not be captured in the data used for the KMI analyses (step 2). Except for mortality, data are mirroring subclinical events more than clinical events. For example, subclinical mammary infections are counted using the data collected during the monthly milk recordings, whereas cows with clinical mammary infections are excluded from these monthly milk recordings and thus lost to surveillance. The same applies for abortions (not recorded) versus impaired fertility resulting in *e.g.* increased number of inseminations per pregnancy.

As census data are used, there is no problem with precision and selection bias. However, data are modelled using statistical regression analyses and changes in the regression estimates of KMIs depend on the magnitude of change in performance indicators as well as the number of herds with changing performance (step 3). Within the agreement between GD-AHS and the organisations providing the data, it is agreed that results of the KMI analyses should not involve fewer than 200 herds, as the objective is not to detect individual herds but to signal trends. For defining a trend, defined cut-off values are needed. These cut-off values are based on what is deemed relevant by the cattle-health specialists instead more than using statistical results.

Figure 2: Scénario tree for surveillance by Key Monitoring Indicators on cattle



When KMI deviations are seen, the available data are used from more detailed analysis to further quantify the exact change in performance. In addition, the data information is checked with the information available through the Livestock Watch such as telephone contacts, test results from submissions for post-mortem or laboratory investigations and information from farm visits (step 4). Until this step, interpretation of data results need great caution as, given the nature of the analysis, it is not possible to reveal causation. Deviating trends can only be associated to putative causes. So, when these 'checks' do not elicit reasons for deviations, additional research projects are conducted in which the relation between cause and effect can be measured. For that reason, the preferred type of study is a cohort study on farms or with veterinary practices. When such additional analysis elicits possible causes for deviating trends, recommendations are prepared for the steering committee (step 5). The way the steering committee deals with these recommendations depends not only on the epidemiological impact to avert trends but also on financial means, the capability to reach consensus between stakeholders and the topicality of the subject (step 6).

The most critical steps in the pathway of active surveillance are 1) the availability of data that cover changing performance and 2) the cut-off values used to define a breach in trend. The former issue is dealt with by constantly trying to include additional KMIs as well as by (re)evaluation of currently used KMIs. The latter issue is dealt with by evaluating the KMI results and the cut-off values with the Cattle-Watch staff on a regular basis.

Discussion and conclusion

The CHSS performs according to the expectations of its stakeholders. So far, its validity has only been assessed qualitatively but not quantitatively. In a qualitatively way, our assessment for the passive surveillance component determined that the most critical step is to have farmers and/or local private veterinarians forward unexplained health problems to Livestock Watch. Motivation of these so called 'eyes and ears' of disease surveillance is pivotal to any surveillance system. This is motivated by ensuring that they are given an answer instantly for them to cope with the herd-health problem. By providing such a direct feedback, farmers and practitioners feel acknowledged and rewarded for reporting adverse-health events now and in the future. In addition, responses are given by knowledgeable animal-health specialists affiliated with a private organisation for free.

For the active surveillance system, the use of census data from five different organisations allows to describe trends and developments in a wide range of cattle health performance indicators. We try to update this surveillance component by looking for additional data sources and adjusting present KMIs to better represent animal health.

The qualitative approach described here is used to initiate the discussion on validation of complex surveillance systems and may be followed by a quantified validity assessment in the near future.

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Acknowledgements

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Management of Emerging Risks in Animal Health Policy Settings

V.J. Del Rio Vilas[*1,2], F. Voller[1], H. Roberts[1], M. Hartley[1] and J.C. Gibbens[1]

Abstract

We describe the design and pilot implementation of specific structures, the Risk Management Cycle, for the management of emerging risks to UK's animal health status.

The Risk Management Cycle provided the adequate framework, in the form of dedicated and empowered structures within the organisation, for the systematic identification and characterisation of emerging risks.

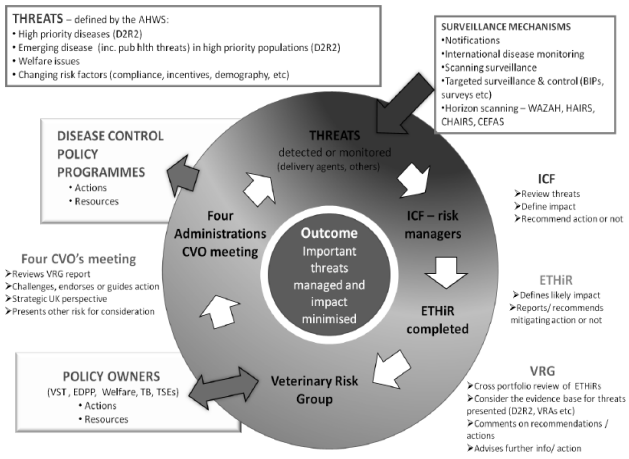
Keywords: emerging risks, identification, characterization, decision making.

Introduction

Great Britain's Animal Health and Welfare Strategy (AHWS) identified a number of strategic outcomes [1], among which and of interest to this work is the early identification of new animal health and welfare threats. A disconnected approach to the identification, evaluation and response to emerging threats, without formal integration with other strategic decision making processes has been reported as a common constraint in many organisations [2].

UK's Department for Environment, Food and Rural Affairs (Defra) is piloting the Risk Management Cycle (RMC), a suite of tools, structures and processes (Figure 1) that would guarantee a systematic and integrated approach to the management of emerging threats and vulnerabilities (T&V) of animal origin. The current work describes the RMC and the results of the first eight months of operation, since its launch in November 2009.

Figure 1: The Risk Management Cycle for animal related threats and its network of inputs and outputs



Materials and methods

Risk managers (RM), or portfolio owners, report on the emerging T&V within their risk streams that represent the different functional groups within the department (*e.g.* International Disease Monitoring, UK's scanning surveillance of animal populations). Emerging T&V are recorded electronically on the Emerging Threat Highlight Report (ETHiR) that is collated and reviewed by the Veterinary Risk Group (VRG) every month.

RM are required to describe the risk path, likely impact and mitigation measures, taken or due to be taken, for each T&V. The VRG's structure allows cross-portfolio review of all T&V and it is best placed to conduct strategic risk comparisons. The VRG may then agree with the RM assessment, make recommendations on mitigating actions or request further information from the RM before submitting the VRG report of the month to the four CVOs (Chief Veterinary Officers for England & UK, Wales, Scotland and Northern Ireland). The cycle is closed with recommendations by the CVOs, if pertinent.

Result

Seventy-one emerging T&V, now considered "closed", *i.e.* adequately managed, from eight risk streams have been reported to and dealt with through the RMC. Of the 71, 27 (38%) could be classified as vulnerabilities mostly reflecting shortages in existing processes. The rest described known conditions, *e.g.* rabies, that could pose a new or re-emergent risk to UK's animal health status. Twenty T&V were reported more than once and/or by more than one risk stream. This indicates the persistence of the threat or its recurrence. It also provides an indication of the spread of impacts affecting different risk streams. On five occasions, the CVOs requested further clarification or evidence before they were content that the risks were correctly managed.

Discussion

A significant number of methods exist to assess the ability of surveillance systems to identify risks. The RMC however targets later stages in the risk management chain, the assessment, communication and mitigation of risks, and aims to provide a framework for their systematic evaluation. At a tolerable cost of 0.3 man-years, the RMC also supports a number of desirable and exchangeable competences, *e.g.* making effective decisions, that deliver benefits across the entire organisation. It also ensures the alignment of effective risk management with the organisation's strategic structures.

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Extensions to the current model are underway to allow the incorporation of standardised approaches to the prioritisation of T&V via a simplified Multi-Criteria-Decision-Analysis (MCDA), applied at the ETHiR stage. MCDA specifically calculates for each T&V an overall impact index, an overall capability index, the ratio impact/capability and the ratio public perception/impact to facilitate comparisons and prioritisation of resources.

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Sensitivity-adjusted BSE Prevalence can be Estimated Using Surveillance Data Without External Information on Incubation Time and Age at Infection

M. Greiner[1*], T. Selhorst[2], W.O. Johnson[3], M. Doherr[4] and C. Müller-Graf[1]

Abstract

We have developed a Bayesian model for estimating the true prevalence of bovine spongiform encephalopathy (BSE) by adjusting for diagnostic sensitivity. The model considers the observed number of detected cases per year of testing and age at testing as a Poisson variate. The Poisson density parameter is a function of a) the unknown prevalence of the given birth cohort, b) the observed number of tested cattle per test year and age at testing and c) the Gompertz function with two unknown parameters for the age-dependent diagnostic sensitivity. We have applied the model to the German BSE surveillance data (19.5 mil. test results obtained between 1997 and 2009, with partially censored data on age at testing). The unknown parameters could be estimated without external information on incubation time and age at infection. The results indicate a BSE prevalence peak in the 1996 birth cohort of 13.9 (upper limit 17.2 of 95% credible interval) cases per 100,000 with a ratio of undetected to detected cases of 1.0. From 1996 onwards, the true prevalence exhibits a continuously decreasing trend. We can also show that the ratio of undetected to detected cases increases for younger birth cohorts.

Keywords: BSE, prevalence, sensitivity, Bayesian model.

Introduction

The BSE infection prevalence is an important input parameter for BSE risk assessments. In this context, it is important to realise that observed prevalence rates may be biased due to false negative test results occurring in BSE infected cattle during the early stages of incubation [1-3]. The age-dependent diagnostic sensitivity of BSE testing [4] has been derived from the distribution of the incubation time period and age-at-infection estimated using UK data [5]. The age-dependent sensitivity is a proxy for the combined effect of the age-at-infection and the incubation period length [4]. However, it is not known whether such sensitivity estimates are generally applicable irrespective of the target cattle population. Therefore, we aimed at estimating BSE prevalence for the German cattle population adjusted for diagnostic sensitivity without using such external information. Our case definition refers to the status "BSE infected" irrespective of the tissue distribution of infectious BSE prions.

Materials and methods

Data: We have used the complete German BSE surveillance data collected between 2001 and 2009 supplemented with BSE test data collected in Germany prior to 2001. The total number of BSE cases and total sample size are 413 and 19,449,774, respectively [6]. We have organised the data by year of testing and birth cohort. The number of BSE tests conducted in 2001 and later was reported in one age category for all cattle slaughtered with an age of 0-24 months (interval censoring). For the purpose of our model, we assigned an age of 0-12 months to all animals in this category. Furthermore, the age at testing is left-censored with variable censoring limits. The censoring limits are 2, 8, 8 and 13 years for the BSE testing reported in 2001, 2002, 2003 and after 2003, respectively. For example, in 2001, a total number of 2,354,527 BSE tests have been reported in cattle of the age category ">24 months". For consistency, we assigned the censored age category to a number of 125 and 6 BSE cases detected in 2001 and 2002, respectively. The number of animals born in cohort i and tested in year j and the corresponding number of positive BSE test results are denoted as n_{ij} and X_{ij}, respectively.

Age-dependent sensitivity (Se). We considered a Gompertz function with the unknown parameters β_1 and β_2 to reflect the *Se* as a function of age (a_{ij}) in years,

$$Se(a_{ij}) = \exp[\beta_1 \exp(\beta_2 a_{ij})].$$

Response variable. We modeled the number of BSE cases from cohort i detected in year j as a Poisson variate with a parameter λ_{ij} expressed as function of the sample size n_{ij}, the unknown true BSE prevalence π_i and sensitivity $Se(a_{ij})$,

$$X_{ij} \sim \text{Poi}(\lambda_{ij})$$
$$\lambda_{ij} = n_{ij}\, \pi_i\, Se(a_{ij}).$$

Model fitting. The parameters of the Gompertz function for age-dependent sensitivity and the cohort specific true BSE prevalence (π_i) have been estimated using a Bayesian model (see details in 7). Beta distributions with parameters (1,1) were chosen as priors for the cohort specific prevalences. The model has been implemented in R [8] using the BRugs package for Markov chain Monte Carlo (MCMC) modelling [9]. The reported point estimates are median values of the corresponding posterior distributions.

Results and discussion

The estimates of the Gompertz parameters β_1 and β_2 were -12.2 (-22, -8; 95% credible interval) and -1.73 (-1.89, -1.43; 95% credible interval), respectively. The estimates of the BSE infection prevalence for birth cohorts 1994-2005 are shown in Table 1.

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We found a peak of Se-adjusted prevalence estimate of 13.9 cases per 100,000 cattle for the 1996-cohort with an upper limit of a 95% credible interval of 17.2 cases per 100,000. The estimated ratio of undetected to detected cases for the same cohort is 1.0 with upper limit of 1.4. It is noted that the cohort specific prevalence estimates are based on all surveillance results accumulated over all available years of testing.

Table 1: Estimate of BSE infection prevalence adjusted for sensitivity (cases per 100,000) and ratio of undetected to detected cases for German birth cohorts 1994-2005.

Cohort	Prevalence (UL)*	Ratio (UL)
1994	3.4 (5.7)	1.0 (2.3)
1995	4.5 (6.4)	1.0 (1.7)
1996	13.9 (17.2)	1.0 (1.4)
1997	6.5 (8.4)	1.0 (1.5)
1998	4.0 (5.3)	1.0 (1.6)
1999	6.4 (7.8)	1.3 (1.6)
2000	1.3 (1.9)	1.2 (2.1)
2001	0.2 (0.5)	1.4 (8.0)
2002	0.0 (0.2)	1.6 (66.8)
2003	0.1 (0.3)	1.5 (61.7)
2004	0.1 (0.3)	1.5 (58.5)
2005	0.1 (0.5)	1.2 (44.9)

*UL=upper limit of 95% credible interval.

The ratio (undetected to detected BSE cases) estimates showed an increasing trend. We interpret this trend as an effect of an increasing proportion of younger animals tested when age-dependent sensitivity is still low.

The number of cattle slaughtered and tested at age of three years and older declined markedly for birth cohorts 2006 and thereafter. Our model provided increasing BSE prevalence estimates for these younger cohorts, which finally reached 50,000 cases per 100,000 for the 2009-cohort (results not shown). We interpret this as an increasing effect of the prior cohort-specific prevalence (expected value of 0.5), which is finally reached in the absence of suitable testing data for the youngest cohort.

Both interval censoring and left censoring occurred in the reporting of age at testing for the BSE surveillance data. In these cases, we have assumed the minimum age (in years) within the known censoring interval. We believe that this is a conservative approach under the assumption that age-dependent sensitivity increases with age. On the other hand, due to collapsing the ages of 125 BSE cases detected in 2001 into a single censored age category of three years (25-36 months) we may expect that the estimated function for age-dependent *Se* is shifted to the left. This calls for additional sensitivity analyses which can be addressed using alternative approaches for dealing with the age censoring.

We can conclude that the parameters of the latent (non-observable) function for age-dependent BSE testing sensitivity could be estimated without external data. The model in its generic form is capable to estimate parameters of a latent function underlying the data-generating process.

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A Practical Framework for the Economic Evaluation of Veterinary Surveillance on National Level

B. Häsler[1*], K.S. Howe[2] and K.D.C. Stärk[1]

Abstract

Economic analysis provides criteria for allocating limited funds to projects to achieve the greatest net benefits. For veterinary surveillance at national level, this should be in the interests of society as a whole. This study aimed at providing a user-friendly practical framework to guide decision-makers (DMs) in planning, designing, and conducting economic evaluation of governmental veterinary surveillance programmes. Two main pathways are presented: i) cost-effectiveness analysis (CEA) for a scenario with constraints, for example when international disease regulations must be observed by law; and ii) cost-benefit analysis (CBA) for a scenario without constraints. The CBA pathway further includes three sub-pathways according to the stage of mitigation and the related surveillance objective. For each pathway, the basic economic framework underpinning the analysis, economic criteria and data requirements are defined. A flow-chart is constructed to guide users step-by-step through a set of questions to ensure that all elements necessary to conduct the economic analysis are available. At the end of each pathway, instructions for carrying out the economic analysis are provided. Appendices include glossaries, explanations of key economic concepts, and information about efficiency criteria. The practical framework helps DMs to grasp the interrelationship of technical and economic considerations that impact on the economic value of surveillance, to list explicitly the necessary elements for the analysis, to estimate the time and personnel resources needed, and finally to choose a suitable approach for the economic evaluation of surveillance.

Keywords: economic evaluation, practical framework, cost-effectiveness analysis, cost-benefit analysis.

Introduction

Since resources are scarce and governments must work within limited budgets, economic analysis of surveillance systems should be required as an aid to decision-making. It shows the consequences of alternatives and helps to identify which of these is to be preferred if the objective is to obtain the optimal level of net benefit from the scarce resources available. This study originates in a project for the Swiss Federal Veterinary Office (FVO) that aimed to develop a practical, generic tool to help DMs evaluate veterinary surveillance programmes that are part of the national control plan of Switzerland. Ideally, such a tool will be user-friendly, transparent and build on solid scientific principles.

Public policy making is a complex exercise characterised by a mixture of epidemiological, economic, political and technical information combined with knowledge on resource limitation and risk [1]. When considering a national mitigation programme, policy makers want to know what strategies should be adopted and when and how they should be implemented. An important element in rational decision making is to weigh and compare the relative costs and benefits of each strategy to come up with measures that allow allocating limited funds to projects in a way that guarantee the best outcome for society as a whole [2].

Economics is a discipline focused on the efficiency criteria for making choices between alternative uses of limited resources. It provides robust criteria to assess how decisions about the allocation of resources impact on the well-being of different groups of people in society and for society as a whole [3]. A unifying underlying principle of economic analyses is to provide a measure of the relative value attached to competing alternative strategies and thereby facilitate decisions about the allocation of resources [4]. A prerequisite for such analysis is description of the economic principles, key relationships, and thus data required for empirical analysis which helps DMs to make better informed choices [4]. This rigorous approach helps complex interactions to be better understood and, very importantly, to highlight the possible outcomes of a given decision – an essential component of sound decision-making.

The objective of this study was to develop a practical framework based on economic principles that would guide DMs in planning, designing, and conducting economic evaluation of current and future governmental veterinary surveillance programmes. The practical framework should be scientifically valid and tailored to the needs of the FVO.

Methodology

First, a classification system for surveillance was developed to explore the technical relationships between mitigation, from which derives economic benefits (*e.g.* reduced output losses, freedom from human fear of zoonotic cross-infection, increased opportunities for international trade), and surveillance and intervention, sources of economic cost. Second, a conceptual framework was developed that used economic principles to investigate in detail the technical and economic relationships between surveillance, intervention and mitigation, and to specify criteria for both technical and economic efficiency. Third, economic evaluations of the Swiss surveillance programmes for Avian Influenza, Bovine

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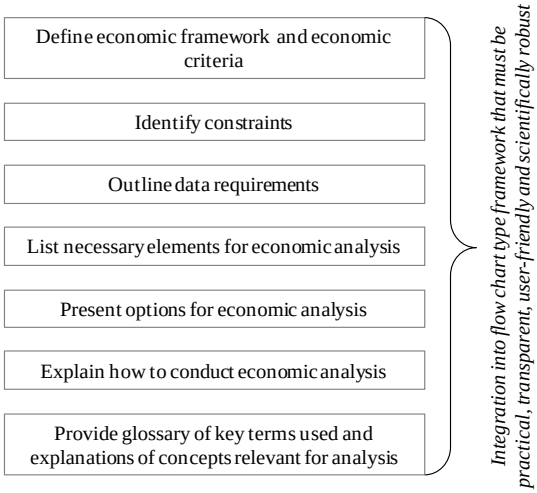
Virus Diarrhoea Virus, Bluetongue Virus serotype 8 and Salmonella in poultry were performed to explore the potential of empirical analysis in relation to the developed conceptual framework.

These steps were precursors for the development of a practical framework to assist DMs with the economic evaluation of surveillance. The lessons learned from both the theoretical and empirical work were used to define and summarise essential features that impact on the economic evaluation of surveillance (Figure 1).

Figure 1: Structure used to develop a practical framework for the economic evaluation of surveillance



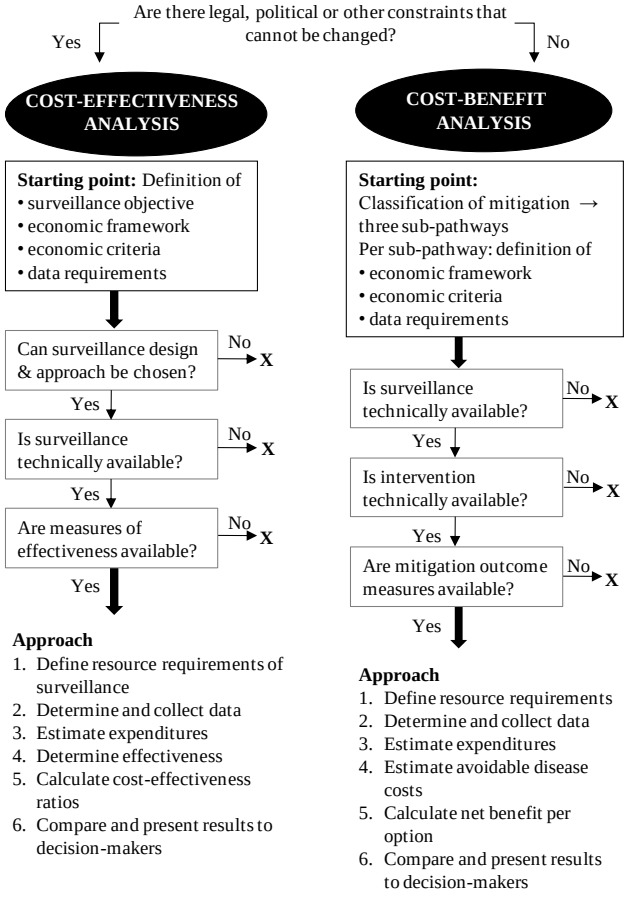
The starting point was identification of the range of constraints DMs face and assessment of their implications for economic analysis. Two main pathways were developed, one for a scenario with constrained options, for example when international disease regulations must be observed by law, and one for a scenario without such constraints. For each pathway, the key economic criteria and data requirements were established. Next, technical requirements for surveillance and intervention, measures of outcomes of disease mitigation, and of disease itself, were identified and supplemented by surveillance and intervention costs. For all necessary elements that could potentially be unavailable (or unavailable within a time frame acceptable to the decision-maker), alternative strategies were considered. Finally, each single step of how to conduct the economic analysis, using the elements identified in the previous steps, was described.

Flow charts were developed to guide DMs through all relevant questions that would identify the pathway and the approach to be chosen. They were complemented by descriptions of the basic economic frameworks, economic criteria and data requirements. The description of how to perform the economic analysis was integrated into the framework as a set of instructions. Whenever possible, the use of technical terms was avoided and detailed glossaries were provided to enhance understanding of terms used. Further, appendices were written to explain in detail the critical concepts and principles used and to provide additional information to facilitate the economic analysis.

Result

Figure 2 illustrates the basic structure of the practical framework. If there are legal, political or other constraints that dictate the implementation of surveillance, economic analysis reduces to the question what the technical procedures are for surveillance and which option minimises costs. In that case, the CEA pathway becomes applicable. If there are no such constraints, the economic criterion is that costs of resource-using activities must be smaller or equal the benefit resulting from mitigation. In that case, the CBA pathway becomes applicable. In this pathway, a classification system is used to define the stage of mitigation as well as the surveillance and intervention objectives. Each stage requires a different mitigation practice. Therefore, three sub-pathways are presented that take account of these differences. At the beginning of each pathway, the basic economic framework underpinning the analysis, economic criteria and data requirements are presented to set the scene for the following steps. The framework then leads step-by-step through a set of questions to ensure that all the necessary elements to conduct the economic analysis are available. If that is the case, an approach presented at the end of each pathway can be used that outlines how the economic analysis should be conducted.

Figure 2: Summarised scheme of a practical framework for the economic evaluation of surveillance. X leads to another set of questions and/or recommendations for decision-makers



Where essential elements, such as the technical procedures for intervention, are not given (marked with 'X' in Figure 2), the framework asks if resources are available to develop these in a time frame acceptable to DMs. If the answer is no, interpretations and recommendations about how to proceed are given (*e.g.* for a situation where surveillance is technically available, but intervention is not: *Surveillance can only be used to detect a hazard when it occurs, but there will not be a response. Thus, surveillance costs shall not be bigger than non-monetary benefits resulting from knowing if hazard is present or absent*). Glossaries relating to key terms of mitigation (*e.g.* definitions for surveillance, surveillance design, surveillance approach) and economics (*e.g.* economic value, expenditure) are provided. Further, explanations are provided relating to key concepts used, such as the relevance of avoidable disease costs, the selection of an appropriate baseline, and the valuation of non-priced benefits. For the economic analysis as such, information is given about how to calculate cost-effectiveness ratios and net benefits, including discounting.

Discussion

The practical framework presented helps DMs to plan and conduct economic evaluations of surveillance programmes. The identification of constraints at the beginning provides an important pre-selection that categorises surveillance programmes into two broad groups that constitute two distinct types of economic questions. CEA is a useful way to assess the technical procedures for surveillance in relation to their costs when constraints such as international legislation or public fears dictate how surveillance must be implemented. CBA attempts to quantify all costs and benefits related to a programme; these may be economic, environmental, biological and medical [5]. Because the quantification of certain impacts is difficult, the framework provides additional information about available valuation approaches.

A classification system that outlines technical relationships between surveillance, intervention and mitigation that impinge on economic analysis has been included. In combination with the presentation of underlying economic principles and criteria as well as data requirements, DMs get a thorough understanding of key technical and economic relationships and the data needs for the economic analysis. The step-by-step flow charts are a way of ensuring that DMs are fully aware of all elements needed to conduct the economic analysis. This will support them in assessing the feasibility of the economic analysis and in estimating time and personnel resources needed.

The importance of quantitative estimation of mitigation outcomes is also highlighted. Epidemiological modelling techniques that capture the dynamics and complexity of disease in animal populations are often used to deliver important input data for economic analyses [6]. They also allow assessment of the impact of mitigation measures on the disease dynamics in the population. Therefore, the use of epidemiological models and their indispensable contribution is explicitly addressed. This ensures that economic and epidemiological modules are developed in an interdisciplinary, fully compatible way that provides DMs with the comprehensive economic and technical information they require.

In its current form, the framework does not include specific data, such as market prices or wage rates, because they soon become out dated. However, the structure of the framework allows such data or indeed any other useful information, to be added to the appendices. Even though the framework is tailored to the needs of a developed country, conceptually it is also valid for developing countries. Relevant parts could readily be modified to increase its usefulness in that context.

The framework outlines basic key concepts that impinge on the economic evaluation of surveillance. The economic analyses building on this foundation can integrate as much detail and complexity as required by the research question posed by the decision-maker.

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Method to estimate loss of exports from a hypothetical CSF outbreak

A.E. Lawrence[1*], A.E. Scott[1] and R.A. Thompson[1]

Abstract
International trade is expanding, and with it come economic benefits and risks based on a nation's disease status. Surveillance plays a crucial role in international trade by providing early detection, rapid response, proof of freedom, and transparency with respect to animal disease outbreaks. Economic analysis plays a crucial role in establishing, assessing, or evaluating surveillance systems. A major factor in economic analysis is the value of exports at risk because that defines to a great extent the limits of benefits to be derived from surveillance. Without data from a recent disease outbreak, potential losses can be estimated from trading behavior observed during other disease events. We describe a method to estimate the value of exports lost should an outbreak of an economically important animal disease occur.

Keywords: surveillance evaluation, trade loss, methodology.

Introduction
Often the largest benefit of surveillance is avoidance of lost exports. Should an outbreak of classical swine fever (CSF) occur in the United States, there would be a significant economic impact not only to the swine industry, but to the United States economy due to loss of exports of swine and swine products. The value of these exports is substantial amounting to $5 billion in 2009. The value of exports at risk depends on how trading partners react to an outbreak of CSF. There likely is a difference in the value of exports lost initially as opposed to the value of exports lost after the United States regionalizes or compartmentalizes its swine industry.

A common method to estimate the value of exports at risk is to postulate a range that fits a hypothetical outbreak scenario. The proposed range is chosen arbitrarily or based on historical experience or adapted from experience in another country. An arbitrary choice may bracket possible outcomes, but is essentially rooted in uncertainty. When a country has no recent experience, as is the case with an outbreak of CSF in the United States, adaptation of other countries' experiences may be misleading or inappropriate due to significant differences in industry structure.

We describe a method to estimate the value of exports at risk based on trading partners' reactions to a disease outbreak as revealed in their historical trading patterns.

We analyzed trading patterns between countries that import United States' swine products and also import from countries where CSF has been reported. Then we analyzed compliance with OIE guidelines and recommendations by countries that import United States' swine products using the 2009 experience with H1N1 swine flu as the proxy. We calculated the percentage of exports at risk for the years 2006 through 2008 and applied these percentages to United States' exports for the year 2009. Two time periods were considered: the initial time period after an outbreak and a time period beginning after regionalization or compartmentalization of the swine industry.

Materials and methods
According to Article 2.3 of the Sanitary and Phytosanitary (SPS) Agreement, "Members shall ensure that their sanitary and phytosanitary measures do not arbitrarily or unjustifiably discriminate between Members where identical or similar conditions prevail ..." and that "Sanitary and phytosanitary measures shall not be applied in a manner which would constitute a disguised restriction on international trade." Assuming major trading partners act accordingly, the United States should not lose exports to countries that import from countries where CSF has been reported and would likely lose exports to countries that do not import from countries where CSF has been reported. Should the United States regionalize or compartmentalize its swine industry so as to attain the status of "confirmed clinical disease but limited to certain zones", the value of these losses would likely be reduced. Therefore, an indicator of potential losses of exports would be revealed in historical trade patterns of the major United States trading partners for swine and swine products.

We also consider the possibility that importing countries may not comply with the SPS Agreement and OIE guidelines and recommendations. Using the 2009 H1N1 flu virus event as a proxy, we assumed that those countries that restricted imports of swine and swine products from the United States when OIE recommended not to do so would also restrict imports due to an outbreak of CSF regardless of their historical trading patterns.

The methodology consists of identifying those countries that have reported outbreaks of CSF and export swine or swine products to importers of United States swine or swine products. Then we evaluated trade patterns for these countries and applied them to United States exports. In the first case, trade patterns are based on CSF status in other countries from which our trade partners import swine and swine products. In the second case, trade patterns are based on whether or not our trade partners restricted United States exports during the 2009 H1N1 swine flu event. We used CSF status as reported in the OIE Health Information Database (WAHD). Trade patterns and trade volumes are reported in the Global Trade Atlas. Countries restricting imports of United States' swine and swine products were reported by Unites States Department of Agriculture's, Animal and Plant Health Inspection Service, Foreign Agricultural Service, Food Safety and Inspection Service reports for May 2009.

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Result

Between 2006 and 2008, forty-one countries had reported some level of confirmed clinical disease for CSF. Of these, thirteen countries (Brazil, China, France, Germany, Honduras, Hungary, India, Mexico, Russia, Slovakia, South Africa, South Korea, and Thailand) exported swine and/or swine products.

The ten largest United States' export markets for live swine in 2008 accounted for 96.6 percent of exports of live swine. Six (Canada, China, Japan Mexico, Philippines, Venezuela) likely did not import from any country where CSF was reported between 2006 and 2008. Hong Kong and South Korea allowed trade with countries zoned for CSF. The value of exports to Guatemala and Vietnam would not be at risk.

The fifteen largest United States' export markets for swine products in 2008 accounted for 94 percent of exports of swine products. Four (Australia, Canada, Mexico, Taiwan) likely did not import from any country where CSF was reported between 2006 and 2008. China and Japan reported trades with countries zoned for CSF. The value of exports to Bulgaria, South Korea, Hong Kong, Philippines, Russia, Singapore, United Kingdom, Ukraine, and Vietnam would not be at risk.

The value of exports initially at risk from a CSF outbreak ranges from 68 percent to 78 percent of total United States exports. Should the United States regionalize or compartmentalize its swine industry, exports at risk would be reduced by approximately half, ranging between 30 percent and 39 percent of total exports. See Table 1.

Table 1: Trade at risk due to historical trade patterns

	Trade Year		
	2006	2007	2008
	(million $)		
Initial response	$ 2,316	$ 2,535	$ 3,387
	78%	76%	68%
After regionalization	$ 1,149	$ 1,129	$ 1,481
	39%	34%	30%

Thirty countries restricted imports from the United States of live swine or swine products during the 2009 H1N1 flu virus event. Of these, China, Guatemala, Philippines, and South Korea are United States major export markets for live swine.

In the analysis of historical trade patterns, exports of live swine to Guatemala were identified as not at risk initially, and exports to South Korea were identified as regained after regionalization or compartmentalization. Since both countries restricted imports of live swine during the 2009 event, their impact on the export account balance changes. That is, exports to Guatemala increase value at risk, and exports to South Korea increase the value at risk after regionalization or compartmentalization.

Of the fifteen largest United States' export markets for swine products, China, Russia, South Korea and Ukraine imposed restrictions on imports of swine products during the 2009 event. In the analysis of historical trade patterns, exports to Russia, South Korea, and Ukraine were identified as not at risk initially. Therefore, the value of exports to Russia, South Korea, and Ukraine increase the value of exports at risk. Exports to China were identified as regained after regionalization or compartmentalization so that these exports increase value of exports at risk after regionalization or compartmentalization.

When the 2009 H1N1 swine flu event is included in the analysis, the United States would expect an additional initial loss of exports ranging between 13 percent and 14 percent, and an additional loss after regionalization or compartmentalization ranging between 16 percent and 20 percent. See Table 2.

Table 2: Additional trade at risk due to non-compliance with OIE guidelines and recommendations

	Trade Year		
	2006	2007	2008
	(million$)		
Initial response	$ 383	$ 426	$ 698
	13%	13%	14%
After regionalization	$ 463	$ 618	$ 983
	16%	19%	20%

We applied our estimated ranges to exports of swine and swine products for the trade year 2009. We estimate the United States would lose between $3,154 million and $4,221 million before the United States could regionalize or compartmentalize its swine industry, and between $1,391 million and $2,509 million after regionalization or compartmentalization. See Table 3.

Table 3: Summary of value of exports of swine and swine products at risk

	Loss in Initial Response	Loss After Regionalization
	(million$)	(million$)
Trade Patterns	$3,154 - $3.618	$1,391 - $1,809
	68% - 78%	30% - 39%
OIE Non-compliance	$3,803 - $4,221	$2,273 - $2,509
	82% - 91%	49% - 54%

Discussion

The value of surveillance depends on preventing loss of exports should an outbreak of CSF occur in the United States. Our estimate of the value of exports at risk from a CSF outbreak represents a major component of the upper boundary of the economic value of the CSF surveillance program. The less time between the initial outbreak and eradication, the greater the proportion of the estimated export loss can be avoided.

It is unlikely the United States would lose 100 percent of its exports of swine and swine products. Estimating value of exports at risk based on historic trading patterns of major United States trading partners is a reasoned approach to determine the benefit of CSF surveillance given our trading partners' propensity to conform to OIE obligations.

H1N1swine flu was chosen as a proxy for a propensity of major United States trading partners to follow OIE guidelines and recommendations because of its timeliness. However, H1N1affects people as well as animals. Other outbreak events with which the United States has had recent experience involve avian influenza (AI) and bovine spongiform encephalopathy (BSE), both of which are also zoonotic diseases. Even though the outcome may be more pronounced for a zoonotic disease than a non-zoonotic disease, it is reasonable to expect these results contain the upper range of possible outcomes on which policy makers can determine the value of surveillance.

Evaluation of passive and active surveillance of notifiable avian diseases in Mali

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Abstract
Our study aimed at assessing passive and active surveillance of notifiable avian diseases (NAD) in Mali by respectively following avian disease events and reporting practices during six months in 32 randomly selected villages, and by compiling active surveillance data from reports produced by the veterinary services. The percentage of notified NAD events was low (ranging between 0 and 28.6%) and did not significantly vary over time, illustrating a certain fatality of poultry owners towards avian diseases and a faulty awareness of the risks linked with under-reporting of NAD. About 14% of the total number of villages in Mali was investigated every month within the frame of active surveillance but it was not possible to assess how representative or well-targeted the investigated villages were. These results provide preliminary data that will be useful for the future construction of scenario tree models aimed at evaluating the sensitivity of NAD surveillance in Mali.
Keywords: surveillance, passive, active, avian diseases, Mali.

Introduction

Different methods have been developed over the last fifteen years for the evaluation of surveillance networks for animal diseases. A tool for techno-economic evaluation based on an implementation of the HACCP method was developed by Dufour [1] and an internal evaluation methodology based on performance and diagnostic indicators was designed by Hendrikx and Dufour [2]. In order to reduce the subjectivity of the evaluation and to make comparisons among countries, standardized tools for semi-quantitative evaluation have been developed in recent years. They include the PVS (Performance, Vision and Strategy) tool of the OIE which is a standardized method of evaluation of veterinary services and the method developed by Squarzoni [3] for the evaluation of rinderpest surveillance in 30 sub-Saharan countries.

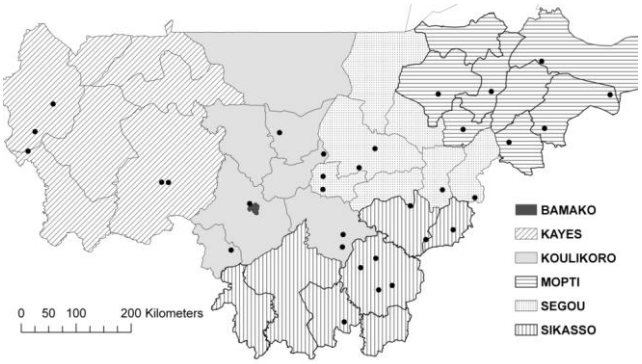
The latter method was adapted for avian diseases and used in a study evaluating the organization and the functioning of the EPIVET-Mali network (National veterinary epidemiological surveillance network in Mali) with regards to the surveillance of highly pathogenic avian influenza (HPAI) [4]. EPIVET-Mali was assigned a satisfactory score of 3.05 out of 4 with some components functioning particularly well (network organization, surveillance strategy, diagnostic laboratory and information dissemination) whereas others had lesser scores (field functioning, network motivation, data management, and efficiency follow-up).

Although this evaluation of EPIVET-Mali was useful to assess the weak points of the network and to draft recommendations for its improvement, it did not provide any insight into how efficient the passive and active surveillance of notifiable avian diseases (NAD) truly was. This is especially critical in a context like the one in Mali where Newcastle disease (ND) causes major economic losses and where outbreaks of HPAI have been notified in neighbouring countries. We therefore aimed at evaluating both components (active and passive) of the surveillance of NAD (that is ND and HPAI) in Mali.

Materials and methods

In order to evaluate passive surveillance, we monitored during six months the avian disease situation in 32 villages of five regions located in the southern half of Mali (Kayes, Koulikoro, Sikasso, Segou and Mopti). The regions in the northern half of the country (Tombouctou, Gao and Kidal) were excluded from the survey because they account for only 2% of the estimated total poultry population, are difficult to access and are unsecure owing to the presence of Al-Qaida du Maghreb Islamique. The 32 villages were randomly selected using probability proportion to population size [5].

Figure 1: Randomly selected villages



Within each village, four households were randomly chosen by village chiefs and pilot-tested questionnaires were used to collect information on the number of birds present, the number of birds which were sick and died over the previous three months, the clinical signs observed and the eventual notification of sick and dead birds to veterinary authorities. Households where birds showed at least three out of the five following clinical signs: diarrhoea, respiratory signs, nervous signs, cyanosis of the combs or wattles, and high mortality were considered as having NAD-like disease. All villages were visited three times: in November 2009,

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February 2010, and May 2010. All data were entered in an Excel datasheet and were analysed using SPSS 10.0 (SPSS Inc, Chicago, IL, USA).

In order to evaluate active surveillance, we explored surveillance data produced by the Direction Nationale des Services Vétérinaires (DNSV) and the PACE. Because no specific disease surveillance database existed at the time of our work, we retrieved a total number of 186 monthly reports out of the 189 produced by all nine regions between October 2007 and June 2009 (no reports available before October 2007) and data on surveillance of birds (either in villages or markets) was extracted and entered into an Excel spreadsheet. Graphs were then produced to visualize the temporal evolution of surveillance efforts. Reports from July 2009 to the present date are in the process of being retrieved.

Result

Evaluation of passive surveillance: The percentage of households where avian disease and NAD-like disease occurred, as well as their respective percentage of notification are presented in Table 1.

Table 1: Percentage of households affected by avian disease and percentage of notification

Parameter	*Nov 09*	*Feb 10*	*May 10*
# of households investigated	128	128	128
% of households where avian disease occurred in the previous three months	51.6	53.1	35.2
% of households where NAD-like disease occurred in the previous three months	21.1	18.0	5.5
% of notification for households where avian disease occurred	10.6	5.9	20.0
% of notification for households where NAD-like disease occurred	18.5	0.0	28.6

The percentage of households where avian disease and NAD-like disease occurred in the previous three months was significantly smaller in May 2010 than in November 2009 or February 2010 ($p=0.006$ for avian disease and $p<0.001$ for NAD-like disease). The % of notification was not significantly different among seasons whether in households where avian disease or NAD-like disease occurred. Whatever season considered, the % of notification was not significantly different between households where avian disease occurred and households where NAD-like disease occurred.

Evaluation of active surveillance: Graphs showing the surveillance data for poultry in the nine regions of Mali and the district of Bamako between October 2007 and June 2009 are presented in Figures 2 and 3.

An average of 1406 villages was visited every month within the frame of active surveillance activities. There seemed to be a slight decrease in surveillance efforts during the hottest months (March-April) of the year and possibly during the rainy season (June to September, when roads are hardly accessible and farmers less available because they are busy cultivating crops). This will be tested by time series analyses once all reports from October 2007 to the present date have been retrieved.

Figure 2: Number of villages surveyed by region and in total

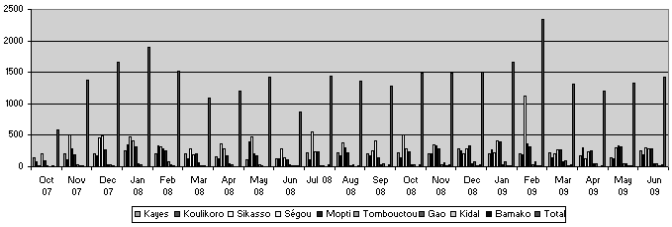
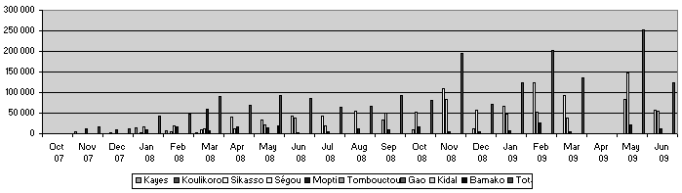


Figure 3: Number of market birds surveyed by region and in total



A lot of discrepancies were observed among regions in the way they recorded the number of inspected market birds (record as individuals or as flocks) and this precluded further analysis of market bird surveillance data.

Discussion

Our results on the higher occurrence of NAD-like disease in November and February (that is during the dry cold season) than in May (that is during the dry hot season) are in line with ND prevalence survey results in Mali by Sylla [6] who found that 63% of ND events occurred during the dry cold season, 22% during the dry hot season and 15% during the rainy season.

The percentage of notification for both avian disease and NAD-like disease was low ranging between 0 and 28.6%. This is linked to a fatalist attitude of Malian traditional backyard poultry owners who are used to losing a large proportion of their flock to avian diseases and therefore do not see the interest of notifying veterinary authorities. This is very concerning if we consider that HPAI and ND cannot be differentiated on the sole basis of clinical signs; HPAI outbreaks could potentially occur and be confused with ND since no notification and no confirmatory diagnostic would be made. To the best of our knowledge, no similar evaluation of reporting practices for NAD-like diseases has ever been performed in Africa but it is likely to be similarly low in other sub-Saharan countries with high levels of poverty and therefore limited concern of villagers over the health status of backyard poultry.

The average number of villages visited every month within the frame of active surveillance represented about 14% of the total number of villages in Mali. This may seem satisfactory considering the limited resources of the DNSV. Nevertheless, it should be kept in mind that veterinary field agents visit villages to investigate the presence of any notifiable disease, bird

diseases but also livestock diseases, and that the time imparted to specific surveillance of NAD may somehow be limited. Furthermore, road conditions, especially during the rainy season, represent a serious constraint to the representativeness of villages investigated because it is likely that less-accessible villages are under-represented. Finally, efforts in active surveillance seemed to vary in time and among regions but further analyses need to be performed before reaching any conclusion.

The evaluation of the performance of animal disease surveillance network can be done through methods based on HACCP, performance indicators or semi-quantitative tools [1, 2, 3] but it is also indispensable to evaluate the sensitivity of the network, that is, how able it is to detect an important proportion of outbreak suspicions [7]. Many factors can affect the sensitivity of passive surveillance including the variety of clinical signs, the sensitivity of diagnostic techniques, the skills of field veterinarians and the motivation to report [8]. Quantitative methods based on stochastic scenario tree models have recently been developed to estimate the sensitivity of the different components of a surveillance system. Initially designed to justify a free-from-infection status [9], they have later been applied to optimise surveillance systems for rare or emerging diseases [8]. The main constraint of these models is that the quality of their estimations is very linked to the quality of the data you feed into them. In the context of a developing country with sufficient good-quality data problematic to obtain, our study provided a simple way of providing a primary estimate for the percentage of notification of NAD. Laboratory analyses are currently under way on biological samples collected in the 32 villages of the survey to refine the prevalence estimates for NAD in Mali which will later also be useful to feed scenario tree models.

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Evaluation of Australian surveillance for freedom from bovine tuberculosis

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Abstract

Australia has been officially free from bovine tuberculosis (TB), in accordance with international standards, since December 1997 and has not recorded any cases in cattle since 2000. An analysis of Australia's surveillance to evaluate the sensitivity of the surveillance system and cumulative confidence of freedom from TB was undertaken to assist Australia's animal health authorities decide on whether to include TB under Australia's emergency disease response arrangements, as for any other disease exotic to Australia.

Analysis of cattle slaughter data from the national Livestock Identification System provided a very high system sensitivity for detection of TB if it were present at a prevalence of 1% of animals in 0.2% of herds, or greater. Confidence of freedom at this level was >99.9% from 2006 onwards. Separate analysis of herd-testing and abattoir data for 90 herds from the Northern Territory and 86 herds from the Kimberley area of northern Western Australia supported the main analysis.

As a result of these analyses, animal health authorities in Australia have now agreed to include bovine TB in Australia's Emergency Animal Disease Response Agreement.

Keywords: Bovine tuberculosis; freedom; surveillance evaluation.

Introduction

Bovine tuberculosis (TB) is a chronic disease of cattle and the causative pathogen (*Mycobacterium bovis*) may also infect humans. In order to protect public health and also to avoid possible future trade restrictions, Australia undertook a national eradication program for TB from 1970 to 1997. This resulted in Australia declaring Impending Freedom from TB on 31 December 1992 and freedom from TB in accordance with international guidelines in December 1997. Ongoing surveillance for TB has continued since 1997, mainly through screening of granulomas detected during abattoir inspection of cattle carcasses. The last detected case of TB in cattle in Australia was in Queensland in 2000. One TB case was detected in Buffalo in the Northern Territory in 2002 and the herd was destocked with no evidence of further spread.

The Australian cattle population has now been apparently free of TB for a period of 10 years, supported by ongoing surveillance for TB-like granulomas at abattoirs. However, management and response for TB were still in place from the previous eradication program, rather than treating it in the same way as any other exotic disease. Consequently, it was timely to consider whether bovine TB should be classified under the Emergency Animal Disease Response Agreement, which provides the basis for responses to incursions of other animal diseases exotic to Australia.

To assist in the decision-making process, Australia's animal health authorities required additional information to address the following question: While we are confident that Australia is free from TB, can we quantify our level of confidence, based on the extensive surveillance that has been undertaken during the last 10 years?

This project was undertaken to evaluate current and historical surveillance data for TB and estimate the sensitivity of Australia's surveillance system and confidence of freedom from bovine TB, with the aim of providing objective information to assist in the decision process.

Materials and methods

Surveillance activities: The surveillance activities and potential data sources considered for the analysis included: 1) abattoir inspection data from the National Livestock Identification System (NLIS); 2) pre-export testing data from regulatory authorities; 3) general surveillance (clinical disease investigations); and 4) herd testing data.

Pre-export testing data was only available in summary form by country of destination and was not suitable for detailed analysis. For the general surveillance system, it was concluded that TB would only be detected as an incidental finding during investigation of another disease and that the probabilities associated with events in this detection process could not be estimated, so that general surveillance was excluded from the analysis.

Individual animal slaughter data by property of origin (immediately prior to slaughter) and property of birth was available from the NLIS for calendar years 2005 to 2009, inclusive. The analysis was primarily based on this data, which included more than 29 million individual animal records from about 190,000 properties.

Herd testing data was also available—in addition to some abattoir data—for herds in the Northern Territory (90 herds) and the Kimberley region of Western Australia (86 herds). This data was analysed separately to provide additional information for these regions. These herds were large herds from which large numbers of animals were routinely exported and were

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thus not well represented in the NLIS data. Therefore, the sensitivity of surveillance in these regions was evaluated separately based on the combination of herd-testing records and the abattoir data that was available

Abattoir inspection analysis: For the abattoir inspection data, a scenario tree model was used to represent the surveillance activity. The analysis was undertaken for calendar years 2005 to 2009, inclusive, with system sensitivity calculated for each year and confidence of freedom aggregated over the 5-year period, after adjusting for a probability of introduction of 0.001 per year. Design prevalence values were set at 0.2% of herds and 1% of animals within herds and a prior probability of freedom of 0.9 was used, based on the successful completion of the eradication program and the fact that no cases had been detected since 2000, despite ongoing surveillance.

The only risk factor included in the model was animal age, with older animals (>1 year old) considered at higher risk than young animals (≤1 year). Geographic region (north vs south) and herd type (dairy vs beef) were considered for inclusion in the model but excluded because we were unable to justify differential risk for these factors and also because herd type was not recorded in the data.

Other nodes included in the scenario tree were related to diagnosis and included: abattoir type (export or domestic, because different meat inspection practices affect the probabilities of detection and submission); probability of a granuloma being present; probability it would be detected if present; probability an observed granuloma would be submitted (varied with abattoir type and year); sensitivity of histology; and sensitivity of culture. Where possible, parameter values were taken from the published literature; otherwise, they were based on analysis of available data or opinion. Slaughter data was aggregated by year, herd, age and abattoir type and herd sensitivity estimates calculated, which were then aggregated to calculate overall system sensitivity and confidence of freedom for each year.

NT and Kimberley analysis: For this analysis, a similar but simpler analytical model was used, which used the same input parameters where possible and produced similar outputs. Data for these herds was provided by the respective jurisdictions and was analysed for the years 1999–2008. Key differences from the abattoir model were that some animals were screened by caudal-fold skin testing instead of abattoir inspection and that age data was not available and so could not be included in the model. For these analyses, prior probability of freedom was set at 0.5 in 1999, because at that time there was limited evidence that eradication had been achieved.

Both models were implemented as stochastic models, with parameter inputs as probability distributions and outputs also as probability distributions.

Results

Abattoir inspection analysis: Data for more than 27 million animals slaughtered from about 190,000 herds were included in the analysis. The mean sensitivity of abattoir monitoring for detecting bovine TB peaked at 99.9% in 2006 and declined slightly thereafter, but exceeded 98% in all years from 2005–2009. Confidence of freedom (assuming a prior of 90% in 2005) was 99.8% in 2005 and greater than 99.9% in subsequent years.

The 95% probability intervals for the estimates were very narrow (<0.05%), reflecting the very large volume of data from which the estimates were calculated. Sensitivity analysis on key parameters produced only modest changes in sensitivity and confidence of freedom, with the exception of changing the design prevalence.

One analysis was undertaken using a herd-level design prevalence of 0.01% (1/10,000 herds or <20 herds in Australia), to evaluate the likelihood of possible persistence in a very small number of herds. For this analysis, the sensitivity of the system varied from year to year between 0.19 and 0.29 per year. However, confidence of freedom reached >95% by 2007 and remained >95% thereafter.

NT and Kimberley analysis: Data was provided for 90 herds in the Northern Territory, comprising 248,000 skin tests and 173,000 animals subjected to abattoir monitoring from 1999 to 2008. System sensitivity for the Northern Territory herds ranged from 7% (2008) to a maximum of 56% in 2003. However, by 2008, confidence in freedom had risen to 95%, based on the cumulative level of confidence provided by the combined herd and abattoir monitoring carried out from 1999 onwards and assuming a prior confidence in 1999 of 50%.

For the Kimberley, data was provided for 86 herds with 63,000 animals tested by skin test and 73,000 animals subjected to abattoir monitoring. System sensitivity for Kimberley herds ranged from 6% (2009) to a maximum of 41% in 2001. By 2009, confidence in freedom had risen to about 91%, based on the cumulative level of confidence provided by the combined herd testing and abattoir monitoring carried out from 1999 onwards and assuming a prior confidence in 1999 of 50%.

Discussion

The ultimate objective of the analysis was to provide information to Australia's animal health authorities to assist in determining the future management of bovine TB in Australia. To achieve this, quantitative estimates of system sensitivity and confidence of freedom were calculated, demonstrating a high level of confidence of Australia's freedom from TB.

The analysis identified that the main surveillance components for bovine TB in Australia are the abattoir inspection system—looking for TB granulomas in slaughtered animals—and herd testing of herds in the Northern Territory and northern Western Australia which send most of their cattle for live export. Because the herds where herd-testing data were available were poorly represented in the abattoir data, it was decided to analyse the two data sources separately.

Data from export testing was inadequate to support a detailed analysis and was therefore excluded. Similarly, the general surveillance system was considered unlikely to detect TB, except as an incidental finding and therefore any attempt to analyse this component would encounter serious limitations for a likely very low sensitivity.

The results of this analysis indicate that abattoir monitoring has a very high sensitivity for detection of TB when considered at a national level. For each year of analysis (2005–2009), the sensitivity of surveillance was greater than 98%; *i.e.* there is a greater than 98% chance that abattoir monitoring would have detected at least one infected animal, if TB were present in at least 0.2% of Australian cattle herds and 1% of animals within infected herds. While the herd-level and animal-level design prevalence are very low, and the probabilities of detection at each step of the detection pathway are also relatively low, the exceedingly large number of animals being processed through abattoirs each year results in a very high sensitivity of this surveillance activity.

Assuming a probability of 0.9 that Australia was free of TB at the beginning of 2005, and an annual probability of TB being introduced to the Australian cattle population of 0.001, the substantial evidence of freedom provided by abattoir monitoring rapidly increased the confidence of Australia being free of TB over subsequent years. By the end of 2005 the probability of freedom was >0.998, and remained high thereafter.

Reducing the herd-level design prevalence from 0.2% to 0.01% (1 per 10,000 or about 20 infected herds in Australia) resulted in system sensitivity being reduced to about 20% in some years, although confidence in freedom still reached 95% by the end of 2007. A sensitivity analysis of other assumptions resulted in only modest reductions in the sensitivity of abattoir surveillance and confidence in freedom remained high in all analyses.

Separate analysis of herds in the Northern Territory and the Kimberley region of Western Australia was required because these herds were poorly represented in the abattoir data but had herd testing data available for analysis. In these analyses, the probability of detecting TB by a combination of herd tests and abattoir monitoring in these herds was relatively low; ranging from 0.07 to 0.56 in the Northern Territory and from 0.07 to 0.26 in the Kimberly. Despite the relatively low sensitivity levels for each year, confidence in freedom from TB in these regions increased progressively over time. By the end of 2009, confidence of freedom was approximately 0.95 in the Northern Territory herds and 0.90 in the Kimberley, assuming a prior probability of freedom of 50% at the start of the analysis in 1999.

The primary aims of this investigation were to evaluate Australia's surveillance for bovine TB, to provide quantitative estimates of the sensitivity of the surveillance system for bovine TB in Australia and to provide quality information on which administrators could base a decision as to future management of bovine TB. These aims were all successfully achieved and the information presented to the decision-making authorities in March 2010. With consideration to the results of this study and other sources of evidence, bovine TB is now included in Australia's Emergency Animal Disease Response Agreement and will be managed in the same way as any other exotic disease, should it ever be detected in the future.

Acknowledgements

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A simplified method for the development of performance indicators for epidemiological surveillance systems – application to two different French surveillance systems

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Abstract

The development of performance indicators of surveillance systems is an internal evaluation method meant to identify weaknesses in the operation of the system in order to optimize the management.

In order to simplify it, we adapted an existing method for the development of performance indicators by applying it to a theoretical model of surveillance system and obtained a list of 25 generic indicators which can be adapted to any surveillance network.

We applied the simplified method to the RESAPATH, the surveillance network for antimicrobial resistance in pathogenic bacteria from animal origin in France and to SAGIR, the French surveillance network of wildlife diseases. The facility of use and the speed of application suggest that the method could be further used to develop performance indicators for other surveillance systems.

Keywords: Performance Indicators, Evaluation, Epidemiological Surveillance.

Introduction

The first finality of an epidemiological surveillance system is to produce reliable information on the health condition or the factors of public health. Considering that the quality of produced information closely depends on the quality of operation of the network, the measurement of the performance could be based on the evaluation of the level of realization of the surveillance activities.

We consider as performance indicators quantitative tools for checking the adequate operation of surveillance systems [1]. They constitute essential tools to identify the weak points of an activity in order to adopt the optimal corrective measures [1-3], they are thus management tools of the surveillance system. Performance indicators represent therefore essential tools for policy makers to increase their confidence in the quality of information produced by the surveillance systems they are using.

When developing performance indicators, a balance has to be found between the desire to have the most precise possible definitions and calculations of reliable indicators and the requirement not to overload the system with a too heavy burden of additional data to record [4-5]. Moreover, a list of indicators must be dynamic; an indicator which does not appear to offer an appropriate margin of improvement for the system can be discarded, while others can be added if they seem more adapted [6].

A detailed method, based on the identification of all the activities of a surveillance system and the development of a dashboard gathering all indicators used to assess their performance was developed in 2004 [7-8]. An important limit identified during the application of this method to several surveillance systems was the length and the complexity of the stages to be implemented [9-10]. Moreover, one comparison of the indicators worked out for different systems according to this method showed that part of these indicators were similar or even identical. The objective of our work was, on the basis of the initial method, to develop a simplified, more accessible and more rapid method, based on the principles of the use of a list of generic indicators adaptable to any network. We then applied this simplified method to the surveillance network of antimicrobial resistance in pathogenic bacteria from animal origin (RESAPATH) and to the surveillance network of wildlife diseases (SAGIR).

Materials and methods

The objectives of the RESAPATH are mainly the detection of emergence and the follow-up in time of the antimicrobial resistance of the bacteria isolated from clinical cases in the animals [11-13].

The objectives of SAGIR are to identify the causes of wildlife mortality in France through the collection and laboratory investigation of wild animals found dead.

The initial method of development of performance indicators is based on the succession of ten stages which make it possible to describe the surveillance system and identify all its activities [7]. To each objective awaited for an activity is attributed one or more performance indicators. In order to obtain a list of generic indicators, appropriable and adaptable to any surveillance system, we applied the initial method to a conceptual model of surveillance system. The work then consisted in developing a user guide allowing the transposition of these generic indicators to a specific system.

A first version of this user guide was submitted to the coordination team of the RESAPATH and SAGIR, in order to assess the feasibility and the difficulties of development of performance indicators using this method.

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For the RESAPATH, the indicators were separately elaborated by each of the two teams involved in the coordination of the system: epidemiology and bacteriology. These two approaches were then confronted and synthesized to lead to a consensus. For SAGIR the indicators were developed by the team in charge of data management.

The tools necessary for the calculation of the indicators were developed using a series of queries carried out on the RESAPATH and SAGIR database managed by the software Access 2007®.

Result

Dashboard of generic performance indicators

The application of the initial method to our conceptual model of surveillance system made it possible to prepare a list of 25 generic performance indicators (Table 1).

Each generic indicator has to be adapted to each system according to the following steps:

a. first approach of the generic indicators: each user is invited to review all generic performance indicators proposed;

b. express the generic indicators with the language of its system: the user is brought to consider the generic indicators one by one, adapting and reformulating them, in order to connect the terms presented in the list with those used within the framework of his surveillance system;

c. carefully consider the case of the not applicable indicators: certain indicators are not relevant for a network, it is then necessary to indicate which are not applicable, and to argue the reason for each one. The objective is to sensitize the user to the possible interest to initiate an improvement of the system, if the indicator is not applicable due to a problem of operation (for example indicator PI21 "completion rate of the steering committee meetings" will not have a value for the system if this one does not have a steering committee; but it is capital to inform the decision maker on the possible interest of the establishment of such a committee). In the same way, an indicator might be not calculable. In this case, several options arise, according to whether the indicator touches or not a sensitive component of the surveillance system. It will be possible to modify the surveillance protocol to allow the integration of the indicator in the dashboard, or to keep the indicator in memory and to consider later the necessary data acquisition, in order to check in the future that there is no drift in this operation;

d. implement the appropriate subdivision: a subdivision of certain indicators is sometimes necessary, according to the needs for evaluation in various sectors (form standards, segments data transmission time, *etc.*), the user must decide how these indicators have to be subdivided and adapted and has to reformulate them consequently;

Table 1: Generic performance indicators

Data collection
PI1: number of collected suspicions or cases
PI 2: rate of forms or reports correctly filled
PI 3: rate of conform samples received at the laboratory
PI 4: rate of suspicion forms received by the central unit within x_4 days following the suspicion
PI 5: rate of samples received by the laboratory within x_5 days following the suspicion
PI 6: rate of incomplete forms leading to complementary information search within x_6 following their reception
PI 7: rate of exploitable samples analysed within x_7 days following their reception at the laboratory
PI 8: rate of laboratory analysis results received by the central unit within x_8 days following the reception of the sample at the laboratory
PI 9: rate of forms entered in the database within x_9 days following their reception
Active surveillance
PI 10: rate of forms and samples planed in the surveillance procedures effectively collected
PI 11: rate of active surveillance visits reports written
PI 12: rate of active surveillance visits reports received by the central unit within x_{12} days following the visit
Information feedback
PI 13: rate of synthetic reports published every t_{13}
PI 14: rate of restitution meeting realised
PI 15: rate of participation to restitution meetings every t_{15}
PI 16: rate of analysis results received by the data collector within x_{16} days following the corresponding suspicion
PI 17: rate of analysis results received by the data collector corresponding to the samples he sent
PI 18: rate of analysis results received by the source of data within x_{18} days following the corresponding suspicion
PI 19: rate of analysis results received by the source of data corresponding to the samples he has provided
PI 20: rate of news bulletins published
Coordination
PI 21: completion rate of steering committee meetings
PI 22: completion rate of technical committee meetings
Training
PI 23: rate of data collector supervision by the central or intermediate levels
PI 24: rate of laboratories participation to ring trials
PI 25: training rate

e. clarify the calculation formula: the numerator and the denominator of each indicator retained has to be defined and reformulated by indicating the parameters of time (forms or samples transmission,…) or of frequency (publication of a synthesis, a bulletin, meetings of a committee,…) adapted to the protocol;

f. count and locate the data necessary: for each indicator, it is advisable to list the data necessary to calculation, to locate them if they exist in the existing database, or to create them by initiating the implementation of a new collection procedure;

g. create the additional indicators linked to the system specificities: this last step consists in seeking if other components of the system have to be taken into account by other indicators. For that, the user guide

gives, as example, a short inventory of certain indicators met in systems which developed performance indicators, and which do not come from one of the generic indicators. The user has to consider particularly active surveillance procedure that can lead to specific performance indicators.

RESAPATH dashboard: on the basis of the generic dashboard, the epidemiology team of the RESAPATH worked out 16 indicators, and the bacteriology team 27. On both sides, this work has been an opportunity to reconsider the objectives of the network and the activities to implement for an appropriate operation.

Finally, after a synthesis of the tables proposed in the presence of the two teams, 14 performance indicators were retained for the RESAPATH. In parallel, the coordinators wished to create two new kind of indicators: "life indicators" of the system, to be calculated regularly but without definite threshold of value to be reached, and "specific indicators", more difficult to calculate, to be considered more irregularly by collecting additional data.

SAGIR dashboard: on the basis of the generic dashboard, the data management unit of SAGIR worked out 28 performance indicators, from which 17 can be calculated using the existing database and 11 can only be calculated performing specific surveys.

Discussion

We identified three critical points for the method we employed. The phase of appropriation and reformulation of each indicator according to the terms of the network constitutes a first critical point. One notes some divergences in the adaptations or the subdivisions operated by the two teams. Finally, these variations were good starting points for discussions on possible indicators before reaching an agreement on a more restricted list of indicators. This is why it appears important to integrate to in the work a large panel of actors belonging to the system in order to contemplate a wide range of possible indicators before being able to concentrate on a shorter list adequately representing the performance of the system.

The verification phase that a non applicable indicator is not due to a dysfunction of the surveillance system represents a second critical point. For the RESAPATH, the indicators considered as "not applicable" are identical for the two teams, and in depth analysis did not reveal major dysfunction of the system. The possibility to reconsider the operation of the system remains an essential step to preserve the interest of the method. The last critical point is the identification of the possible missing indicators in the generic dashboard. In the case of the RESAPATH and SAGIR, the generic indicators provided were frequently used as starting points to identify the activities of the network to be taken into account by new indicators.

The method was considered simple and rapid to use by the teams of both systems it was applied to. The simplified method preserves a capacity of reconsideration of the operation of the network, therefore a structuring capacity. The discussions generated by the implementation and calculations of the performance indicators made it possible to imagine the new indicators and to reconsider the system in order to improve it. These discussions oblige to formalize deadlines, frequencies of meetings, criteria of conformity in relation with the protocol. Therefore, implementation of performance indicators can retroact on the operation of the system (modification or implementation of new procedure data collection, exchanges between actors of the system, *etc.*), and bring to reconsider the objectives of the network and the limits of its activities.

Even simplified, the method still requires a strong initial input of the coordinating group which must involve the whole system in the procedures, by making accept the idea that identification of dysfunctions is likely to bring to certain modifications.

The facility of use and the speed of application suggest that the method could be further used to develop performance indicators for other surveillance systems. These new applications would support the first indications of acceptability and usefulness of the method.

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Assessing the coverage of farmed animal populations included in the Veterinary Laboratory Agency scanning surveillance activities in England: methods and issues

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Abstract

Evaluation of surveillance activities is essential to assess their efficacy and identify how this could be improved. Coverage is defined as the proportion of the population of interest that is included in a surveillance activity [1] and is a key criterion for the evaluation of a surveillance program. We have assessed the coverage of the population achieved by the current Veterinary Laboratory Agency (VLA) scanning surveillance activities in England for different livestock species using various methods. Issues arising in carrying out these assessments and the work we are doing to investigate and address these issues is described. The methods used and issues discussed would be relevant to assessing the coverage of alternative scanning surveillance strategies which may be introduced in the future.

Keywords: surveillance, evaluation, coverage, methodology

Introduction

Scanning surveillance is used to monitor the health of defined populations in order to increase the likelihood that there will be timely detection of undefined or unexpected disease or changes in the nature of endemic disease [1]. The current scanning surveillance program for farmed livestock in England relies mainly on contact between veterinary practitioners and the Veterinary Investigation Officers (VIO) working in the regional laboratories (RL) of the Veterinary Laboratories Agency (VLA). This interaction provides an interface for collation of surveillance information using laboratory data and direct communication with practitioners. The laboratory data is obtained on a standard form which accompanies all submissions of carcases and samples for diagnostic investigation from veterinary practitioners. These data are recorded on the VLA's 'FarmFile' database [2] which includes information about the submitting practice, the farm holding and epidemiological data.

Since 2008, we have assessed and reported on the level of coverage for cattle, sheep, pigs, goats and poultry to meet a government objective to assess scanning surveillance activity. In 2009 we included data for camelids and gamebirds.

The FarmFile database provided numerator data and we sought denominator data for the number of farm holdings and the number of veterinary practices. The main criteria for selection of the denominator data was that it should be robust and updated annually, so as to allow comparison of the results from the current year to those obtained in previous years.

In England, data on livestock populations (animals and holdings) is available from Defra's RADAR system [3]. RADAR is a data warehouse and includes data from multiple sources. Most relevant to this work were data from the annual Agricultural Survey (AS), the Cattle Tracing System (CTS) and the GB Poultry Register (GBPR). Data on veterinary practices is available through the Directory of Practices held by the Royal College of Veterinary Surgeons (RCVS).

Materials and methods

The number of farms submitting samples to VLA and therefore included in the FarmFile database was estimated using the unique numerical identifier for each holding the County Parish Holding (CPH) number. The CPH is a requested data field on the laboratory submission form and is complete for the majority of cattle, small ruminant and pig submissions (97, 92 & 90% respectively) but less so for poultry submissions (30%). To account for the lack of farm identifying information the number of holdings making one or more submissions was estimated using the following equation.

*Estimated number of holdings making one or more submissions to VLA = (Total number of submissions * number of holdings where CPH known) / Number of submissions where CPH known*

To assess coverage at holding level during 2009 we used different sources of denominator data for different species because a count of these holdings for 2009 was not available from the AS when our report was produced. For cattle, data was available from the CTS and for poultry and gamebirds data was available from the GBPR. For sheep, goats and pigs data from the June 2008 AS were used. Camelids are not covered in the annual AS and we were unable to identify any readily available data on the number of camelid holdings in England.

The number of practices recorded as treating animals of each species on the RCVS Directory for January 2009 was used as the denominator for assessing coverage at veterinary practice level. The directory lists practices and indicates whether each practice treats cattle, sheep/goats as a single entry, pigs, poultry and camelids. There was no classification of practices providing gamebird work. As a small number of veterinary practices are responsible for the treatment of a large proportion of the pig and poultry population coverage was also assessed using an estimate of the number of specialist pig practices submitting material to FarmFile.

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Specialist practices were identified by the appropriate VLA species expert group using their knowledge of the industry. All data were available electronically and were handled in an Excel (Microsoft) format.

Results

Estimates of the proportion of holdings keeping different species submitting material to VLA during 2009 are shown in Table 1.

Table 1: Estimated coverage of holdings keeping different species represented by scanning surveillance submissions made to VLA in England in 2009

Species	No. holdings making at least one submission to FarmFile	No. holdings*	% coverage
Cattle	12,747	52,241	24%
Sheep	3,477	48,599	7%
Goats	426	6,763	6%
Pigs	688	10,221	7%
Poultry	2,949	15,902	19%
Gamebirds	214	7,957	3%
Camelids	396	Not known	-

* From agricultural census, CTS or GB poultry register

Tables 2 and 3 show the proportion of veterinary practices submitting material to VLA for all practices recorded in the RCVS Directory of Practices (Table 2) or specialist veterinary practices identified by members of VLA pig expert group (Table 3)

Table 2: Estimated proportion of veterinary practices treating different species making scanning surveillance submissions to VLA in England in 2009

Species	No. practices making at least one submission to FarmFile	RCVS count of practices	% coverage
Cattle	522	698	75%
Sheep	448	737*	61%
Goats	235	737*	32%
Pigs	175	612	29%
Poultry	338	557	61%
Camelids	188	256	73%

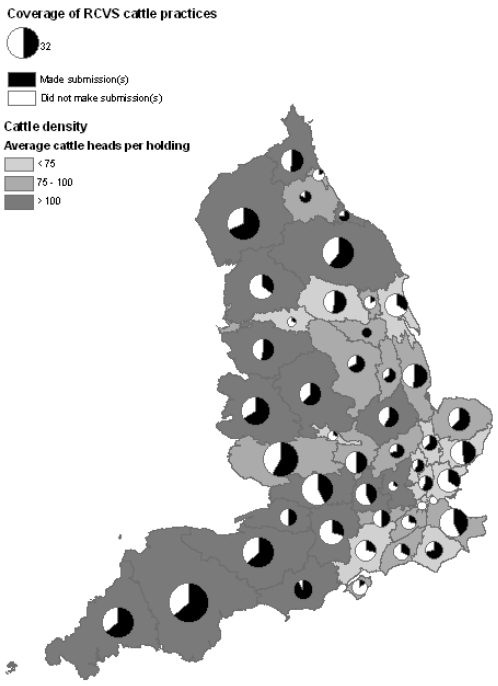
* RCVS list of practices uses combined sheep/goat classification.

Table 3: Estimated proportion of veterinary practices specialising in pigs or poultry making scanning surveillance submissions to VLA in England in 2009

Species	No. specialist practices making at least one submission to FarmFile	No. specialist practices	Estimated coverage of specialist practices
Pigs	15	16	94%
Poultry	16	18	89%

We have also investigated the geographical variation in coverage which reveals that coverage is not uniform. In cattle a higher proportion of practices in cattle dense areas submitted samples to FarmFile and therefore had contact with VLA (Figure 1). Coverage of the cattle population has also been shown to be higher for dairy farms than beef farms, for larger farms and for those farms closer to VLA RL

Figure 1: Cartogram showing the proportion of cattle practices making submissions (pie charts), number of cattle holdings (county area), and average number of cattle per holding (colour gradient) in England in 2009



Discussion

Evaluation of surveillance activities is essential to assess the efficacy of these activities and facilitate improvements. Coverage of the population is one of the key criteria for assessing the effectiveness of surveillance, particularly surveillance aimed at the detection of emerging diseases. Where coverage of a target population is high then it can be expected that disease outbreaks will be more rapidly detected and controlled. This has obvious economic and welfare implications.

Coverage of the population can be defined in different ways; we have assessed coverage at both holding and veterinary practice level. Assessment at practice level should provide a more accurate assessment of the proportion of the population that is included in surveillance activities for the detection of emerging diseases. It could be argued that if a farm is served by a veterinary practitioner who is in contact with the VLA then it is likely that if a new or emerging disease occurs on this farm, it will be reported and investigated through the VLA although it is likely that not all of these farms would submit material for diagnosis of endemic disease to VLA.

At present, our coverage of veterinary practices has been determined using information about the receipt of one or more submissions for laboratory work. This is not the only means of contact between Veterinary investigation officers at VLA and veterinary practices but is a relatively simple one to quantify through receipt of laboratory samples. However, VLA laboratories have frequent telephone contact with veterinary practices so the estimate of coverage based

only on submission of clinical material may be an underestimate. In addition the coverage estimates are based on practices submitting clinical material within a single year. A more accurate assessment of coverage may be obtained by considering those farms or practices that had contact with VLA over a longer period assuming that these farms or practices would contact VLA if an unusual disease occurred.

We have identified some issues which impact on our ability to obtaining accurate coverage estimates. The most important of these is the availability of consistent, reliable and timely denominator information. At holding level accurate data is readily available for cattle from CTS which is updated monthly. The GBPR provides information about flocks with more than 50 birds and is updated daily. For sheep, goats and pigs only the AS data from the previous year was available. In addition to the issue surrounding the availability of timely data for pigs, sheep and goats the accuracy of the AS data has been questioned. A full census is only carried out every 10 years with data updated in the intervening years based on information obtained from a sample of farms of one third of farms. We were unable to identify any readily available data on the number of camelid holdings in England.

There are also issues surrounding the quality of the data for identifying veterinary practices; provision of information for the RCVS Directory of Practices is voluntary therefore not all practices are listed. Preliminary results from an ongoing study to investigate the validity of these data by identifying all practices in selected counties of England suggest that less than 80% of veterinary practices were included in this Directory. However, it is unclear how many of those practices that were not included in this directory treat farmed animal specie. , We are currently investigating this by identifying all practices in selected counties that treat pigs. However, one advantage of using practice level denominators is that if accurate information about practices dealing with farmed animal species can be obtained it is likely that the number and type of work undertaken by veterinary practices will vary less over time than the count of farm holdings or individual animals.

Although assessing coverage at veterinary practice level is, in theory, likely to provide a better estimate of how many farms are covered by scanning surveillance activities the data currently available make it difficult to assess the proportion of herds or animals covered. The RCVS Directory does not distinguish between practices specialising in the treatment of a particular species and those practices with only a few clients keeping this species. The nature of veterinary practices in England has changed progressively in recent years, there are increasing numbers of specialist practices replacing the more traditional mixed species practices. This means that a large proportion of the animal population may be covered by fewer practices engaged in species specialist work. This specialisation is relatively common in the pig and poultry sector and is becoming increasingly so for cattle and other livestock sectors. For example, there were 175 veterinary practices recorded as carrying out pig work in the RCVS Directory, but only 16 specialist pig practices were identified by members of the VLA pig expert group and 94% of these submitted samples to VLA compared with 29% of those practices recorded as treating pigs on the RCVS directory. It is estimated that 90% of the commercial pig herd is covered by these specialist practices. This estimate is currently being investigated by collection of information from veterinary practices about the number and type of pig herds treated which will allow us to make and accurate assessment of the proportion of herds and animals covered by surveillance activities.

Conclusions

There are many factors that influence the likelihood that an emerging disease would be identified by farmers and subsequently investigated by veterinary services. Understanding how well the population is covered by current scanning surveillance activities provides a baseline measure of the efficacy of these activities and will allow us to identify how these activities could be improved.

Identifying the most appropriate methods to assess coverage and addressing any issues impacting on the accuracy of these assessments for existing and alternative surveillance strategies is important to facilitate improvements in surveillance efficacy and ensure the protection of animal health. We will continue to address the issues identified by this work to develop appropriate methods to assess the coverage of the animal population and to ensure that timely and accurate denominator data are available.

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Bovine Tuberculosis Surveillance in Belgium: Evaluation of Current Surveillance Components

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Abstract

Intro: Belgium gained the bovine tuberculosis (bTB) officially free (OTF) status in 2003 [1]. The present study was carried out in order to evaluate the different surveillance components of the current bTB surveillance program and, to estimate how this program could be optimized in accordance with European legislation [2].

M&M: Separate scenario trees were designed for each component of the surveillance program. Surveillance data over the past 5 years were collected, as well as population and movement's data. Different stochastic simulations were carried out to measure the impact of modifications in each surveillance component, regarding the diagnostic test used and the fraction of population sampled, towards the animal, herd and component level sensitivities (ModelRisk).

Results-Discussion: The sensitivity (mode) for the following 3 surveillance components was respectively 0.92 for testing 50% at slaughterhouse, 0.87 for testing 50% of purchased animals, and 0.20 for testing all animals during the winter screening. Large variations around the average values were observed. The sensitivity analysis showed that the most influential parameter explaining this variability came from the uncertainty distribution around the diagnostic process parameter.

Keywords: Bovine, Tuberculosis, Risk based, Surveillance, Sensitivity.

Introduction

Belgium, like other European Union Member States (MS), has maintained the OTF status for bTB (herd prevalence <0.1%) since 2003 [1]. Yet, sporadic outbreaks do still occur, as has recently been the case in Germany and in the Netherlands [Hooyberghs, personal communication, 3, 4].

The current official surveillance program in Belgium consists of different components, in accordance with the guidelines laid down in the European and Belgian legislation [2, 5]:

- Imported animals must be tested with an intradermal single bovine tuberculin test (SST) (IMP surveillance component);
- Post-mortem visual inspection at slaughterhouse is carried out on all slaughtered animals (SLGH surveillance component);
- Purchased animals, except for young fattening calves (FC)) for veal production, are tested with the SST (PUR surveillance component);
- During the winter period (WS surveillance component), the following categories are tested with the SST: i) All animals aged 6 weeks and above which have been in contact with a herd which was confirmed bTB positive in the last year; ii) All female animals above 24 months of age which belong to 'on-farm milk selling' herds; iii) All imported animals, above 6 weeks of age, from non OTF Member States for 3 consecutive years.

This study was carried out to evaluate the current surveillance system sensitivity for bTB in Belgium, and simulate the impact of changes in the different surveillance components on the component sensitivity (CSe) and on the total surveillance system sensitivity (SSe) for bTB.

Materials and methods

For the purpose of this study, 4 separate scenario trees (Figure 1), as described by Martin *et al*. [6], were designed for each surveillance component, namely the IMP, SLGH, PUR and WS surveillance component.

The choice and the sequence of the nodes representing these components in the scenario tree were done following a review of literature, and expert opinion using Belgian experts [7]. The nodes and node's branches of these trees were similar for each component except for the detection node. The following risk category nodes were retained: imports from non OTF MS (yes/no), past bTB status (positive/negative), animal movement rate (low/high), herd type (fattening calves (FC) for veal production or other bovines (B)) and herd size (low, medium, high). Population proportion (PPr), sampled population proportion (SPr) and the relative risk (RR) were the parameters which enabled the categorization of the whole herd population in Belgium. The following nodes were the infection nodes: animals and herd status with their respective parameters, the average within herd prevalence (PA) calculated on data of the historical registered bTB outbreaks (2005-2009) and the legal herd design prevalence (PH). These parameters enabled the computation of the effective probability of infection of an animal (EPIA) and herd (EPIH). In turn, these EPIH and EPIA allowed the computation of the animal sensitivity (ASe) for each limb of the tree, defined by the combination of each category node's branch, as well as the herd sensitivity (HSe), according to the different diagnostic processes methods sensitivities (TSe) applied to each limb of the tree (post mortem inspection (PM) or Intadermal SST test (ID)) and to the number of animals sampled. These individual herd sensitivities, for each limb of the tree, allowed the computation of the CSe and the SSe for each component under study (IMP, SLGH, PUR, WS).

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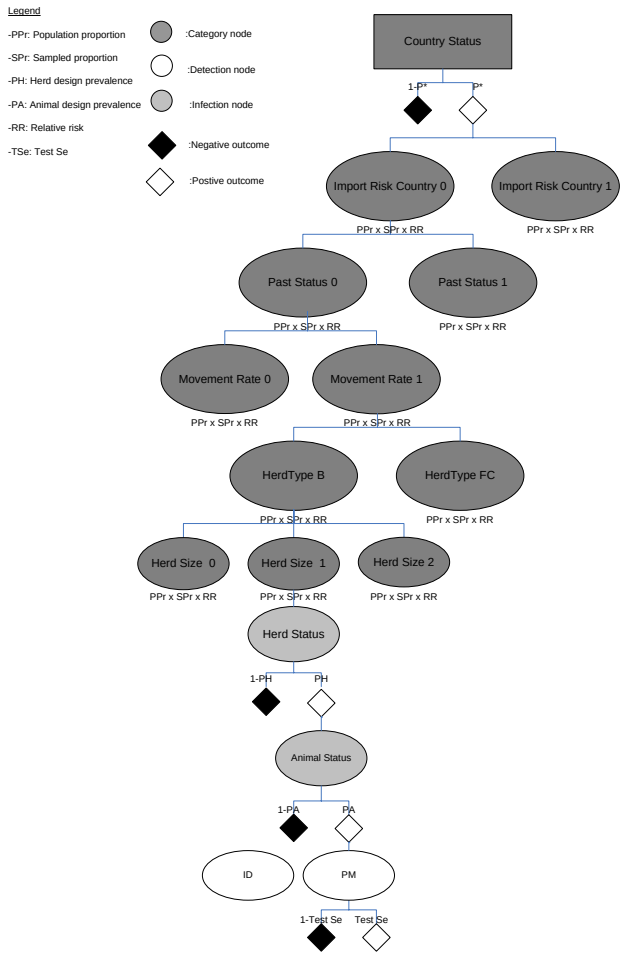
Figure 1: Scenario Tree for the detection of bTB in Belgium



For each herd active in 2009, data regarding imports, purchases by national trade, herd structure and bTB status over the past 5 years (2005-2009) were collected from the Belgian animal identification system (SANITEL). In total 96,413 herd records grouped all historical data from 2005 to 2009 for each of these herds still active in 2009.

Cut-off values enabling the categorization in the different risk category node branches, of animal population proportion (PPr), and sampled population proportion (SPr), were determined following separate univariate analysis (SAS 9.2.). To estimate the relative risk (RR) of each branch of the risk category nodes, a risk factor analysis was carried out in SAS 9.2. to model the probability of a herd of being bTB positive given the category node branch of interest. A pert distribution was fitted around the average value of the RR estimates for each category node branch, the minimum and the maximum values being the confidence interval limits. Literature review and bTB expert opinion were used to estimate the different diagnostic test sensitivities [8].

Spreadsheets were created in Excel 2007 to represent each surveillance component investigated (IMP, PUR, SLGH, WS). Distributions were fitted on each input variable taking into account the variability, as well as the uncertainty of the key parameters. Simulations of the following scenarios were carried out (10,000 Iterations/Simulation) (ModelRisk 3.0, Vose Consulting): i) In which limb of the tree would it be the most efficient to sample ii) what is the impact on the CSe and on the Sse, of reducing the sampling size in the different surveillance components (testing only 50%, 75%, or 100% of the samples only)?

A sensitivity analysis was carried out for this scenario tree model to determine what input parameter was most influential on the output parameters CSe and SSe.

In order to validate the output, a generalized estimating equation (GEE) model was built in parallel to investigate the probability to detect a single positive animal given the diagnostic motive used. For this purpose historical data regarding the detected bTB outbreaks during 2005-2009 were used (SAS 9.2).

Result

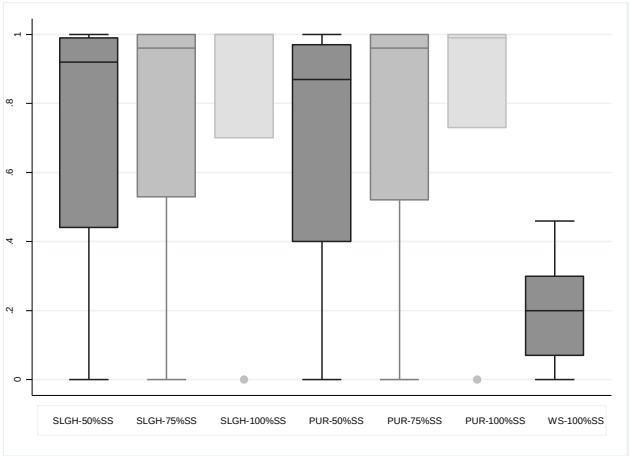
The number of animals sampled was the highest in PUR, followed by SLGH. Only very few samples were taken within the WS component. The diagnostic process sensitivities were similar for PUR and WS (VosePERT (0.54; 0.68; 0.95)). The SLGH diagnostic sensitivity was slightly higher (VosePERT (0.5; 0.7; 0.99)).

According to the individual HSe obtained in each component for each limb of the tree, the best sensitivity was seen when sampling was done in adult bovine herds of medium size, where movement rate was low or high, where no bTB infection was observed previously, and where no imports from risk countries were registered.

The mode (50% percentile) across 10,000 iterations for the CSe of the following 3 surveillance components was, respectively, 0.92 for testing 50% at slaughterhouse, 0.87 for testing 50% of purchased animals, and 0.20 for testing all animals during the winter screening (Figure 2).

The sensitivity analysis showed that the most influential parameter explaining this variability came from the uncertainty distribution around the diagnostic process parameter.

Figure 2: Impact of changing sample size in each component. (50, 75, 100% of the samples)



The GEE model, developed for validation purpose, showed by investigating the outbreak detection methods, that the most significant method was slaughter surveillance, followed by tracing-on and tracing–-back, which confirmed the findings of the scenario tree model simulations.

Discussion

The output of this study has underlined interesting features such as the importance of slaughterhouse surveillance (SLGH), followed by tracing-on and tracing-back (WS). One of the main reasons that could explain the high CSe of slaughterhouse surveillance is the large sampling coverage of this component over the whole population. However, the efficiency of this component is highly dependent on the visual inspection sensitivity, as confirmed by the sensitivity analysis. The WS CSe, is relatively high in comparison to the very small number of samples taken in that component; this high value can be explained by targeted sampling in that component, which is especially focused on high risk groups. It was comforting to see that the GEE model, supports these findings. Surveillance at slaughterhouse, and by tracing-on and tracing-back, have has proven in the past to be effective at national level and in other MS [2, 9, 10, 11].

When implementing a surveillance system or evaluating some alternatives, scenario tree methodology has proven to be a useful tool, as proven in the past [6, 12, 13, 14, 15, 16, 17, 18, 19], providing that data regarding key parameters are available [20]. The empirical approach in the present study, making use of historical breakdown data, allowed to achieve reliable parameter estimates and provided sufficient confidence to the output results of this model, such as CSe and SSe values.

The present study provided interesting clues for policy makers to optimize the bTB surveillance program, depending on the efficiency of detection, feasible field work and financial resources, such as required by European legislation and international standards.

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Comparison of spatial patterns of recorded mastitis incidence and somatic cell counts in Swedish dairy cows

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Abstract
Disease recording in Swedish dairy cattle is made by veterinarians. The study objectives were to study if there were any geographical regions of possible under-reporting of clinical mastitis. We did this by comparing mastitis incidence to udder health measures based on somatic cell counts, a parameter recorded on a monthly basis regardless of the cow´s disease status. The approach was to estimate a surface of relative risk for clinical mastitis and compare areas of significantly lower relative risk to an extraction map of udder health. There were areas with a significantly lower relative risk for clinical mastitis with a high proportion of cows with poor udder health thus suggesting an under-reporting of clinical mastitis. The result enables targeted studies of reasons for discrepancies and proper measures to be taken in areas with a deficit of registered clinical mastitis. High quality of disease recording for dairy cattle is of interest not only for the dairy producer but also for disease surveillance and food safety purposes.

Keywords: disease recording, validation, mastitis, surveillance, spatial analysis.

Introduction

A well-functioning system for disease recording for cattle is a valuable tool. It can be used for industry purposes, in herd management and breeding programs, and also to support national needs for surveillance of emerging diseases and for traceability from a food safety perspective. For all objectives it is important to have knowledge about the validity of the information generated by the system.

In Sweden, veterinarians are by legal enforcement obliged to report all diagnoses and treatment on cattle, both on individuals and on herd level. Reporting should be done to the Swedish Board of Agriculture (BoA) within a week of the consultation. In principal, a veterinarian has to clinically examine and establish a diagnosis for each animal and initiate adequate treatment. Furthermore, veterinarians are not allowed to supply antibiotics directly to farmers except for the initial treatment of each case.

Like many countries with a developed dairy production, Sweden has a milk recording scheme (MRS). The scheme's database, which is managed by the Swedish Dairy Association (SDA), includes production data as well as demographic information and disease records on individual cows. The latter are routinely transferred to the MRS database from the BoA. The information from the MRS is used by the farmers, advisors, in breeding programmes and has been used in several research studies.

Previous validation studies have compared the disease information in the MRS against farmer records and found an overall completeness of 73% for veterinary treated disease events [1] and, at a comparison against copies of veterinary records left at the farm, a total completeness of 87% for cases but with differences between geographic regions and veterinary employment type [2].

The somatic cell count (SCC) is a corner stone in milk recording as a measure of the udder health status of the cow. There is a known relationship between SCC and clinical mastitis (CM), see for instance [3]; hence SCC could be used as a standard to which veterinary records of CM are compared to evaluate the surveillance capacity of the disease recording system. The geographical locations of dairy herds are available and thus allow the use of spatial epidemiology as a tool to validate the disease recording system.

Our hypothesis for the current study was that there is a spatially non-random distribution of veterinary registered incidence of CM in Swedish dairy cattle. More specifically, our aim was to study if there were any regions with possible under-reporting of CM. We did this by estimating the relative risk for registered CM and comparing this to udder health measures based on production parameters from the milk recording.

Materials and methods

The study was a retrospective cross-sectional study. We retrieved annual production data at herd level from the MRS database for all herds participating in milk recording for September 2008 to August 2009. Within the MRS a number of health parameters are calculated. One such parameter is the udder disease (UD) score which is based on the individual cow's geometric average SCC from the last three monthly test milkings and is adjusted for the effects of breed, lactation number, days in milk, and milk yield in Kg. It is reported on a scale from zero to nine where six to nine is regarded as "poor" indicating that the cow is likely to have a subclinical mastitis. Clinical mastitis cases in MRS are primarily veterinary diagnosed and registered cases, as only a minor amount of CM cases are registered directly by the farmers. The MRS applies a 21 day lag–period for CM meaning all mastitis diagnoses registered on the same animal within 21 days from the first are treated as one case. Herds with a size of less than 25 cow-years or with incomplete data were

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excluded from this study. Descriptive statistics on bilk milk somatic cell count, UD score, CM incidence and herd size were produced for the study herds.

The study herds' geographical locations were retrieved from the Swedish Board of Agriculture. All data were entered into a database (MS Access, Microsoft Corporation, Redmond, WA, USA). Data management was done using the query language in Access.

The first step in comparing CM to udder health measures was to calculate the relative risk of CM. We used the novel package "sparr" (version 2-0.1) for R (www.cran.r-project.org). This package uses well-established methods for calculation of kernel smoothed density functions for cases and controls and combines these in a ratio as the (log) relative risk (RR) of disease. The kernel smoothed density function for cases was estimated including only herd locations with at least one CM during the period of interest. The number of cows with a CM was used as weight for each herd location. Accordingly, the density function for controls included the herd locations with no CM with the number of cows without any mastitis case, *i.e.* the herd size, as weight. We used a Gaussian kernel function and the grid cell resolution was 200, *i.e.* the length and width of Sweden were divided into 200 segments each. The distribution of dairy herds in Sweden is strongly heterogeneous and therefore adaptive smoothing was used. A cross validation was performed to estimate the optimal bandwidth, both with all of Sweden and with only the southern quarter of Sweden's area (*i.e.* the most dairy dense counties) included. When including only the dairy dense counties, bandwidths of 19, 22 and 19 km were suggested for case herds', control herds' and all herds' locations, respectively and were used as pilot bandwidths for the adaptive smoothing.

To test whether the relative risk of CM was significantly greater or smaller than one at any point, asymptotic p-values were calculated based on a Z-test [4]. This approach takes into account how many observations there are in an area and gives conservative p-values in areas where data are sparse.

It was not possible to use the same approach to identify case and control herds to calculate a (log) RR of poor udder health (as indicated by poor UD score), because all herds had at least one cow with poor UD score at one or more test milkings. Instead, a ratio function was calculated, so called extraction mapping, with the kernel smoothed density function for number of cows with poor UD score at one or more test milkings (cows per km^2) as numerator and the kernel smoothed density function for stock density (cows per km^2) as denominator. The same grid resolution as for the RR of CM incidence was used. The pilot bandwidth for the adaptive smoothing was 19 km. The extraction map was plotted and contour lines encircling areas of significantly, at $p < 0.05$, decreased (log) RR of registered CM was added to the plot.

Result

In 2009 approximately 85% of the dairy herds were enrolled in the MRS while the national disease recording system has 100% coverage, at least in theory. A total of 4,657 herds were included in the production data from SDA and of those 4,564 had coordinate data. In all, 3,851 (83%) herds met the inclusion criterion of a herd size with at least 25 cow-years. Four herds were removed because of identical coordinates with another (larger) herd, and located in the removed area in the North were another 33 herds, resulting in a study population of 3,814 (82%) dairy herds.

The size and udder health parameters for study herds are presented in Table 1. In total, the 3,814 study herds contributed with 265,024 cow-years. The number of cows with at least one test milking with poor UD score was 109,749 and the number of cows with at least one registered case of CM was 37,148. Of these, 36,539 from 3,318 herds were veterinary registered and 609 (1.6%) cases from 197 herds were farmer registered. There were 496 herds with no veterinary registered case of CM during the study year; of these 37 herds had farmer registered CM cases.

The areas of significantly lower RR of registered CM did not follow the patterns of good udder health (Figure 1) thus suggesting that there is under-reporting of CM in certain areas.

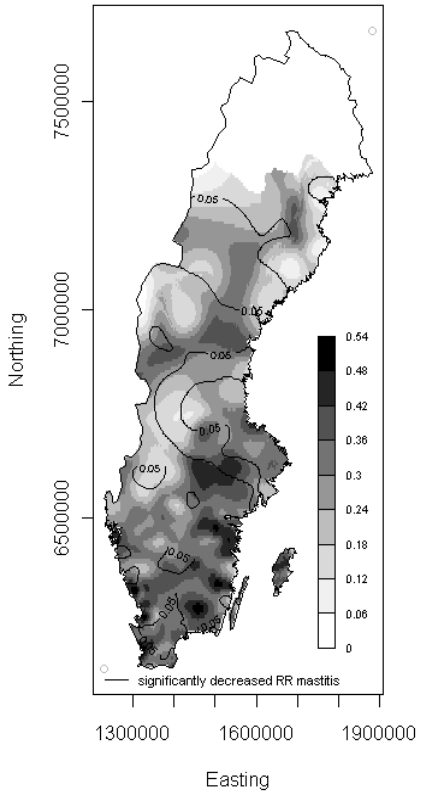
Discussion

Theoretically, a good udder health should be reflected in a low risk of CM and poor udder health in the opposite. Discrepancies in either direction (poor udder health and low RR of clinical mastitis or good udder health and high RR of clinical mastitis) are both anomalies. If the low RR for CM reflected a truly low incidence of CM, then the proportion of cows with poor UD score is expected to be low. This means that our results indicate a possible deficit of registered cases in the delimited areas with low RR for CM but a high proportion of cows with poor UD score.

Table 1: Descriptive statistics of production and udder parameters for the study herds.

	Case herds with registered CM (n = 3355)			*Control herds without registered CM (n = 459)*		
Parameter	*q.10*	*q.50*	*q.90*	*q.10*	*q.50*	*q.90*
Average size (cow-years)	30.9	54.8	132	28.6	45.3	114
Average BMSCC (1000 cells/ml)	144	228	342	145	240	360
Number of cows with poor UD score at > 0 test milking	10.0	22.0	58.0	8.0	17.0	47.2
Average monthly proportion of cows with poor UD score (%)	7.0	14.0	22.0	7.0	14.0	22.0
Number of cows with any registered CM	2.0	7.0	24.0	0	0	0
Incidence risk of registered CM (%)	2.0	11.0	30.0	0	0	0

Figure 1: Extraction map illustrating distribution of cows with poor udder health (based on somatic cell counts) and contour lines representing areas of significantly decreased (log) RR of registered CM



Mastitis is the most common clinical disease among Swedish dairy cows; in 2009 the incidence for herds in the Swedish MRS was 14.5 cases per 100 cows. The geographical distribution of dairy cows in Sweden is strongly heterogeneous with a few smaller areas with a significant proportion of the dairy cows. If there is under-reporting of CM in a dairy dense area this could have a substantial impact on the number of cows with a biased (too few cases) mastitis history. In addition, one could question the data quality for other diagnoses in dairy cattle.

Veterinary registrations of CM will never include all CM cases in the dairy cattle population since. individual farmers have different attitudes to mastitis treatment [5]. When detecting a cow with clinical mastitis the farmer does not necessarily decide to contact the veterinarian for treatment. This could even be in accordance with the mastitis management promoted by the veterinarians in the area and may to some extent explain our results.

Spatial analysis can be applied to understand geographical patterns of disease and, as in the present study, geographical patterns of disease recording. The results from the present study could be used to focus future studies of the disease recording system to regions with poor veterinary reporting and thus find ways to improve the recording system and the completeness of the disease data. Disease records from an already in-use system such as the MRS, or directly from the Board of Agriculture, are a cost-effective way to monitor the health status of a large proportion of the Swedish dairy population. However, this assumes no geographical differences in the disease-recording ability of the system. The method of spatial relative risk surfaces used in this study could by itself be applied for pattern recognition for evaluation of surveillance capacity.

In conclusion we found areas in Sweden with a significantly lower relative risk of registered clinical mastitis, where the udder health, measured as udder disease score, was not better compared to areas with a higher relative risk of clinical mastitis. This discrepancy may be caused by poor reporting by veterinarians or by farmers having a region-specific higher threshold for consulting a veterinarian for treatment.

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