OPTIMISATION

The need for surveillance – from the livestock and meat industry's perspective

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Abstract

This paper considers the livestock and meat industry's need for monitoring and surveillance. The aim of monitoring and surveillance is either to improve animal and public health or to document freedom from a given disease for various trade reasons. However, resources are constantly scarce which provides a need to identify cost-effective solutions to the current challenges faced by the European livestock and meat industries. The paper illustrates these challenges by examples: 1) H1N1, 2) antimicrobial resistant bacteria, 3) food safety in outdoor poultry production and 4) control of classical swine fever. Further, suggestions on how to improve monitoring and surveillance are presented based on experience from the field and lessons learnt. We argue that solutions will more likely emerge from a cross-disciplinary approach seeking to optimise areas with a focus on the entire production chain. In conclusion, all stakeholders viz academia, veterinary services and the livestock and meat industry need to collaborate to identify effective and timely solutions and to share experience based on their practical working experience.

Keywords: surveillance, livestock, meat industry, cost-benefit.

Introduction

The livestock and meat industry in the EU is continuously presented with new challenges within the discipline of veterinary public health. Recent concerns are the discovery of the H1N1 virus in pigs, the spread of antimicrobial resistance, public perception of outdoor and indoor production systems, and control of potential outbreaks of exotic animal disease, such as classical swine fever.

In the world of academia, experts are trained to gather knowledge about hazards in such situations, *e.g.* the genome behind the H1N1 virus, the surface proteins on antimicrobial resistant bacteria or designing a vaccine to combat classical swine fever. Despite the often impressive results presented by academia, the industry has not always found the solutions to match their problems. On occasions, the recommended solutions have neither been cost-effective nor practicable, which is especially problematic in a period of serious economic difficulty. The following sections look at four case studies, which clearly illustrate the challenges for the improvement of monitoring and surveillance for animal and public health.

Case Study 1 – H1N1

The worldwide epidemic of H1N1, which quickly acquired the name 'swine flu' at its outset, led to negative public perception of pigs and pork, which had no scientific basis. When a pig herd in Canada was diagnosed with H1N1, the animals were quarantined and subjected to testing based on the assumption that once negative results were obtained they would be released. However, when the quarantine was lifted, the abattoirs would not accept the pigs for slaughter, and the herd was eventually depopulated (http:// www. allheadlinenews.com/articles/7015424954). This sequence of events took place even though information had been published that H1N1 caused a mild influenza and was primarily a disease related to human rather than animal health. At a general level, H1N1 is not a veterinary public health issue, because human-to-human transmission is the main spreading mechanism and the virus is not believed to be transmitted through meat (http://www.oie.int/eng/press/ en_090713.htm).

The WHO definition of the different levels of an epidemic, of which the highest is a 'pandemic', may also have contributed to these events. The WHO primarily bases its assessment on the virus' capacity to spread rather than its capacity to cause severe disease and mortality. In conclusion; while proper management seemed to be in place, the risk assessment was misleading causing risk communication to fail.

A more accurate assessment would result if the severity of the disease was also taken into account by the WHO. The name given to an infection, which has limited implications for livestock, should be made carefully to avoid any unjustified negative perception of livestock and meat products.

Case Study 2 - Antimicrobial resistant bacteria

When multi-resistant *Salmonella* Typhimurium DT104 (DT104) initially emerged in the United Kingdom more than a decade ago, there were reports relating to its severe impact on the health of infected human patients. The presumed risk resulted in major concerns for both the veterinary and public health authorities. In response, a surveillance and control programme was implemented in Denmark in 1996. Detection of DT104 on Danish pig farms lead to culling, and its detection in carcasses resulted in mandatory heat-treatment. After a three year period the strategy was re-evaluated by the industry. Experience from the field revealed that it was possible to eradicate DT104 from infected farms – but impossible to stop the spread to other farms. Therefore, the industry moved from an eradication strategy to a reduction strategy. However, the official requirement for heat-treatment of carcasses from infected herds remained. The question soon arose; whether DT104 would become the problem originally envisaged? According to surveillance data, DT104 established itself in Danish pig farms at a low level; currently it constitutes 5-8% of the *Salmonella* Typhimurium isolates found annually.

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Moreover, research has shown that the most common type of DT104 in Denmark – penta-resistant DT104 - did not cause any more serious disease than a sensitive type of *Salmonella* Typhimurium.

Thus, significant resources were deployed to counter a relatively small proportion of the *Salmonella* burden. Likely, these resources could have been invested more effectively in other interventions such as the use of hot-water decontamination of carcasses from high-risk herds at slaughter [1]. The DT104 example demonstrates that it is actually more difficult to unwind a surveillance and control programme than to introduce it. In 2009, however, the Danish DT104 programme was finally terminated.

Case Study 3 - Food safety in outdoor poultry production

The risk profile of poultry from outdoor production systems is different from that originating from the indoor equivalent. The prevalence of *Campylobacter* is significantly higher in poultry raised outdoors, especially during the summer months [2]. This factor, apparently, is not fully appreciated by consumers, nor is it recognised by some of the farmers managing outdoor systems. Moreover, consumers tend to perceive meat from outdoor production as “safer”, mistakenly attributing higher food safety standards with possibly higher welfare production systems. Traditional measures to limit *Campylobacter* such as control of feed and the quality of drinking water [3] cannot be fulfilled as meticulously in systems with multiple environmental interactions. The demand for outdoor-reared chicken will probably increase in response to consumer demand for improved animal welfare. Increasing quantities of poultry from outdoor production systems on the market offer new challenges to the industry to maintain the level of safety in broiler production.

A new risk-reducing invention with the potential to eliminate *Campylobacter* from broiler carcasses, by use of hot steam and ultrasound, is being investigated in a processing plant in Denmark. The initial results are promising; however, its effect on organoleptic quality as well as its cost and practical implementation during processing need further study. In addition, consumer acceptance of the higher price needed for additional risk-reducing measures needs to be assessed carefully.

To summarise: It is critical that the veterinarians employed by the industry is close to and co-operate with academia to assist in the development of applicable solutions to new threats and risk profiles.

Case Study 4 - Control of classical swine fever

Outbreaks of exotic and contagious livestock diseases, such as classical swine fever, require actions to limit the spread of disease and eliminate infected animals. The EU has specified minimum requirements for measures to be implemented by Member States in the event of a disease outbreak. The current control strategy includes the cull of infected herds and potentially dangerous contacts. During the outbreak of classical swine fever in the Netherlands during 1997 and 1998, large numbers of animals were culled. The majority of these animals were not infected but were culled to stop the epidemic from spreading (pre-emptive culling).

Public indignation and concern about the apparently unnecessary slaughter of healthy animals initiated an intensified search for other solutions. One possible solution may be a wider use of vaccines. Laboratory experiments and simulation modelling have shown that use of vaccines may deliver promising solutions as they can reduce the need for pre-emptive culling significantly. One scenario is to vaccinate finisher pigs by use of so-called marker vaccines. Vaccinated pigs will be killed at the usual slaughter age, and, after a period of six months, all vaccinated animals have left the population. At first sight, this appears to be an elegant solution to the problem. However, for a country with a large export of livestock products, use of either marker vaccines or the classical live vaccines will likely result in an extended ban on exports to certain markets because countries outside the EU may not have confidence in the disease free status of the exporting country if vaccines have been used [4]. In fact, in these situations it may be the vaccine and not the epidemic which presents the largest financial risk to the industry.

Identification of other cost-effective and risk-mitigating measures is still needed, as well as an understanding of what went wrong when an outbreak turned into an epidemic. For example, was the spread of disease due to a delay in the introduction of a national stand-still on animal movements? Was it due to the illegal transport of animals or an unusually high number of animal movements linked to a religious holiday? Was it due to the high density of animals or herds in the outbreak area? Furthermore, the analysis must clearly distinguish between risk of introduction and risk of spreading infection as well as distinguish between measures taken in normal trading conditions and during an outbreak.

Discussion

Our learning from these cases can be summarised as follows:

1. Take great care with the design of a survey or a surveillance programme. Clearly identify the objective(s) and assess the likely reaction to the various outcomes that may be expected. Protect all participating farmers and slaughterhouses against any unreasonable side effects to ensure their acceptance and support of the surveillance programme and their co-operation in future research. Consider whether the survey or the surveillance programme will produce the necessary knowledge and whether the stakeholders – industry or tax payers - will get value at least equal to the investment. Bear in mind the difference between a surveillance programme to be carried out in consecutive years and a research project that is usually conducted during a limited time period.

2. Surveillance of *Salmonella* should focus on all types causing harm to humans. Such an approach will lead to prevention of more illness and disease than measures directed towards a single group of *Salmonella*. A similar situation may apply to other

kinds of bacteria. Forget the competition to be the first to find a new strain of resistant bacteria and devote the resources to areas where most disease in both animals and humans can actually be prevented.

3. Do not blindly follow conventional wisdom – advocating, for example, that all infections should be dealt with at the source. Perhaps other risk-mitigating measures, such as those applied during or after slaughter are more cost-effective and more capable of providing the same level of safety assurance.
4. Carry out a thorough cost-benefit analysis (CBA) or cost-effectiveness analysis of any planned actions. Remember to take account of the effects on trade related to various control measures, especially for the containment of exotic and contagious livestock disease. Take into account that pay-back time is important as costs are often paid immediately whereas benefits typically become visible later.
5. Introduce risk-mitigating measures in cases of emerging diseases, when only limited knowledge is available. There is a possibility that actions taken during an earlier stage of an outbreak may not adequately deal with the risk because of imperfect knowledge. However, we should not - and cannot always - wait for complete knowledge before an action is initiated. This may result in action being taken too late. We suggest that once preliminary actions are implemented, it should be clearly communicated that these are 'preliminary' measures and later modifications may be expected as necessary. Risk communication is an important part of this approach, because it makes it easier to implement emerging knowledge in the decision making process to implement improved risk-mitigation measures. Thus, we should be willing to change or even remove measures if it turns out that the hazard is not as great as originally expected. Similarly, we should be prepared to redirect or adjust our actions if it becomes clear that the risk was in fact different than originally expected. Disease monitoring and surveillance is a dynamic process by definition.

The livestock and meat industry call for focus on the challenges faced at all stages of the production chain. It must be acknowledged that the industry needs cost-effective solutions, which are meaningful and timely as well as easy to communicate and implement at farm level. If used intelligently, financial penalties and incentives can play a beneficial role to improve food safety standards. Conversely, if used wrongly, such an approach may undermine the competitiveness of European agriculture.

Risk communication is a discipline in which we can all improve by sharing knowledge and experiences. Focus on better risk communication may also result in an increased understanding of the implications of decisions taken and identification of the most suitable solutions to a problem, as well as the early correction of mistakes. Consequently, the livestock and meat industry must seek more regular contact with the world of academia to present the day to day (as well as long term) challenges it faces and explain their context. Also, the industry must improve its contact with the veterinary services, who, together with the farmers, are the true risk managers at farm level. Risk communication must be an integral part of obtaining public understanding and support for animal health surveillance.

Participation in common research projects, both on a national or international basis encourages the development of more constructive dialogue between stakeholders. In line, research projects, involving a wide range of stakeholders, are more likely to identify sustainable solutions than those involving a single interest group. In other words; research projects related to the scientific discipline of veterinary public health will benefit from a cross-disciplinary approach. It is also important to be open-minded about the interactions between management practices at farm level and the spread of contagious diseases, zoonoses and the consequences for public health [5]. Such an approach will eventually improve mutual trust and understanding about the challenges faced by the industry. A useful start to the development of this process is the specialist training offered by the European College on Veterinary Public Health and the active involvement of the industry in the continued education of young veterinarians, *e.g.* teaching at universities or supervising Ph.D.-projects.

Conclusion

There are many inherent challenges in the overall improvement of animal and public health – and resources are scarce. All stakeholders need to contribute to improved collaboration between academia, the industry and veterinary services to identify effective and timely solutions, and to share experience based on their practical working experience.

Acknowledgements

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Animal health surveillance system in the Netherlands

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Abstract

In this paper, we discuss the Dutch Animal Health Surveillance System (AHSS) in which multiple surveillance objectives for livestock are integrated. It is organised by a private organisation and is financed by both public and private stakeholders. The focus will be on the relation between surveillance objectives and components developed to achieve these objectives and the process of aggregation and interpretation of information generated by the AHSS.

Keywords: different surveillance objectives, integrated approach.

Introduction

Public and/or private stakeholders are often interested to have a complete picture of livestock health in certain production systems, regions or country. To achieve this, an overall surveillance system has to combine several objectives, which require different instrumental components as well as well established procedures to aggregate and interpret the gathered information through such an integrated surveillance system. In this paper, we discuss the Dutch Animal Health Surveillance System (AHSS) in which multiple surveillance objectives for cattle, pigs, poultry and small ruminants are integrated. It is organised by a private organisation and is financed by both public and private stakeholders. Our focus will be on the relation between surveillance objectives and components developed to achieve these objectives and the process of aggregation and interpretation of information generated by the AHSS.

Surveillance objectives

The AHSS was developed over a one-year period between 2002 and 2003. During that time, stakeholders and GD-Animal Health Service staff met regularly to define the objectives of the surveillance and to discuss required instrumental components to materialize these objectives as well as to estimate the costs involved. During these discussions, support was given by the food and consumer product safety authority (VWA) and Dutch farmer's organizations.

As a result, three major objectives for the AHSS were decided:

1. Early detection of well known exotic diseases
2. Early detection of new/emerging diseases/ syndromes
3. Description of trends and developments in animal health

Surveillance components

In Figure 1 the objectives and surveillance components are depicted. For the objectives on early detection, two surveillance components were developed. The first component is called "Livestock Watch", "GD-Veekijker" in Dutch. It has a well-known free telephone number and serves as an active helpdesk that responds to questions from farmers and private veterinarians related to animal health. It is manned on rotation by a group of veterinary specialists. These species-specific specialists serve as consultants with a weekly average of about 200 phone calls. The specialists at this helpdesk help farmers and private veterinarians with any kind of animal health-related problem they encounter. Moreover, calls on unexplained health problems may be related to (re)emerging diseases. Therefore, all calls are screened for possible indications of a (re)emerging disease, as for the stakeholders this is the primary objective of the helpdesk.

The second surveillance component that is dealing with the early detection of (re)emerging disease is the GD-AHS gross pathology and veterinary toxicology. Pathologists of GD-AHS conduct the large majority (95%) of all post-mortem examinations on livestock in the Netherlands. All laboratory results are available for further data analysis.

For the objective to record the reference situation and to keep track on trends and changes in animal health over time, three components were developed: prevalence surveys (cattle), analyses of key monitoring indicators (cattle and small ruminants), and sentinel veterinary practices (poultry).

Surveys are carried out to estimate the prevalence of endemic infections (such as BVD virus, BHV1) in dairy and non-dairy herds by repeated biennial studies. Every other year stakeholders decide which endemic infections to monitor based on zoonotic and economical aspects as well as the availability of tools to control the infection. The prevalence results are used as input for simulation models for decision support on alternative control strategies.

The second surveillance component for the description and analysis of trends in ruminant health are the so-called key monitoring indicators (KMI). These KMI are determined by using census data originating from nationally-operating organizations covering all Dutch ruminant herds. The KMI are divided into groups, for example for cattle: durability, herd health, udder health, fertility and metabolic disorders. As with the choices on infections for the prevalence surveys, the stakeholders made the choice for these groups. From these data, monitoring indicators are developed based on census data covering a period of five years and aggregating to quarter-level. Herd numbers are made anonymous to prevent back tracing to individual herds. These KMI are, where applicable, calculated for different herd types.

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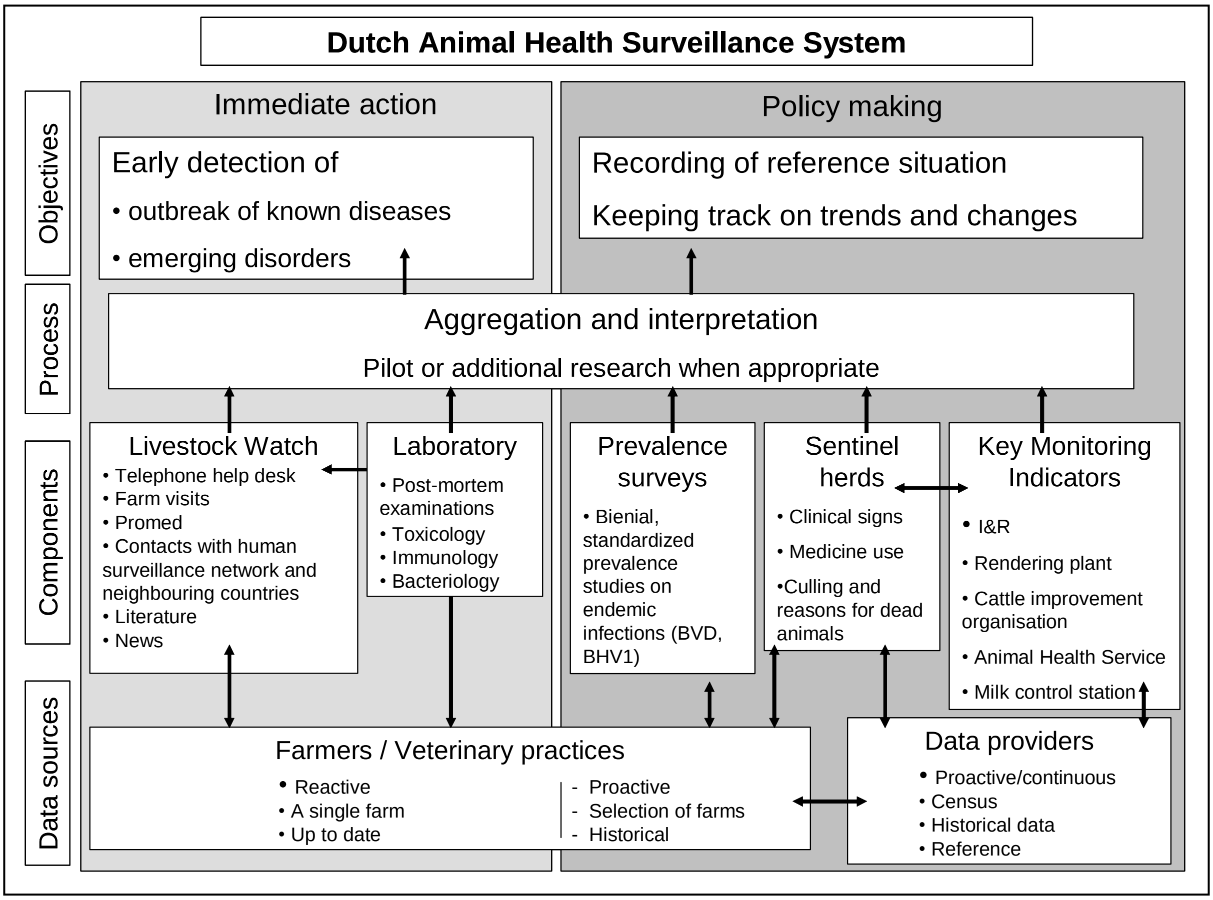
Figure 1: Schematic presentation of the Dutch Animal Health Surveillance System, with lines indicating information flow from input (data sources) to various surveillance components serving the different surveillance objectives



The census data of the participating organizations are not only used as outcome variables (KMI) but additional information is also used as explanatory variables for modelling the KMI. Thus, the best possible predictions of the trends in time of the KMI are obtained.

Aggregation and interpretation of information

After collection of data, aggregation and interpretation of this information is essential to learn its value with regard to the surveillance objectives. There are two types of processes to aggregate and interpret the information from the different surveillance components: formal and informal. Informal discussions are the ones where GD-AHS staff meets randomly as they all work for the same organization in the same building. Although difficult to quantify, the relevance of these informal discussions is probably large.

Formally, representatives (veterinary specialists, pathologists, diagnosticians and epidemiologists) of the surveillance components on early detection meet weekly to discuss the cases that were received. The focus of these meetings is to evaluate the received information in relation to known exotic and new or emerging disease situations. When there is a need for further investigation, either the farms concerned are visited (around 150 visits per year) or a pilot project is initiated (5-10 pilots per year). Both are meant to collect more information (disease history, clinical signs, literature review, *etc.*) to assess the situation.

Every three months, when the results of the KMI analyses are known, the epidemiologists consult with veterinary specialists that are also involved in the telephone service. These discussions inform the veterinary specialists about trends and developments related to mortality, udder health, fertility and metabolic problems while the epidemiologists are informed about cases from the field. These meetings can lead to additional analyses of the census data. In return, epidemiologists are involved in the design of pilot projects for further investigation of clinical health problems.

Routinely, stakeholders are informed about AHSS findings every three months through a meeting of the surveillance steering committee. In these regular meetings, stakeholders are informed about animal health in The Netherlands. Where animal health problems arise, possible intervention options are suggested to the stakeholders to decide. Once again, the role of GD-AHS is to collect, analyse and interpret information where as the stakeholders are in the position to decide on follow-up actions or define changes in policy. When an urgent matter arises, stakeholders are informed by the AHSS manager instantly.

Discussion

The AHSS is an integrated system with both active and passive data collection components. It is possible to operate efficiently because all staff and laboratory is located in one organisation at one location. This facilitates the exchange of findings. In addition, as informal discussions are abundant, it contributes greatly to exchange of information and in-depth discussions on the interpretation of AHSS outcomes.

Another key qualification of the AHSS was to start small and to keep the system comprehensive. For example, the telephone service for passive data collection is a free telephone number manned by veterinary specialists. And the collection of data from national-operating organisations for the calculation of KMI is simply done by sending data on DVDs by ordinary mail. At the start of the AHSS, this choice was made as it was much easier and quicker to establish than building a data warehouse system. By now, it has proven reliable and there is no need to change this routine. As the functionality (and thus the confidence) of the AHSS became established, extensions to the initial framework were made.

For the component of passive surveillance farmers and veterinarians want help with the animal health problem that they encountered and feel confident to share information on disease problems with the veterinary specialists of the GD-AHS. First, these specialists are highly appreciated as knowledgeable animal-health consultants, second they are affiliated with a private instead of a governmental organisation and third, their services are for free. This makes that farmers and private veterinarians are interested in seeking their advice and thus to fuel the passive surveillance component.

In conclusion, the AHSS performs according to the expectations of its stakeholders by executing public activities through a private organisation. It is fundamental for a successful surveillance system to have extensive and accurate passive surveillance through farmers and field veterinarians. Motivating these so called ‘eyes and ears’ of disease surveillance is pivotal. In addition, existing data sources provide useful additional information. The use of census data from different national organisations allows to describe trends and developments for a wide range of ruminant health performance indicators with relatively low input but providing robust reference data on ruminant health in the Netherlands. The sustainability of the AHSS is guaranteed as both public and private organisations contribute to its operation and feel that the information of the AHSS supports their own tasks.

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The Canadian Integrated Program for Antimicrobial Resistance Surveillance: An approach to building collaboration for a voluntary farm surveillance framework

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Abstract

The potential public and animal health impact of antimicrobial use and resistance in food animals is a contentious issue for industry, producers and veterinarians. To build collaboration in the development and implementation of a farm-based surveillance system that protects the biosecurity and confidentiality of data providers requires extensive consultation and transparency. Taking this approach, the CIPARS Farm program developed as a national network of volunteer sentinel swine veterinarians and producers that provides trend data on antimicrobial use and resistance. These data contribute to related animal and public health policies in Canada.

Keywords: collaboration; communication; participatory surveillance; incentives.

Introduction

Antimicrobial use (AMU) in livestock and associated antimicrobial resistance (AMR) has emerged as a significant global public health concern over recent decades. In 1997, the Canadian Consensus Conference on Antimicrobial Resistance provided an Action Plan [1] that outlined several recommendations to contain the development and dissemination of AMR. Among these was a recommendation to establish a national surveillance system to monitor AMU and AMR; the recommendation specified that such a surveillance system include food animal agriculture. Subsequently a report of the Advisory Committee on Animal Uses of Antimicrobials and Impact on Resistance and Human Health prepared for Health Canada recommended the implementation of a permanent ongoing national surveillance program to detect the emergence of AMR in indicator and pathogenic bacteria isolated from animals and food [2]. In response, the Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) was developed as a multi-component framework initiating active surveillance programs in abattoirs (2002) and retail meats (2003), focusing on the core commodities beef, pork and chicken [3]. The CIPARS passive surveillance components, that monitor AMR among human and animal clinical isolates of *Salmonella*, contribute a greater understanding of AMR epidemiology in Canada when integrated with abattoir and retail AMR data, and human and animal antimicrobial use data. However, there were recognized information gaps in CIPARS, specifically, a lack of farm level AMR and end-user animal AMU data.

This paper will describe the approach taken in developing the Farm component of CIPARS including the engagement of industry collaborators and experts, producer and veterinary data providers, to build a sustainable framework considerate of farm biosecurity and confidentiality.

Materials and methods

Initial funding for this surveillance initiative was provided for five years under the Food Safety and Food Quality component of the Agricultural Policy Framework, which is a federal, provincial, territorial and industry action plan for sustainable agriculture in Canada. A CIPARS working group (WG) of veterinary epidemiologists was created to lead the development of a farm-based surveillance program for AMU and AMR that was national in scope. Consultations were conducted with national and provincial commodity organizations and researchers representing the beef, pork and broiler poultry sectors. Information gathered through these consultations directed a decision to pilot the concept of farm surveillance in the swine industry with the following objectives:

- To establish an infrastructure supporting a national surveillance framework for the continuous collection of data on AMU and AMR in Canadian swine herds;
- To describe trends in antimicrobial use in swine herds and antimicrobial resistance in select bacteria from grower-finisher pigs in Canada;
- To assess potential associations among on-farm AMU and AMR in conjunction with targeted research;
- To provide data for human health risk assessments.

A transparent, consultative and iterative approach was taken in designing the surveillance framework (Figure 1). The WG initiated a draft document outlining the essential elements of the surveillance framework [4]. This draft framework document was then circulated to an Expert Review Panel (ERP) with expertise in veterinary epidemiology [4] and pharmacology [1], swine health [2] and production [1], the animal feed industry [1] and public health [1]. Over two review periods, panel members were asked to provide general comments on the framework design moving to specific recommendations on each aspect of the surveillance methodology.

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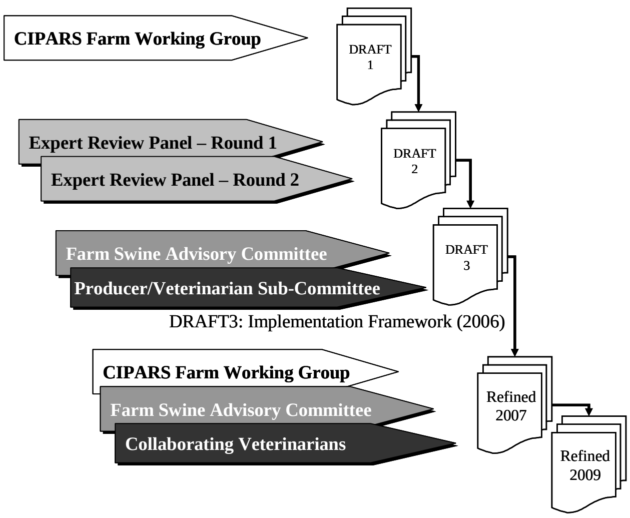
Recommendations from the ERP were provided to a commodity-specific Advisory Committee (AC) for development of an implementation framework. Core members of the AC were swine producers [5], designated by their provincial pork industry organization, representatives from the Canadian Pork Council [2], swine specialist veterinarians [4], and veterinarians from provincial ministries of agriculture [7]. Other members on the swine AC included academics specializing in swine health, epidemiology and pharmacology [4]. Additionally, the AC included a Secretariat with representation from various federal agencies with interests in AMR surveillance: the Public Health Agency of Canada (PHAC) [12], the Veterinary Drugs Directorate, Health Canada [1], the Canadian Food Inspection Agency [3], Agriculture and Agri-Food Canada [1]. In addition, because of an intention of harmonizing with a similar initiative in the US, an expert from the US Department of Agriculture, APHIS, Veterinary Service was included in the AC [1].

A final review of the framework operational logistics was provided by an AC Sub-Committee of swine veterinarians and producers. This Sub-Committee provided direction on sampling protocols and data collection instruments.

Sampling protocols and questionnaire instruments were evaluated using data tracking information and data quality assessments. Subsequent program refinements were made with input from the AC, the Veterinary-Producer Sub-Committee and sentinel herd veterinarians.

Figure 1: Surveillance framework development process



Results

Based on recommendations made during the framework development process, the CIPARS Farm surveillance component was implemented in 2006. The grower-finisher (G-F) phase of production was selected as the livestock class of interest, because of its proximity to the consumer

At implementation the surveillance network consisted of 108 sentinel G-F swine operations and 29 swine veterinarians in each of the major pork producing provinces: Québec, Ontario, Manitoba, Saskatchewan and Alberta. The number of sentinel sites was distributed across the provinces in proportion to each province's contribution to the number of G-F operations nationally. Supplemental provincial funding from Alberta (2007-ongoing) and Saskatchewan (2006-2007) provided 10 additional sites in those provinces.

Sentinel veterinarians were purposively selected from provincial sampling frames of swine practitioners. Veterinarians who agreed to participate were contracted by PHAC to recruit and enroll sentinel farms, and to conduct sampling visits. Contracts provided monetary compensation for veterinarians and producers for each visit. Two supervisory veterinarians were also contracted to protect the confidentiality of data from corporate (vertically integrated) sentinel sites.

Each veterinarian selected candidate herds according to set inclusion/exclusion criteria that would provide a national network of sentinel sites representative of production systems that are typical of the Canadian pork industry [5]. On enrollment veterinarians and producers signed an informed consent document, which in outlining collaborator roles and responsibilities indicated that the veterinarian would hold herd identity codes confidential. On-going sample and questionnaire data collection is conducted by veterinarians on sentinel farms according to set protocols.

Each sentinel site was sampled three times per year to reflect pig flow dynamics through G-F units. On each sampling visit, composite fecal samples were collected from two pens of close-to-market (CTM) pigs (>80 kg). A questionnaire was completed by the veterinarian and producer to collect data on antimicrobial use, animal health, biosecurity practices, herd demographics and pig inventory. Approximately half of the enrolled herds also sampled pigs on arrival to the G-F unit once per year.

Samples were submitted to provincial (Alberta and Saskatchewan) and PHAC laboratories for primary isolation and susceptibility testing of generic *Escherichia coli*, *Salmonella* and *Enterococcus*. The Sensititre® Microbiology System (Trek Diagnostic Systems, Cleveland, OH, USA) and the National Antimicrobial Resistance Monitoring System (NARMS) Public Health plate configuration are utilized for susceptibility testing.

Data management and analysis is conducted by the CIPARS Farm Program and consultant epidemiologists. Descriptive surveillance findings were reported in the CIPARS Annual Reports [3] and peer-reviewed publications [5]. Herd-specific reports of 2006-2008 data were provided to collaborating veterinarians and producers.

Data are tracked on a weekly basis. Surveillance methods and data quality are reviewed and assessed by the WG annually. Program refinements are made in consultation with the AC, external epidemiologists and sentinel veterinarians.

Participation in this voluntary program has been consistent since implementation with little variation in submissions beyond that related to program refinements (Table 1).

Table 1: CIPARS Farm Swine program summary by year

	2006	2007[1]	2008[2]	2009[3]
Veterinarians	29	29	29	26
Herds	108	108	108	98
Samples	462	612	483	698
Questionnaires	79	173	232	177
Salmonella isolates	94	110	61	124
E. coli isolates	2,197	1,575	1,425	1,800
Enterococcus isolates	867	985	1,266	1,704

1 Saskatchewan funding for additional 10 herds ended in Dec. 2007;
2 Discontinuation of arrival cohort sampling;
3 Revised sampling: 6 close-to-market pens sampled per sentinel site once per year.

Discussion

The success of this national farm-based surveillance program for AMU/AMR depended greatly on extensive consultation and transparency given the contentious nature of these issues in food animal agriculture and their potential public health impacts, and that data provider participation was voluntary. Preliminary consultations with commodity groups and provincial Ministries of Agriculture and Food provided information that led to the decision to pilot this surveillance program in swine. The Canadian swine industry had a mature certified on-farm food safety and quality assurance program (CQA®), and this commodity had not experienced a recent foreign animal disease outbreak, unlike the beef (BSE, 2003) and broiler poultry (Avian Influenza, 2004) sectors. Also the United States, a major trading partner in this commodity, had launched a similar surveillance system in swine [6].

The engagement of a commodity-specific ERP and AC ensured the surveillance infrastructure would be practical, efficient and effective. Involvement of national and provincial industry organizations and government agencies in the development phase of this surveillance initiative ensured timely and transparent communications to constituents. Major concerns for industry were related to time management, farm biosecurity, data confidentiality and the dissemination of surveillance findings.

Producer members of both committees identified veterinarians as the primary candidate group to manage and conduct surveillance field work for this program. The herd veterinarian was viewed as a trusted professional who could execute surveillance protocols in a bio-secure and confidential manner. Insight by herd veterinarians on animal health status and herd-level AMU provided an additional advantage to a "sentinel vet" model. Collaborating veterinarians have also played a key role in the development and refinement of surveillance instruments.

There is no legislated mechanism in Canada that facilitates the collection of antimicrobial usage surveillance data from the pharmaceutical industry, feed and farm supply retailers, veterinarians or producers [2], although since 2006 the Canadian Animal Health Institute has been voluntarily providing non-species specific veterinary antimicrobial distribution data aggregated to antimicrobial drug class [3]. Given the volunteer nature of this surveillance system, members of the AC recommended that producers and veterinarians be compensated for the time required to complete the detailed questionnaire. Situations where payment for data is appropriate and effective are limited [7] but there is evidence for the importance of monetary compensation in sustaining the participation of data providers in this particular surveillance program. Through 2009-10 there were significant declines in hog prices, slaughter volumes and exports [8]. In the face of this significant down turn in the Canadian pork industry, the CIPARS Farm program continued with minimal erosion in the number of sentinel sites. The importance of compensation in maintaining on-going surveillance operations was also supported by comments provided by collaborating veterinarians.

The sustainability and relevance of a surveillance system is a function of its methodological and operational flexibility and responsiveness [4, 7]. Refinements made during the implementation year were in response to poor questionnaire compliance and data quality. Further refinements were made for the 2009 sampling year based on variance component analysis, which indicated little temporal variation. Sampling protocols changed from two pens sampled per sentinel site three times per year to 6 pens sampled per sentinel site once per year, and revisions were made to further simplify the questionnaire.

Industry concerns regarding the reporting of surveillance findings were addressed through the development of a communications plan that provides notification to core AC members prior to publication. Oversight of data management and analysis is provided by the WG; other than input from experts on the utility of different parameters in presenting data, industry is not involved in data interpretation or reporting.

In meeting its objectives, the Farm surveillance program provides AMU and AMR data that can be integrated with data and findings from the other components of CIPARS to inform animal and public health policies related to antimicrobial use and food safety.

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Formal and informal surveillance systems: how to build bridges?

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Abstract

Within the framework of highly pathogenic avian influenza (HPAI) surveillance in Vietnam, interviews were carried out with poultry breeders and local animal health operators in 2 communes of the Red River Delta (RRD) with a view to documenting the circulation of sanitary information concerning poultry and the economic and social incentives for disseminating or withholding information. The main results demonstrate that [1] active "informal" surveillance networks exist, [2] the alert levels vary and the measures applied by the breeders are myriad and often far-removed from the official recommendations and [3] the commune veterinarian represents an interface between the formal and informal systems.

Keywords: Surveillance, influenza, socio-anthropology, Vietnam.

Introduction

Against a backdrop of growing emergence or re-emergence of sanitary problems, surveillance has become an essential tool of international sanitary governance: "*without well-functioning surveillance and reporting systems, we are stuck*" declared Dr D. Nabarro, United Nations System Influenza Coordinator [1], in 2009. In the case of animal health, numerous problems are associated to the low level of breeders' participation in the surveillance networks and their reluctance to implement recommended biosafety measures [2, 3]. We thus occasionally call on the social sciences to explain this fact based on individual perceptions and local cultures. These disciplines are nevertheless somewhat unwilling to be made the tools of the normative procedures underlying these calls and are reluctant to participate in the associated education projects (modifying perceptions by means of "awareness") of social groups deemed to be poor implementers of strategies defined by the actors of the public area (veterinary services, international community, *etc.* in the present case).

The study presented here is the result of collaboration between the fields of socio-anthropology and epidemiology. Socio-anthropology, as reflected by the works of J.-P. Darré [4] is called upon initially to identify the operators' practices and rules governing these practices and to understand the specific rationales underlying them. In the context of the present study, it is a question of analysing the dynamics at work to assess and confront the sanitary risks in a community of breeders. Particular attention is paid to the role of sanitary information produced and circulating locally. These results are then discussed from an epidemiological standpoint: comparing the reasoning of the breeders with the rationales of the parties responsible for implementing national or international surveillance networks.

In Vietnam**,** at present, the breeders have to declare cases of HPAI (as well as cases of porcine reproductive and respiratory syndrome – PRRS – and foot and mouth disease). These declarations must be made to the commune veterinarian who then refers them to the local authorities, the communal People's Committee. From the committee, the information has to be sent to the district authorities, and then to the provincial authorities and finally to the Ministry of Agriculture. Theoretically, confirmation of the existence of one of these diseases leads to the zone being placed in quarantine and the animals may be culled. This action is accompanied by compensation measures, officially variable over time and place, and for which operational implementation is somewhat unclear.

Materials and methods

Our study examines two communities of breeders on the front line of the fight against the emergence of sanitary problems: the poultry breeders of two communes in the RRD in Vietnam facing HPAI outbreaks.

The choice of the communes studied was dictated both by the importance of poultry breeding in the local production systems and by familiarity acquired with farmers and local authorities during previous research works. These two communes will be referred to as A and B. Commune A, highly specialised in poultry breeding, is located in one of the provinces early and seriously affected by the H5N1 virus when it appeared in Vietnam in 2003 and 2004. However, since then no outbreak has officially been declared in this province. In the province where commune B is located, outbreaks have regularly been declared during the subsequent epidemic waves.

The breeders in these communes breed poultry (chickens, ducks and Muscovy ducks) by combining different production systems (meat, eggs and chicks). While certain breeders have relatively "large" farms in the local context (more than 500 heads), the vast majority of breeders work on a more limited scale (100-400 heads). We eliminated from our study families with only a small number of poultry primarily intended for home consumption.

In 2010, we interviewed 19 breeders as well as commune veterinarians (private veterinarians with a public mission) and veterinary drug sellers working in the areas concerned.

The interviews dealt with the circulation of sanitary information concerning poultry: content of the information; method, scope and speed of circulation;

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actors involved; actions triggered as a result of the information received; the economic and social incentives for disseminating or withholding information and for treating animals; the role of the veterinarians, *etc.* The interviews were recorded and a written interview sheet was produced for each interview.

Result

Active "informal" surveillance networks

The first observation from our interviews is that an informal sanitary information network exists. The information circulating within this network concerns the symptoms observed on different farms (mortality, diarrhoea, *etc.*); it does not relate exclusively to poultry but also to pigs, common in this area. It also includes technical economic information (prices of animals and inputs, breeding techniques, *etc.*). It is shared between neighbours and parents, on markets and during encounters with other breeders in the veterinary drug store. According to the breeders, the volume of sanitary information circulating since the appearance of avian influenza has increased.

What we call here the *breeders' epidemiological territory* (which we define as the radius within which the information is considered useful by the breeder and may trigger the implementation of measures on his own farm) is nevertheless limited (from 500 m to 3 km). The information relating to more remote farms, which nevertheless share the same stakeholders for feed or chicks supply, do not seem relevant by the breeders interviewed, showing that they consider the disease dissemination more by proximity than by the value chain.

The breeders claim to be satisfied by this informal network (nature, scope, speed, reliability). They judge the information issued from this network more useful than that disseminated by the veterinary services by the loudspeakers placed in residential areas and through the intermediary of the commune veterinarians because it is considered to arrive late and to be too general in nature.

It is interesting to note that the breeders clearly distinguish two types of information: (a) information relating to common diseases (for example Newcastle Disease, *Ga Ru* and Gumboro Disease, *Gum*), which the breeders feel they can control (even if they cause numerous deaths) and (b) information concerning new diseases or symptoms with regard to which the breeders feel powerless to act. PRRS falls into this second category. However, while HPAI belongs to this category in commune B, this is not the case in commune A. How can this be explained?

A variable alert level and differing measures, often far-removed from the official recommendations

In commune A, breeders mention frequent cases of avian influenza among their entourage. These events would appear to be a part of the breeders' routine; they believe that they are capable both of clearly identifying HPAI cases (in particular due to the speed at which mortalities occur) and of coping with them. However, the criteria used to identify the disease vary considerably from one person to the next. There is no fear of possible consequences for human health and the measures taken by the breeders are essentially aimed at protecting the health of their animals and limiting economic losses: the breeders can thus decide to anticipate the date of the booster vaccination against avian influenza (the poultry vaccination seems to be common practice except in backyard farms), to increase disinfection measures in the poultry pens and their immediate surroundings and to limit their own movements. The animals can also be given vitamins and various supplements. However, this information can also trigger destocking measures if the animals have a commercial value: to avoid potential losses, the farmers sell broilers close to their sale weight or laying hens close to the end of their production life. Animals which are already infected or dead are often sold (to the usual collectors) even if the prices are very low. We thus see that numerous measures are taken by the breeders (and that, in their own way, they act as risk managers), but that the main measure officially recommended is not mentioned, i.e. report to the commune veterinarian. According to the breeders themselves, they feel confident that they can manage this situation : "*with experience; we have succeeded until now in controlling the extent of the epidemic with outbreaks here and there, so there is no need to inform the district or the province*" explained one breeder. This is even more so the case as they consider the public sector veterinarians (including the commune veterinarian) to be incompetent. On the other hand, the breeders are more willing to consult veterinarians in the private sector who give them medicines and advice. Furthermore, there is nothing to indicate that the breeders concerned are trying to evade administrative authority or social control by hiding sanitary events. This is supported by two facts: first because, in their own words, it is important for breeders to provide each other with information in order to be protected and, in any case, it would be impossible to hide a massive number of animal deaths in the context of very close living conditions of Vietnamese villages. Second, because these cases only rarely result in the implementation of restrictive measures by the authorities.

In commune B, however, breeders indicate no cases of avian influenza other than the last cases officially declared in 2007. The breeders therefore have only a very limited experience which would explain why avian influenza is referred to as a new disease which is dangerous to people and with regard to which breeders feel powerless to act. The breeders state that in the event of new cases, they would immediately inform the commune veterinarian as they would not know what to do.

The commune veterinarian, an interface between the formal and informal systems

Despite apparently playing a limited role in the local information networks, the commune veterinarians nevertheless claim to be well informed of the sanitary situation of the farms, in particular via the drug sellers who are at the heart of the information circulating within the commune and a have no problem about sharing the information. So why are there not more control measures or official declaration in this commune? In all probability, it is the result of economic considerations as the province is an important source of poultry and chicks for the capital Hanoi and the Northern provinces. The drug seller admits that it is important to give the breeders the chance to sell their animals before taking the matter to the next level. Similarly, the People's Committee would also appear to exercise its own judgement concerning the speed at which the information is to be communicated in the official network. Furthermore, while the breeders claimed several times to be sure of their own diagnoses, the commune veterinarians pointed to the fear to launch a false alarm which would discredit them in the eyes of their superiors.

It can therefore be seen that the logic of the commune veterinarian, and probably of the local authorities as well, is primarily to temporise. This does not enter into conflict with the rationale of the breeders. In this way, the commune veterinarian has found a compromise between the position of the breeders and the demands of the official system, acting as an interface between the two.

Discussion

From an epidemiological point of view, if we consider the objective of monitoring and controlling the disease, the situation described reveals numerous obstacles to a fully operational national HPAI surveillance system in a context where the disease has become endemic.

From the point of view of surveillance, the cases recognised as HPAI would appear to take varying forms depending on the actors and their experience. It would appear that the breeders keep a *case definition* close to the outbreaks experienced before the vaccination starts, involving massive and sudden mortalities, and cannot imagine that the disease can take a different form among a partially immunised population. The epidemiology of the disease therefore changes more quickly than the knowledge of local breeders. Similarly, in a national context which aims to identify and index every case, the logical strategy would be to adopt a sufficiently sensitive case definition. However, at local level, key actors – the commune veterinarians– only trigger an alert when they are absolutely sure of their clinical diagnosis, which can nevertheless prove to be problematic for this disease in certain contexts.

From the point of view of control, a local body of knowledge was quickly created within this breeders' community focussing on the recognition and monitoring of outbreaks of what, rightly or wrongly, they associate to HPAI. This knowledge, which we could compare to that of the experts in order to assess its real efficiency, corresponds to a means of managing an endemic disease. This is out of step with the crisis management approach still applied by the government, in particular in response to pressure from the international community [5]. This discrepancy between control policy, the current epidemiology of the disease in certain areas and the vision of the local actors hampers the constitution of expert knowledge, primarily because the sanitary information relating to this disease remains sensitive.

If the breeders do not necessarily see any interest in declaring cases as they feel confident in their management approach, do they nevertheless feel any obligation? The *legal framework* governing the incentive or obligation to report suspected cases of regulated diseases is a pivotal question in a surveillance system. In the case of a commune where the disease is no longer exceptional, the only incentive to declare a case would appear to be the social incentive to inform neighbours so that they can protect themselves. It is rarely a question of a legal obligation. While it exists and is recognised (the breeders know that they are supposed to inform the commune veterinarian), the regulatory incentive framework is ineffective. However, in the case of commune B where the disease is still an exceptional occurrence and the breeders have yet to learn how to manage it themselves, the commune veterinarian would appear to be the favoured contact partner to whom they turn. Consequently, while the surveillance system is based on the declaration of specific diseases or syndromes, the breeders identify levels of "seriousness" and "loss of control" which justify recourse to the commune veterinarian and thus to the official system.

Finally, the local objectives do not always appear to correspond to the national objectives of the surveillance and control system. Locally, it would seem that a balance between the economic interests of the commune and the control of the disease is reached. The objective being to keep the disease to a level considered to be acceptable by the operators. Our study was unable to clearly identify this level, although it would appear to correspond to outbreaks capable of causing high mortality rates but the progression of which is contained or diminished. At the central level, an accurate estimation of the disease prevalence throughout the entire territory is a key element for the assessment of control policies. However, local management of cases using criteria defined locally gives a biased vision of the real epidemiological situation.

In conclusion, the commune veterinarians, who represent the interface of the two systems, must therefore reconcile the technical demands of the ministry which they represent with the political and economic requirements of the local authority (under whose direct control they fall) and with the individual rationales of the breeders. As repositories of valuable sanitary information, they should be given more responsibility in their role by their technical superiors while following a more comprehensive professional training with a view to increasing their legitimacy vis-à-vis the local operators.

With regard to the breeders it would appear necessary to accompany them in redefining the risk, in particular by providing them with more information concerning the sanitary risk linked to the value chains. This could thereby extend their epidemiological territory and the number of operators to whom, professionally speaking, they feel committed.

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A Holding-Level Simulation Applied to Surveillance of Classical Scrapie in Great Britain

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Abstract
A simulation framework was used to assess the performance of flock-level scrapie surveillance in Great Britain. Foremost in our investigation was evaluating the ability of existing surveys to detect a change in scrapie prevalence, the costs to government for surveillance as existed in 2006/7 and for appropriate and feasible alterations.

This simulation suggests that sampling dead-on-farm sheep appears to be the most effective form of targeted surveillance.

Keywords: classical scrapie, surveillance, evaluation, optimization, simulation.

Introduction
In Great Britain, the surveillance for scrapie, a fatal prion disease of small ruminants, constitutes a complex system with multiple surveillance streams/sources. The aim of the surveillance effort is to inform eradication policies. Surveillance must remain sensitive to detect progress towards the eradication goal.

A second primary surveillance attribute is cost. Given the low prevalence of scrapie in the country, the cost of the surveillance effort is considerable and requires regular assessment. The combination of multiple surveillance sources that target different populations and provide conflicting evidence [1], the need to consider alternative approaches, possibly more efficient, and the number of parameters of interest and possible combinations make the optimization of surveillance a complex exercise. Simulation frameworks provide a flexible means of studying the behavior of complex systems such as the surveillance of scrapie.

This paper describes a stochastic simulation to assess the performance of holding-level scrapie surveillance in Great Britain. Principally, we evaluate the ability of the existing surveillance to detect a change in scrapie prevalence and recommend alternative and more efficient surveillance sources.

Materials and methods
The model is made up of demographic, disease and surveillance modules. The demographic module allocates region and flock size to sheep holdings, which are the unit of interest. The disease status of the holdings was drawn from a logistic regression of region, flock size and breed from records of scrapie notifications and postal surveys of scrapie [2]. Holding and within-holding prevalence distributions were inputted at this stage.

The surveillance module replicates the four existing surveillance sources for scrapie in Great Britain at the levels of sampling and submission of 2006: fallen stock (FS), abattoir survey (AS), the dead-in-transit sheep (DIT) and the Scrapie Notifications Database (SND). The input of the surveillance module was the annual probability for a holding to be sampled and its output the annual number of holdings sampled and detected scrapie positive by each surveillance source. Annual reductions in holding and within-holding prevalence distributions were simulated to assess the ability of the surveillance stream to detect them.

Overall costs for each surveillance stream, costs per sample and costs per detected holding were calculated and compared with those of alternative sources of samples, in particular the National Fallen Stock (NFS) scheme, a non-subsided collection of dead-on-farm-sheep.

Result
The simulation replicated the demographic and geographical biases identified by the analyses of actual surveillance data. The simulated FS was the only source capable of detecting an annual decrease in sheep-level prevalence, but at a minimum of 75% (equivalent to a 50% decrease in both holding and within-holding prevalence) with 95% confidence. Our simulations showed that only 7% of infected flocks reported to the SND, the stream which historically has led to the greatest number of scrapie infected flocks being detected. The overall sensitivity of surveillance was 7.4%; in other words, every year only one in every thirteen infected holdings in Great Britain is detected under the assumptions of our model.

The FS had the highest mean cost per sample tested, at £228/sample. However, the AS had the highest cost per infected holding detected, estimated at over £700,000. The FS, at a cost of £196,279/detected holding, was 3.6 times, and the DIT 14.4 times, more efficient than the AS per pound spent on detecting infected holdings. The NFS scheme reduced the cost per sample to £184, a saving of 24%, whilst maintaining the sensitivity of the FS.

Discussion
Sensitivity analyses showed that the key to understand the ability of the surveillance to detect change over time is the interaction between sheep and holding level prevalence, via the within holding prevalence. The flock-level sensitivity of targeted surveillance decreases if within-flock prevalence declines. Sampling higher risk holdings, without targeting high risk sheep would be ineffectual due to the low within holding prevalence of classical scrapie in British flocks. Priority should be given to the sampling of dead or wasted animals.

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Considering in combination the cost per detected flock, accuracy and precision of the estimated flock-level prevalence, and the ability to respond to changes in true prevalence, the FS appears to be the most effective form of targeted surveillance. Our simulation suggests that resources should be shifted towards the FS, in particular, towards schemes that allow planned targeting of holdings and high risk sheep within, *e.g.* dead. The NFS scheme appears to fulfill both requirements.

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Tool for Assessment of Intervention Options (TAIO): An Example of Decision Support for Surveillance

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Abstract

Time constraints in disease outbreaks can force policy decisions before a thorough analysis can be completed. Decision makers are then faced with the equally bad alternatives of making an uninformed decision or taking no action in the front of an emergency event. A multi-disciplinary group of analysts at the USDA, Animal and Plant Health inspection Services (APHIS), Veterinary Services (VS), Centers for Epidemiology & Animal Health (CEAH) have developed a decision support process for comparing disease intervention and surveillance options utilizing the best information available within the short time-frame allowed for the decision. Termed the 'Tool for Assessment of Intervention Options', the TAIO decision support process utilizes subject-matter experts and available data to predict the epidemiologic and economic benefits and costs of disease management, surveillance or response actions. The TAIO output provides a weighted benefit cost (wBC) ratio accompanied by the breadth of uncertainty tied to the decision. We describe TAIO using an example of surveillance options for an outbreak of Contagious Equine Metritis Organism (CEMO).

Keywords: Disease Surveillance, Decision Support, Contagious Equine Metritis, Value of Surveillance.

Introduction

In public and animal health, disease outbreaks may unfold rapidly and relevant information for decision-making often spans multiple disciplines, including economic, epidemiologic, and logistic factors. In these situations, the need for decisions may precede a solid empirical basis for their support [1]. We describe a decision support tool wherein relevant information is incorporated into a relatively simple simulation model to compare predicted decision outcomes and capture inherent uncertainty. Termed the 'Tool for Assessment of Intervention Options', the TAIO decision support process utilizes subject-matter experts and available data to predict the epidemiologic and economic benefits and costs of disease management, surveillance, or response actions. The TAIO process is designed to reduce complexity while ensuring transparency in evaluation of actions under consideration. Political or social impacts are not a part of TAIO, although they may play a role in the decision-making process. Thus, TAIO informs, but does not determine decisions about the most efficacious, feasible, and cost-effective approach to disease management. We describe TAIO using an example evaluation of surveillance options for an outbreak of Contagious Equine Metritis Organism (CEMO) in the United States (U.S.).

On December 15, 2008 the CEMO was confirmed present in the United States. APHIS-VS began the process of conducting an epidemiologic investigation with the intent to trace all infected horses and achieve disease eradication. Epidemiological considerations for CEM include the following points. It is a highly contagious venereal disease of equids that mainly manifests as reproductive disease in mares [2]. Infected stallions are the most frequent source of new infections [2, 3]. No effective vaccine is available to prevent infection with CEM [4]. Treatment may successfully remove the organism although infertility may persist for some time. It is perhaps most relevant to the thoroughbred industry where delayed birthdates of foals can impact racing success and artificial insemination is not routinely practiced; however, this outbreak was primarily in other breeds. Finally, cost of testing and treatment are high; and trade restrictions may apply.

By May of 2009, a total of 19 stallions had been confirmed and the federal funding allocated for the response was running short. VS requested the CEAH TAIO group to assess the cost effectiveness and scientific validity of the eradication effort and to consider alternative surveillance options provided by the APHIS-VS National Center for Animal Health Emergency Management (NCAHEM). Options included the following:

- Option 1: Suspend the federal outbreak investigation and response And allow the equine industry to deal with the disease through a proposed industry code-of-practice involving routine testing of at-risk stallions and mares.
- Option 2: Complete the federal outbreak investigation. In addition, use data from export and owner requests for testing as further evidence that the introduced CEMO had been successfully eradicated from the United States.
- Option 3: Complete the federal outbreak investigation by tracing and accounting for all exposed and infected animals. In addition, fund a survey of horses not associated with the investigation to augment evidence that CEMO was eradicated from the full breeding population.

Materials and methods

The TAIO process predicts the epidemiologic and economic success of disease response options as a success-weighted benefit cost ratio (wBC) describing, in this case, the relative value of the surveillance options. The basic equation of the model is: P(success)* benefits/costs.

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Benefits are modeled to describe the net benefit likely achieved by fulfilling the objectives of the option. Costs are derived from basic cost accounting procedures. The success weight represents the likelihood of achieving disease control taking into account the uncertainty around a series of factors. These include epidemiological control factors such as testing sensitivity, success of disease tracing, success of treatment regimens, characteristics of the agent, and transmission pathways. Feasibility and projected compliance with proposed solutions are considered in the derivation of epidemiologic success.

The outcome of disease control is defined at the start of the analysis, and generally is structured to reflect the option's potential to achieve eradication, prevent disease spread, or demonstrate disease freedom in a particular species, sector, or region. For CEMO, demonstration of disease freedom was the chosen benchmark of success. To demonstrate CEMO freedom, the TAIO team evaluated each option's likelihood to: 1) achieve disease eradication and 2) provide sufficient evidence to demonstrate freedom to international trade partners.

The TAIO process depends upon iterative discussion and data analysis. Interviews with decision makers are conducted initially to define options and objectives. This interface is critical in that neither policy makers nor technical experts have the full spectrum of disease, budget, and political knowledge to establish the best options for resolution of the issues at hand. Model parsimony is considered critical to efficient, timely, and transferable decision support. Consequently, at each stage of the model building process, TAIO aims for a minimal, yet sufficient, set of relevant factors and predictive relationships. Where data are available and sufficient, parameters are estimated empirically. Where data are lacking or analyses are incomplete, expert opinion is elicited. Available data and expert opinion are then combined to populate a joint probability model predicting epidemiologic and economic success of proposed management options. Data sources and uncertainties are tracked. The resulting TAIO model is run on stochastic simulation software (Palisade @Risk) to incorporate uncertainty in parameter estimates. Quantitative results provide a wBC for each proposed option and potential disease scenario.

The CEMO model took the following form: Epidemiologic success was the joint probability of effective eradication and effective demonstration, i.e., the probability of 1) completion of the outbreak investigation to justify freedom within the contact network of exposed animals, and 2) sufficient surveillance to demonstrate disease freedom outside of the contact network of exposed animals. Detected infected animals were effectively removed from the breeding population until proven cleared. However, non-detected infected animals were also subject to some measure of control. This is because large sectors of the industry utilize artificial insemination, mares typically self-clear the infection with time, semen extenders contain antibiotics that partially or completely inactivate the CEMO, and best practice biosecurity measures substantively limit spread through semen collection and artificial insemination equipment. Consequently, 'detected infected' and 'un-detected infected' breeding animals were assessed separately. The probability of disease control depended on a series of joint and conditional probabilities describing the predicted compliance, efficacy, and extent of disease control measures available for detected, and undetected-infected breeding stallions. Costs were derived for each option separately. Uncertainty was tracked throughout the process. However, to simplify discussion, only expected values are described in this summary.

Result

The predicted ability to control CEMO did not vary widely between options. This is due to the self-limiting nature of the organism in mares and the routine use of antibiotics in semen extenders. Stallion to stallion transmission is reduced through standard biosecurity practices. Consequently, though the 'detected infected' sector was predicted to achieve better control than the 'non-detected infected', the predicted difference was minor and related in part to the level of expected compliance. Similarly, federal and non-federal surveillance efforts to identify infected animals differed principally in their costs and level of expected acceptance from external trade partners. The economic benefits of CEMO demonstration of freedom were described as the testing costs avoided in export to countries (*e.g.*, Mexico and Canada) which previously recognized the U.S. as free from the CEMO. These costs were approximated at 44 million USD per year. Additional economic impacts to the industry could result from disruption of the breeding season, a factor of greatest relevance to the thoroughbred population. However, the described CEMO outbreak was centered on other breeds.

Expert predictions and existing patterns of detection suggested there were likely additional infected and undetected stallions within the network of epidemiological traces. Completion of the outbreak investigation was estimated to result in a mean of 24 infected stallions that in turn, would generate an additional 1,234 traces. The cost of completing the investigation would be approximately 5.9 million USD. We were 95 percent confident that the number of traces would not exceed 1,800 and the cost would not be above 8.2 million USD. Suspending the outbreak investigation could lead to an endemic disease situation in the United States. Completing the outbreak investigation; however, would not generate sufficient evidence of disease freedom in the horse population outside the investigation network. Consequently, the most successful option combines evidence of control of the existing outbreak with evidence of lack of disease spread outside the known exposed network. The latter could derive from export and voluntary owner testing data, or could derive from additional surveillance.

The horse breeding industry considered adopting a "Code of Practice" based on a similar program applied in the United Kingdom. This voluntary Code of Practice would aim to test all breeding horses before each breeding season. Initial laboratory capacity, however, would only allow testing of 23 percent of the breeding population. A scaled-down version of an industry-operated "Code of Practice" might test only stallions and high risk mares; The current laboratory capacity would be able to handle this volume of samples. However, benefits would only accrue for either alternative if APHIS had oversight over the program, thus enabling it to issue an official declaration of disease freedom to international trading partners. APHIS was not considering instituting or overseeing a program for CEM, therefore the wBC ratio for this or other surveillance without APHIS oversight collapse to zero. Administering a Federal/State/Industry cooperative surveillance program or surveillance oversight could improve this situation and return the value of this factor in the model.

The level of testing conducted for export and owner requested testing at the National Veterinary Services Laboratories (NVSL) already indicated with 95percent confidence that the prevalence in the population outside the current investigation did not exceed 0.2 percent. Assuming that trading partners would accept this as sufficient evidence of disease freedom, the wBC ratio for a completed outbreak investigation coupled with evidence for disease freedom derived from available testing data would be 6.4. If trade partners viewed available evidence as insufficient, wBC would drop to zero. The analysis estimated that an additional 2,000 samples at a cost of 800,000 USD would be needed to achieve 95percent confidence for declaration of disease freedom at the NCAHEM-defined prevalence threshold of 0.1 percent.

Consequently, the TAIO process identified Option 3 as the most effective approach. Option 3 completes the federal outbreak investigation, utilizes available testing data, and also conducts an additional survey to demonstrate disease freedom for the population of breeding horses not connected to the known exposed network. This option is an efficient approach to disease control and also provides what we consider to be sufficient evidence with which to document disease freedom. The wBCA ratio of this option is 5.7. While this figure is lower than the one discussed above, it provides greater assurance that trading partners will accept the evidence of disease freedom. In comparison, alternative options scored as being either inefficient in disease control or relatively unreliable in demonstration of disease freedom for trade partners.

Discussion

The TAIO process provides transparent, science-based support for time-sensitive decisions, and predicts the success of disease control options given available empirical and expert knowledge and uncertainty. Scores depict risks and benefits associated with each option. The process also identifies parameters with the greatest uncertainty and impact to target for further investigation. The decision maker can then review the supporting information, estimated values, and consider the uncertainty to inform a decision.

Stopping the CEM outbreak investigation without further expenditure was an appealing decision to budget conscious decision makers. However, TAIO identified Option 3, completion of the outbreak investigation coupled with a national surveillance effort, as the preferred option. This option combined a high probability of disease control with high feasibility of implementation, high cost efficiency, and the opportunity to document disease freedom. Based on the TAIO evaluation, this was APHIS VS' final conclusion on preferred investment of federal funds.

Herodotus, in 450 B.C. supposedly provided council that the "best" answer may ultimately prove to be incorrect, but is still the appropriate choice given consideration of all evidence available at the time. TAIO provides a framework for a structured evaluation of available evidence and informs a "best" decision based on that evidence. It results in a standardized, methodical, and repeatable format for comprehensive interim analysis of situations requiring rapid solutions. The iterative nature of the TAIO process allows revision of results as new or better information becomes available. While a longer in-depth analysis may provide a more certain answer, and new information could even support a different answer, TAIO results are available within the time frame pertinent to the emergency or decision at hand, and shift a relatively uninformed decision to a "best" decision.

Though structured for time-sensitive decisions, the TAIO process can also form the analytical approach to guide complex decisions that are not as time-critical and provide support for selection of disease intervention options, or modifications to an existing disease control response. The CEM outbreak is one example.

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Economic Evaluation of Avian Influenza Virus Surveillance in Switzerland

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Abstract

The aim of this project was to explore the potential of cost-effectiveness analysis (CEA) as a method to advice policy makers on the economic value of Avian Influenza Virus (AIV) surveillance in Switzerland. A qualitative risk assessment approach was used to assess the impact of surveillance on the transmission and spread of AIV in Switzerland. The effectiveness of surveillance was expressed as the difference in defined probabilities between a scenario without surveillance and a scenario with surveillance. The probabilities investigated were probability of i) transmission of Highly Pathogenic AIV (HPAIV) from wild birds to poultry, ii) mutation from low pathogenic AIV (LPAIV) into HPAIV in poultry, and iii) transmission of HPAIV to other poultry holdings given a primary outbreak. The cost-effectiveness ratio was the difference in costs (ΔC) divided by the difference in probability (ΔP). Our results indicated that surveillance in both wild birds and poultry did not change the probabilities of primary and secondary AIV outbreaks in Switzerland. This may partially be due to a low sensitivity of the qualitative assessment. The over-all surveillance costs were estimated to be 31,000 €/year, which reflect the value policy makers attribute to non-monetary benefits. The results further suggest that measures aimed at increasing disease awareness among backyard poultry holders may reduce the probability of secondary outbreaks in backyard holdings given a primary outbreak. The proposed approach was shown to be practical and transparent and able to help policy makers understand the impact of surveillance, prevention and intervention measures on AIV disease dynamics.

Keywords: Economic evaluation, cost-effectiveness analysis, Avian Influenza.

The full text of this paper will be published in a special edition of Preventive Veterinary Medicine.

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Collating information about developments in surveillance methods to improve the efficiency of animal health surveillance

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Abstract

This paper describes a system that we have developed to collate and distribute information about developments in surveillance methods to both policy makers and scientists to facilitate improvements in the efficiency of animal health surveillance. The method is based on an efficient, ongoing review of surveillance related articles from both the animal and public health surveillance fields to identify those thought most likely to provide information that could improve the efficiency of animal health surveillance. The information contained in these articles is used to identify and prioritise actions that could be taken to improve the efficiency of the surveillance activities carried out to achieve the objectives of selected surveillance stakeholders.

Keywords: surveillance methods, prioritisation, efficiency, decision-support.

Introduction

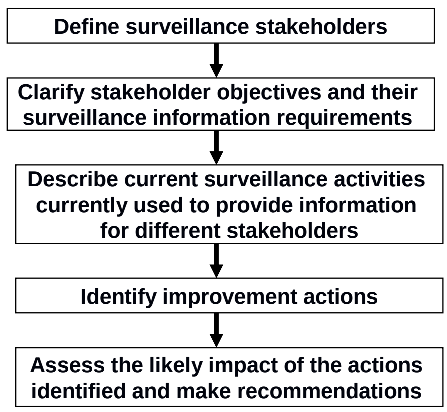
The information provided by animal health surveillance activities provides an essential component of the evidence required to make decisions about the protection of animal health. Timely detection of disease outbreaks can facilitate their control and limit the number of cases occurring and the impact of these diseases [1]. There are many ways to obtain and process surveillance data and the approach chosen has implications for both the decisions made and therefore the effectiveness of the disease control measures implemented and also for the cost of carrying out surveillance. The resources available for funding surveillance activities are finite and there is a need to ensure that the approach chosen is efficient, meaning that it achieves the required outcome with minimum use of resources. This is particularly important in the animal health field in which resources are under more pressure than in the public health field and in the current economic climate in which funding for animal health surveillance is likely to be reduced further. The Department for Environment, Food and Rural Affairs (Defra) published a strategy to improve animal health surveillance in 2003 [1]. This paper describes a method we have developed to identify the actions that could be taken to contribute to the implementation of this strategy

Materials and methods

We have identified a number of steps required for deciding which actions should be prioritised to improve the efficiency of animal health surveillance, these are summarised in Figure 1.

The first two steps in this process are to identify surveillance stakeholder and define their objectives. There are a number of different stakeholders interested in obtaining animal health surveillance information to facilitate decisions about protecting animal health. These stakeholders have differing objectives and requirements for surveillance information. In England Defra require information to help protect against animal diseases with an impact on trade, human health, animal welfare and the wider economy. The information of interest to Defra includes evidence about incursions of exotic disease or the emergence of new diseases and about the occurrence of endemic zoonotic diseases. Animal producers are most interested in diseases which impact on the health and production of their animals for which information about a wider range of endemic diseases may be required.

Figure 1: A strategy for making recommendations about the prioritisation of actions that could be taken to improve the efficiency of animal health surveillance



Having established which surveillance information is required by different stakeholder it is important to describe the surveillance activities currently used to obtain this information. We then need to identify the possible actions that could be taken to improve the efficiency of these surveillance activities. Finally we assess the likely impact of these possible actions on the cost of obtaining the required information and the benefits derived from it before recommending which actions should be prioritised

The remainder of this paper focuses on the methods that we have used to identify the possible actions that could be taken to improve animal health surveillance. We have developed a six step strategy (Figure 2) for carrying out an ongoing review of the literature to identify articles likely to provide information about how the efficiency of surveillance activities could be improved.

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Figure 2: Six step strategy for selecting, categorising, prioritising and reviewing articles to develop recommendations for actions to be taken to improve the efficiency of animal health surveillance

Step 1 – Identify surveillance related articles published each year using bibliographic databases, selected journals, selected conference proceedings and team members

↓

Step 2 – Select articles likely to provide information that could improve the efficiency of animal health surveillance methods based on a review of the article abstract

↓

Step 3 – Categorise articles according to the purpose of the surveillance activity (e.g. disease emergence, demonstrate freedom), the aspect of surveillance improved (e.g. data collection, analysis) and the type of disease (e.g. exotic, endemic)

↓

Step 4 – Prioritise articles based on likelihood of providing information that is highly relevant to the development of animal health surveillance strategies

↓

Step 5 – Review those articles thought highly likely to provide relevant information to identify actions that could be taken to improve the efficiency of surveillance

↓

Step 6 – Assess the likely impact of the actions identified on the efficiency of surveillance

The first step in this strategy is to identify surveillance related articles. The majority of articles were identified using health surveillance related search terms in bibliographic databases to identify articles relating to both animal and public health surveillance. Articles published in selected journals and the abstracts from selected conferences were also included as were additional articles identified by members of our project team. Information about all of these articles was stored on an MS access database. This database was used in steps two to four to review the abstracts of the articles identified and select, categorise and assign a priority score to those articles thought likely to provide information about how animal health surveillance could be improved (Figure 2). Copies of the articles thought highly likely to provide information that could improve the efficiency of animal health surveillance were obtained and reviewed. This allowed us to identify actions that could be taken to improve the efficiency of surveillance activities aimed at providing information to achieve different surveillance purposes for different types of disease. In the final step an assessment was made about the likely impact that taking this action will have on the efficiency of animal health surveillance. This assessment took into account the objectives of the stakeholder; the likely impact of the action taken on the cost of surveillance activities and the likely change in the cost of the disease resulting from the change in the information provided by these surveillance activities.

Result

In 2009 the review of various sources identified 1,074 surveillance related articles of which 165 (15%) were thought highly likely to provide information that could contribute to improving the efficiency of animal health surveillance methods. The detailed review of these articles identified 48 actions which could be taken to improve the efficiency of animal health surveillance. Consideration of the relevance of these actions to improving the surveillance activities that contribute to the achievement of Defra's objectives and the likely impact of taking these actions on the cost and benefits of these activities produced a number of recommendations for actions that could be taken immediately to improve the efficiency of Defra's animal health surveillance activities.

Many of these recommendations relate to the detection of the emergence of new animal health threats. The approach currently used in Great Britain to identify emerging diseases relies heavily on the analysis of information collected about unsolicited submission of material submitted to the Veterinary Laboratories Agency (VLA) Regional laboratories (RL) by veterinary practitioners who wish to obtain a diagnosis. This investigation of diagnostic material is subsidised by Defra [3]. We identified a number of ways in which the efficiency of emerging disease detection could be enhanced and Defra is currently using this information to contribute to the development of a vision for animal health surveillance in 2015. The specific recommendations that could contribute to enhancing the efficiency of surveillance to detect emerging diseases based on the results of the literature review included

- Use alternative data sources, for example data from markets, abattoirs or industry data
- Collate and analyse data about veterinary practitioner phone calls to VLA RL
- Investigate how farmer attitudes and behaviour influence the ability to detect emerging disease
- Provide additional feedback to producers to enhance their engagement with surveillance systems
- Investigate the use of new technology for data collection *e.g.* farm level data entry using personal digital assistants (PDA) or mobile phones
- Improve information systems for processing, analysis and presentation of information to facilitate detection of emerging disease
- Investigate analytical methods for the integration of different data sources
- Consider the role of event-based surveillance systems
- Review the guidelines for investigation of outbreaks of atypical disease
- Investigate the impact of the statistical methods used on outbreak detection efficiency

A number of actions that could improve the efficiency of animal health surveillance to achieve Defra's objectives but which were not aimed at improving the methods used to detect emerging diseases were also identified. These included developing methods to assess the value of surveillance activities and evaluation of surveillance systems, developing risk based surveillance strategies for exotic diseases, enhancing communication between scientists to facilitate developments in surveillance methods and the provision of information to decision makers about the benefits of surveillance, the importance of assessing its efficiency and the selection of appropriate methods.

Discussion

Defra currently provides funding for a wide range of animal health surveillance activities which are designed to facilitate the protection of animal health and limit the impact on society of disease in animal populations. The current economic downturn makes it essential that scarce resources are allocated effectively to achieve this objective efficiently. Keeping track of the rapid developments in surveillance methods and assessing how these new methods might contribute to enhancing the efficiency of animal health surveillance is not easy. We have developed an efficient method for collating information about how surveillance methods could be improved and used this to recommend actions to be taken to improve animal health surveillance in Great Britain. This was used to identify actions that could be taken to improve the efficiency of animal health surveillance based on articles published during 2009. This list of possible actions will be updated annually using the information gathered from surveillance related articles published each year.

Whilst many of the suggested actions were not new, our strategy provides a systematic method to keep up to date with developments in surveillance methods and summarise recent evidence about their use in different situations. It also facilitates open discussions about how actions to improve surveillance efficiency could be prioritised in order to make best use of scarce resources.

There is scope for further development of this strategy, in particular a more comprehensive description of the current surveillance activities and the development of methods to assess the value of surveillance activities are required, and we are currently working on both of these areas. A clear description of the current surveillance activities would mean that a more specific evaluation of the impact of improvement actions on selected surveillance activities could be carried out possibly using methods similar to those developed previously [4]. The development of methods to assess the value of surveillance activities will be particularly useful in assessing the likely impact of the recommended actions and should help to reduce the uncertainty in these assessments. A review of the efficiency of the search terms used to identify surveillance related articles would also be useful to determine whether the efficiency of this system could be improved further.

Our recommendations have focused on improvements that are relevant to achieving government objectives but some of the actions recommended could also contribute to achieving the objectives of other stakeholders. For example integration of data sources could also enhance the assessment of the occurrence of specific endemic diseases of interest to animal producers. It is therefore important that work to enhance the efficiency of surveillance carried out for different stakeholders is carried out collaboratively to maximise efficiency and avoid duplication of effort.

In addition to facilitating the production of recommendations for decision makers about actions that could be taken to improve the efficiency of surveillance the MS access database provides a source of information about recent publications describing the development and implementation of surveillance methods. This has been used by members of our scientific team considering how to develop or implement improvements to various surveillance systems. For example the database has recently been used to assist with the production of plans to develop risk based surveillance strategies and to contribute to the development of a generic framework for the evaluation of surveillance activities.

Conclusion

The system developed for identifying and prioritising actions that could be taken to improve the efficiency of animal health surveillance is an efficient and useful tool for contributing to the decisions made by surveillance stakeholders about how to enhance surveillance efficiency. The information collated in the development of this system has also been used by scientists to assist with the development and implementation of new surveillance methods. Further development of the system is required, particularly to incorporate information about the value of different surveillance approaches to assist with the prioritisation of the actions to be taken.

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Risk assessment and Surveillance in Animal health

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Abstract

The links between risk assessment and surveillance are discussed using some examples of the work developed by EFSA–AHAW panel on animal health risk assessment. Surveillance and monitoring systems data is essential for risk assessment and informed decision making. Often the available data resulting from surveillance activities is inadequate for use in risk assessment models, leading to high uncertainty. Risk assessment approaches can be used to identify needs for surveillance and to design more effective systems once prior knowledge is available for the identification of risk factors. The evaluation of surveillance systems in terms of their effectiveness in providing information for risk assessment and management is also discussed.

Keywords: Risk assessment, animal health surveillance, impact.

Introduction

The three interconnected components of risk analysis (risk assessment, risk management, and risk communication) provide a systematic methodology for the determination of effective, proportionate and targeted measures to protect health. Risk assessments should be undertaken in an independent, objective and transparent manner, on the basis of the available scientific information and data. The European Food Safety Authority (EFSA) was set up in January 2002 to provide an independent source of scientific advice and communication on risks associated with the food chain to European policy makers. EFSA's remit covers food and feed safety, nutrition, plant protection, plant health and animal health and welfare. The World Animal Health Organization (OIE) methodology for import risk analysis is the standard more often used in the context of Animal Health EFSA's risk assessment opinions. The first step is hazard identification, i.e. identifying the pathogenic agents or disease which can produce adverse consequences. Risk assessment is constituted by 3 steps: release assessment, exposure assessment and consequence assessment [OIE, 2010]. The value of risk assessment is dependent of the knowledge of the disease epidemiology and monitoring/surveillance data are fundamental. The adequacy of monitoring/surveillance systems for providing such information to risk managers and the need for an applied quality assurance system was discussed by Salman *et al.* [2003]. The concept of risk based surveillance is becoming increasingly popular. Risk based surveillance is a surveillance program in which exposure and risk assessment methods have been applied together with traditional design approaches in order to assure appropriate and cost-effective data collection [Stark *et al*. 2006].

The objective of this paper is to discuss the use of risk assessment to provide animal health surveillance guidelines but also to highlight the difficulties faced by risk assessors when using existing surveillance data for the scope of risk assessment.

Materials and methods

The Animal Health and Welfare panel issued 43 risk assessment opinions in the area of animal diseases. For this paper 5 EFSA –AHAW opinions were chosen to illustrate the links between risk assessment and surveillance design and evaluation (Table 1).

Table 1: Risk assessment and surveillance in animal health

Assessment	*Surveillance*	*Example /Reference*
Risk of disease introduction	Recommending targeted surveillance	Migratory birds and highly pathogenic Avian Influenza. EFSA, (2006)
Risk of disease introduction	Assessing the value of surveillance	Avian Influenza EFSA, (2008).
Risk of disease introduction	Assessing disease impact and the need for surveillance	Epizootic hemorrhagic disease. EFSA (2009a).
Risk of disease spread	Assessing disease impact and the value of surveillance	Q Fever. EFSA (2010)
Control measures efficacy	Assessing the value of surveillance	Classic Swine Fever in wild boar EFSA (2009b)

Results and Discussion

Risk of disease introduction - targeting surveillance

In 2005 after the spread of Highly Pathogenic Avian Influenza (HPAI) H5N1 virus from Southeast Asia to central and western China, Russia (Siberia), Kazakhstan, Mongolia, *etc.*, serious concerns were raised that migratory birds might be one of the more important causes of the geographical spread of the disease. A qualitative risk assessment was conducted to determine 1) the likelihood of introduction of Asian lineage H5N1 highly pathogenic avian influenza virus by migratory birds into the EU. Release pathways of Asian lineage H5N1 HPAIV in territories outside the EU were considered that may result in potential transmission of the virus leading to a release into EU territory (Figure 1).

Taking in account these pathways it was concluded that the probability of migratory birds becoming infected and releasing the virus could vary from low to high depending on the species. Surveillance activities should then focus on the species identified as bird "bridge" species, those most likely to lead to a release of the virus. In this case the knowledge of release pathways was used to target surveillance activities.

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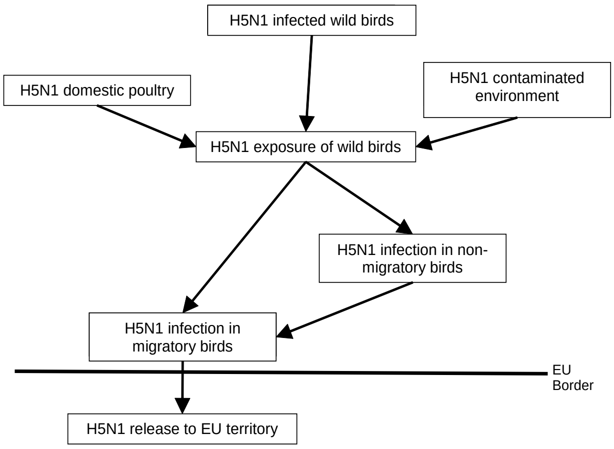
Figure 1: Release pathways of Asian lineage H5N1 HPAIV into the EU [EFSA, 2006]



Risk of disease introduction – assessing the value of surveillance

During 2006 the outbreaks of HPAI in poultry were mainly observed in association with wild birds' infection or where biosecurity was insufficient. For the poultry outbreaks in 2007, the findings in wild birds did not in all instances provided an "early warning". EFSA was requested to further assess the risk factors for the introduction of avian influenza into poultry holdings taking in account new scientific findings as well as the results of existent EU surveillance. The EFSA panel concluded that enhanced surveillance both in poultry and wild birds in the EU during 2006 to 2008 was effective for the early detection of H5N1 HPAI. Passive surveillance proved to be important for the detection of H5N1 HPAI infections in wild birds. Active surveillance proved a better surveillance source to detect low pathogenic avian influenza infections.

Active surveillance was considered to be an important source of epidemiological information of H5N1, especially around sites with active outbreaks. However due to the heterogeneity of the survey in the EU, the mobility of wild birds and the relatively small sample sizes compared to the overall population of wild birds in the EU, the surveillance results cannot be used to estimate the true prevalence of AIV subtypes or their geographical distribution within the EU. A risk assessment approach to the evaluation of surveillance data was used to demonstrate the efficiency of the surveillance system giving scientific base for a possible change in the existing EU regulations.

Risk of disease introduction – assessing disease impact and the need for surveillance

Epizootic Hemorrhagic disease (EHD) a vector borne disease listed by the OIE together with Blue Tongue (BT) is considered exotic to the European Union. Outbreaks of the disease reported during 2006 in the Mediterranean basin (Morocco, Algeria, Tunisia and Israel) and also in 2007 in cattle in western Anatolia and in Turkey, together with the observed pattern of BT virus spreading from North Africa to South European regions in Spain, Portugal, France and Italy, constituted a reason of concern. An assessment of the extent of the problem in affected countries and the risk of EHD virus to spread to and within the EU to persist was requested. The assessment of the extent of the disease was based on data collected by literature review. It was concluded that serotypes of EHDV normally considered as non pathogenic for cattle were able to cause disease with morbidity varying from 1 to 18% but low mortality. Production losses associated with disease in cattle may be significant, especially in dairy farms, in the form of lowered milk production but insufficient data did not allow for a more precise conclusion. Insufficient and incomplete understanding of the disease epidemiology did not allow for an accurate impact assessment. The assessment of the risk of introduction was made considering 2 pathways: introduction of live infected animals and infected vectors. It was concluded that when quarantine and testing for EHDV are in place the probability of importing an infectious animal into a EU Member States (MS) was negligible. The probability of introducing an infectious animal through illegal movement was considered not negligible and the risk of disease introduction could be high depending on the animal origin and season of movement. Based on recent experience with BTV the risk of introduction of EHDV into the EU from neighboring countries by wind dispersal of vectors was rated as high. A probabilistic model was used for estimating the consequences of release and exposure. Vector abundance and climatic conditions would be favorable to sustain EHDV circulation; therefore, presence of EHDV in neighboring countries poses a significant risk for introduction and establishment of EHDV in EU. Taking in account the release assessment, exposure assessment and consequence assessment recommendations were given regarding possible surveillance for early detection of EHDV introduction. Passive surveillance is complicated by the similarity of clinical signs with BT. Monitoring of disease prevalence (active surveillance schemes) is difficult at present due to the non availability of commercial serological diagnostic methods. A surveillance program (active and passive) in high risk areas using sensitive diagnostic tests was recommended for early detection. The models developed could be used for design of adequate targeted surveillance.

Risk of disease spread - assessing disease impact

The number of human cases of Q fever reported from EU MS in 2008 was of 1554 a 165.5% increase compared with confirmed cases reported in 2007. In 2009 in the Netherlands the number of human cases was 2018, the largest outbreak ever recorded. In view of this situation EFSA was requested to assess the significance of the occurrence of Q fever at a European level both on farm animals and humans as well as to assess the risk factors for Q fever occurrence and persistence in animal husbandry and the related risks for humans. Regarding the assessment of infection and disease prevalence it was noted that no harmonized rules or recommendations for either monitoring or reporting of *C. burnetii* infection and Q fever in animals were available. Comparability of data between EU MS was affected by variations in regulatory aspects (including case definitions), laboratory capacity and monitoring/surveillance intensity. In its current form, EU-level data (as compiled in the EFSA/ECDC zoonoses database) should be interpreted with care, due to incomplete and uneven reporting, the use of inconsistent case definitions, and difficulties in distinguishing active and passive data collection. A incomplete understanding of the disease epidemiology made the disease exposure and consequence assessment very difficult and led to high uncertainty. Strong recommendations were given on the need for harmonized field and laboratory data collection about *C. burnetii* infection in animals in EU MS, to allow comparison of prevalence/incidence estimates over time and between countries.

Control measures efficacy - assessing the value of surveillance

The threat for outbreaks of Classical Swine Fever (CSF) in the EU still exists. CSF virus is still present in wild boar of some MS. Assessment over the efficacy of the available surveillance was part of the EFSA opinion on control and eradication of CSF in wild boar. Official data regarding wild boar population density are often inconsistent. The actual sampling is mainly derived from hunted animals (% of hunted animals in EU data base with respect to any other sources) and therefore, the sample size is not designed to detect certain – prefixed – level of actual prevalence (design prevalence), either through viral isolation or seroprevalence, with a certain level of confidence. However a simulation-based assessment of the sensitivity of surveillance systems (SeSS) revealed that sample size is not the only factor that dictates the overall sensitivity of surveillance systems (SeSS) but also wild boar habitat, hunting patterns, and disease distribution. It is also recommended that surveillance strategy and evaluation of the results should always consider the epidemiological situation/evolution of the infection and vaccination status.

Conclusions

The discussed examples demonstrate the importance of good epidemiological data for the development of risk analysis. Quality data is necessary for risk assessment and informed decision making. Surveillance systems should be efficient in supporting the ongoing systematic collection and analysis of data for risk assessment.

Risk assessment methodologies are adequate for the targeting of surveillance and contribute to development of efficient surveillance systems however uncertainty must be taken into account. Evaluation of surveillance systems data taking in account risk pathway considerations is with essential to improve its effectiveness.

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Government and industry sharing the responsibility for animal health surveillance in Victoria, Australia

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Abstract

Although the livestock industries of Victoria, Australia, have an enviable animal health status, there is an ever increasing need to maintain effective animal health surveillance. To address this, a range of surveillance initiatives was implemented in 2009 through a partnership between the Victorian government and livestock industries. This cooperative approach is refocusing animal health surveillance in Victoria and delivering a broad range of outcomes to all beneficiaries.

Keywords: government, livestock industries, surveillance.

Introduction

Victoria is Australia's largest food and fibre exporting state. Most sectors of the Victorian livestock industry are focused on export, with export sales being worth AUD$4.15 billion in 2009 for these industries [1]. Victoria produces approximately 20% of Australian beef, 40% of Australian lamb and 60% of Australian milk [2].

With growing global trade, tourism and migration, as well as a changing climate and the subsequent changes required in land-use and agricultural practices, biosecurity management is becoming increasingly complex. Although the Victorian livestock industries have an enviable health status, these changes are imposing an ever increasing need to maintain effective animal health surveillance to ensure early detection of diseases that can potentially impact on trade, public health and productivity.

Victoria's animal health surveillance system is principally based on structured non-random activities. These activities include targeted surveillance programs, disease investigations, disease reporting and notifications, endemic disease management programs, surveillance at livestock aggregation points and sentinel units. Key stakeholders in Victoria's animal health surveillance system include all levels of the livestock industry, government, private veterinary practitioners, veterinary laboratories and universities.

In Australia, the national government is exclusively responsible for pre-border and border related animal health matters, including quarantine, export certification, trade negotiation and disease reporting. Under the Australian constitution, state and territory governments are responsible for animal health services within their respective borders, including disease control and eradication and quarantine.

The Victorian Department of Primary Industries (DPI) develops and delivers government policies and programs that enable Victoria's primary and energy industries to sustainably maximise the wealth and wellbeing they generate. The DPI works in close partnership with the livestock industry, through a number of advisory and consultative committees, to protect Victoria's reputation as a producer of safe, wholesome livestock and livestock products.

The purpose of this paper is to describe a new approach to animal health surveillance in Victoria, based on a partnership between industry and government.

A shared approach to animal health surveillance

The *Biosecurity Strategy for Victoria* was launched by the Victorian state government in 2009 and highlighted how increasingly complex it is to safeguard the state from new pests and diseases [3]. The strategy recognised that Victoria needs continuously operating, comprehensive, flexible and sensitive surveillance systems to accurately and efficiently monitor disease and pests. The focus of the DPI over the coming years is to implement the strategy and once implemented, this will help protect Victoria from emerging biosecurity threats and better ensure that the DPI remains forward-looking, innovative, flexible and constructively engaged with stakeholders.

The DPI has for many years implemented structured control programs for endemic livestock diseases including Johne's disease, ovine brucellosis, footrot and sheep lice. These programs have historically had a significant regulatory component. Although these control programs have enabled DPI staff to maintain a regular presence on many farms, they have imposed a significant financial burden on government and the livestock industries.

The approach to managing and funding endemic disease control in Victoria has shifted in recent years towards individual livestock producers taking greater responsibility for control, with minimal regulation imposed by government. This is now providing a significant opportunity to redirect resources towards priority activities such as surveillance.

For some livestock producers, particularly those in the sheep and goat industries, the relatively low value of livestock and high costs of disease investigation has made the establishment and maintenance of contact with DPI and/or private veterinarians, considerably challenging. As a result of this, there are significant opportunities for instituting on-farm animal health and biosecurity-orientated programs, including in peri-urban areas, and increasing the overall level of on-farm surveillance.

To address these issues, and the direction provided by the *Biosecurity Strategy for Victoria,* a suite of animal health surveillance initiatives, supported by both the Victorian livestock industries and government, was

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developed. The purpose of these initiatives is to describe more accurately Victoria's animal health profile, increase the ability to rapidly detect and diagnose animal health threats, deliver outputs of commercial benefit to industry at a producer level and elsewhere in the supply chain, encourage good on-farm biosecurity and welfare practice, strengthen the relationship between producers and the DPI and private veterinarians, and develop and refine information support systems for surveillance and emergency response.

The implementation of these new surveillance initiatives would not have been possible without both the Victorian government and livestock industries making funding available. Industry co-funding for the initiatives is provided from duty collected on the sale of cattle, sheep, goats or swine, or their carcasses, in Victoria. Duty is paid into several trust funds overseen by the state Minister of Agriculture. The Minister receives advice from three committees of cattle, sheep and goat, and swine industry representatives about the use of funds for compensation payments, administering relevant legislation and projects for the benefit of the livestock industries. This is the first time that a significant amount of industry funding has been allocated from these trust funds for new surveillance initiatives in Victoria. Significant 'in-kind' contribution is provided by the DPI, particularly in the form of field staff time.

Most of the surveillance initiatives were designed as three year projects, to be implemented by DPI staff using standard project management methodology. The implementation of the projects commenced in 2009. Examples of these initiatives follow.

(i) Surveillance at livestock aggregation points

Livestock aggregation points such as knackeries, sale-yards and abattoirs provide a convenient and cost effective opportunity to conduct surveillance on livestock. Knackeries provide an important service to farmers by processing dead and unsalable livestock. There are 19 licensed knackeries in Victoria, processing approximately 90,000 adult cattle annually for pet food. Surveillance is undertaken by DPI staff for the four largest knackeries in Victoria with the aim of identifying the major causes of cattle losses, enhancing capability for the early detection of emergency animal diseases and providing development opportunities for DPI staff. Cattle are examined on-farm and/or a necropsy is performed at the knackery. During the year to 30 June 2010, over 500 cattle were examined. The most common causes of loss recorded included birthing complications, endemic infectious diseases, metabolic diseases, non-infectious disease and traumatic injury. An advisory letter was sent to producers whose cattle were examined through this surveillance.

The cause of death and loss in sheep and goats presented for sale or slaughter in Victoria is also being examined by undertaking surveillance at 25 sale-yards and 27 abattoirs.

(ii) Lamb and kid mortality investigations

Each year the Victorian sheep and goat industries face significant productivity and financial losses due to lamb and kid mortalities. This project has the aim of determining the major causes of mortality of lambs and kids on commercial farms. On-farm investigations are undertaken by DPI staff and private veterinarians. Approximately 200 investigations were undertaken in the year to 30 June 2010 and common diagnoses included mis-mothering, trauma, trace element deficiency, internal parasitism and bacterial infection. Written advice was provided to producers whose sheep/goats were investigated.

(iii) Sentinel flock/herd monitoring

Sentinel flock/herd monitoring is being undertaken to collect baseline information on animal health and production, and identify the cause and prevalence of mortality and morbidity in 20 sentinel sheep flocks and goat herds, and 6 swine herds. It is anticipated that the findings will assist with establishing best-practice techniques for decreasing on-farm losses, increase farm productivity and profitability, and quantify the financial impact of losses. In the year to 30 June 2010, over 2,800 animals were examined for disease during 660 visits by DPI staff to the 20 sheep flocks and goat herds. Production data was additionally collected from 13,650 animals. The predominant causes of death during this period in adult ewes/does and lambs/kids were nutritionally mediated. A close relationship has been developed with the sentinel flock/herd owners through the regular farm visits undertaken by DPI staff, and technical advice is provided on an ongoing basis.

Monitoring of sentinel swine herds was being commenced at the time of writing. In conjunction with on-farm monitoring, abattoir surveillance will be utilised for the sentinel pig herds.

(iv) Specialist staff

Two sheep and one goat health specialists have been employed by the DPI to provide technical support to enhance services to the sheep and goat industries. This includes promoting good on-farm biosecurity and welfare practices, educating producers in relation to the relevant livestock management standards, providing advice to industry and DPI staff on endemic disease issues, and networking with veterinary practitioners. Some examples of recent activities of the specialist staff include the holding of field days for farmers on a range of topics, production of newsletters and other extension materials, and provision of seasonal advice through regular media releases.

(v) Data management systems

A large volume of surveillance data is generated from on-farm disease investigations undertaken in Victoria. Unless managed and utilised properly, this can present a significant missed opportunity for animal health surveillance. A fully queriable database, known as the Yes Epidemiology System (*Yes!*), was developed by DPI for recording cases of clinical disease in production animals and analysis of this data. The query interface allows rapid data manipulation and mapping of disease events. Google Map© technology was incorporated to allow all users to easily and rapidly generate maps. In the year to 30 June 2010, over 2,000 occurrences of clinical disease were recorded on this system. These cases represent both investigations undertaken by DPI staff and notifiable disease events reported by veterinary practitioners or laboratories.

(vi) Communications

The timely dissemination of information is a fundamental component of surveillance. Regular reports on the surveillance initiatives are provided by project managers to stakeholders, with a comprehensive final report for each project due in 2012. Summary findings and technical advice are conveyed through media releases, field days for farmers, newsletters and other extension activities. Written and verbal advice is provided to individual livestock owners and their private veterinarian when surveillance activities are undertaken on their property. A comprehensive annual report on DPI animal health activities is also produced (available from www.dpi.vic.gov.au/vetsource).

Discussion

Although many of these surveillance initiatives will not be completed until 2012, they are already delivering a broad range of outcomes to all beneficiaries. The animal health profile of the dairy, sheep and beef sectors in Victoria can now be better described quantitatively using the data collected from these activities and recorded in the recently implemented *Yes!* data management system. Individual livestock producers participating in these surveillance activities are receiving advice, and are being provided an opportunity to improve the animal health situation of their herd/flock in conjunction with their private veterinarian. Communication of findings from the surveillance initiatives and promotion of good biosecurity and welfare practices is being undertaken through the broader media, farmer newsletters, field-days and other means. With the increased number of surveillance visits to farms, knackeries, sale-yards and abattoirs, the ability of the Victorian animal health surveillance system to rapidly detect emergency animal diseases is being further enhanced.

The challenge to protect and enhance Victoria's reputation as a supplier of disease-free and wholesome livestock produce is dependent on the partnership between all sectors of industry and government. The commitment made to these new surveillance initiatives demonstrates the strength of this partnership. This cooperative approach is significantly refocusing and enhancing animal health surveillance in Victoria.

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Strengthening veterinary field capacity in the Philippines through the Applied Veterinary Epidemiology Training (AVET) Program

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Abstract

The field veterinarians at the local unit levels in the Philippines are tasked to oversee animal health programs in their respective localities and very often these field veterinarians lack the sufficient knowledge and applied skills needed to conduct successful disease control and response activities. The Applied Veterinary Epidemiology Training (AVET) Program which was launched in 2006 is an appropriate response to strengthening capacity of field veterinarians.

Keywords: veterinary services, capacity building, epidemiology

Introduction

Veterinary services play a key role in controlling animal diseases by means of surveillance, early detection, and rapid response [1]. In 2005, when countries in the region were reporting the HPAI, the national veterinary services in the Philippines were bracing itself to get ready if HPAI occurs in the country. During this preparation stage, an Avian Influenza Protection Program (AIPP) was developed detailing the standard operation procedures for field veterinarians locally termed as local unit veterinarians. It was during the planning process that the local unit veterinarians indicated the need to develop their capacities to respond to HPAI and other disease emergencies. Such capacity building effort would produce sufficiently knowledgeable, skilled and confident staff who can perform the task properly [2] and who can effectively carry out essential health research at the national level [3].

Recognizing this need, the FAO HPAI programme (consisting of donor-funded projects) in the Philippines, together with the most qualified epidemiologists in the country began the process of developing a practical training course for local unit veterinarians. The team agreed that the course must be easily understood and applied to local conditions. Likewise, it should be of short duration since local unit veterinarians cannot be kept away from their offices for a long time. While duration is a factor, the quality of the course offered must not be sacrificed, hence important modules were developed which include principles of epidemiology, surveillance, outbreak investigation and animal health program management.

Development Process

In late 2005, FAO convened a meeting of the most qualified veterinary epidemiologists in the Philippines (mostly from the academe), government veterinarians and the private sector to discuss the need to develop capacity among the local unit veterinarians since they are the frontline staff for any disease emergency.

The group brainstormed on the objectives of offering a capacity building activity that would provide a significant impact on the daily work of the local unit veterinarian. The AVET objectives are as follows: to strengthen epidemiological capacity at the local level specifically in disease surveillance and in disease investigation, control and response and to plan and implement a relevant animal health activity based on sound epidemiological principles. Graduate attributes as well as selection criteria for trainees were formulated to level off expectations with the trainees. Epidemiology topics were listed and grouped together under appropriate headings and module titles were developed.

The team members were tasked to develop particular module topics in an easy to understand language with examples taken from local scenarios. This then formed the manual reference for the trainees. This exercise undertook a series of meetings until the course content was finalized and lectures in word and powerpoint formats were developed.

From the pool of epidemiologists, one or two members have teaching experience and they were tapped to handle the training course. It was decided that the curriculum would be delivered one week at a time for each month where all trainees will attend a formal lecture for a week to learn the theory after which, they will be sent back to their duty stations to do a project that is part of their animal health programme. Since there are four modules, namely: principles of epidemiology, surveillance, outbreak investigation and animal health program management, the trainees were required to do a project related to these modules. A surveillance project could be setting up a surveillance system in their province or it could focus on a specific disease. A project on outbreak investigation may involve investigating a new outbreak or going through past disease reports and doing the proper outbreak investigation. Lastly, a project on animal health management involves planning an animal health programme for their locality with matching budgets. All these projects are to be implemented and funded by their respective offices as the teaching team wanted the trainees to implement projects that are part of their office's program. It will also encourage the trainees to be more creative in planning projects given their limited budget allocations.

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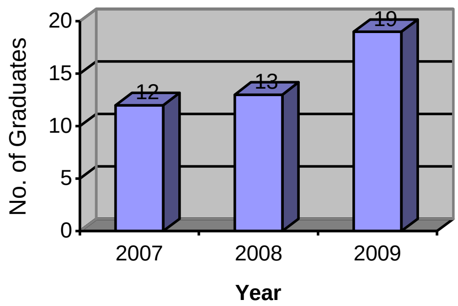
Results and Discussions

The AVET Programme was launched in 2006 with its first batch of trainees graduating in 2007. The core teaching team which consisted of academicians, government and FAO staff served as the core organizers of the AVET and took charge of the selection of trainees and the delivery of the entire course. The courses were funded from various FAO projects with government sharing the cost. To date, there have been three AVET courses churning out 44 graduates, 32 of whom are local unit veterinarians and 12 from the central veterinary services and other project staff.

Figure 1: Number of AVET graduates, 2007-2009



Two of the courses (AVET 1 and AVET 2) were completed maximum in six months where participants gathered for a week per module and then went back to their duty stations to do their projects and assume their work. The first two batches were attended mostly by senior local unit veterinarians who could not afford to be away from the office for long periods. The staggered approach for teaching and learning by doing, proved more manageable for the trainees as they were only away from office one week at a time. This also allowed for better understanding and immediate application of the modules. Further, their projects were more thought out and well implemented. However, since the teaching is on a per module basis, the approach to an animal health program was on a per topic basis rather than having a holistic animal health management plan. For instance, a module on surveillance will allow the trainees to focus on surveillance alone and not to investigate the situation if there are data that should trigger an investigation since the module on outbreak investigation was still on the second module. In terms of travel costs, the various projects and their offices had to fund travel three or four times since the course was done on a staggered basis.

To address the issue on holistic animal health planning and to cut travel costs, the core teaching team then decided to offer for its AVET 3, a more intensive training course where all modules were compressed in one month. This was then termed AVETi, an intensified training course. AVETi offered the trainees an opportunity to learn all modules at once and apply an integrated approach to animal health planning. The teaching team however, has to guide the trainees more closely to ensure better understanding and application of lessons. In terms of teamwork and camaraderie, trainees under AVETi were more cohesive allowing them to network more closely after the training. In terms of cost, since there was only a one-time travel to and from the venue, the cost was considerably reduced. However, only local unit veterinarians who are staff of the senior local unit veterinarians and only those who could be away from their offices for a month could attend the one-month training. It was observed that the one-month training course was not suited for local units that are understaffed but could be of benefit and value due to reduced costs, if such offices can manage to allow staff to be away for a month.

After completion of three AVET courses, all graduates were called for a general meeting and a scientific conference. The teaching team provided the venue and the AVET graduates paid for their travel costs. There were 44 attendees with 26 of them AVET graduates and with their offices shouldering the cost of their participation. To the teaching team, paying for their own participation meant the program could be sustained. During the meeting, the graduates gave an update on the application of their learning. They shared the impact of the training course in their respective workplaces. They affirmed that the knowledge and skills they have gained gave them the confidence to plan and prioritize animal health programs. As a result, reports of disease outbreaks were investigated properly and not just treated as a mere case of sick animals.

The participants also agreed to organize themselves into a veterinary epidemiology network (VEN) that will allow for exchange of information and sharing of technical knowledge on animal health issues. Partners present during this VEN conference committed to support the network. For instance, a non-profit organization consisting of local veterinarians from various disciplines, the PhilVet Health Services, Inc., volunteered to act as secretariat to the VEN and has now initiated a website for the VEN members. Private sector veterinarians also signified their interest to send participants to the next AVET programme and expressed commitment to pay for their trainees.

At the time of this writing, AVET 4 has been launched with trainees from the private sector joining the course. The teaching team had adjusted the modules to include examples from a private production setting and have conducted field exercises in both smallholder and commercial production systems. This was done because efforts to strengthen veterinary services require the active participation and investment on the part of both the public and the private sectors [4]. The teaching team is seeing a robust exchange of ideas and perspectives in dealing with animal health issues.

The AVET program and its approach to teaching have the potential to equip frontline staff in handling animal health issues and programs. It can also forge close partnerships between the public and private sectors, thus strengthening animal health planning and implementation.

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The Alberta Veterinary Surveillance Network: a Multi-Component Approach to Animal Health Surveillance in the Province of Alberta, Canada

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Abstract
A multi-component, multi-stakeholder approach has been adopted for farmed animal health surveillance in Alberta. The Alberta Veterinary Surveillance Network (AVSN) [1] is a loose organization of surveillance components (detection, investigation, response, communication) that succeeds through the collaboration of producers, veterinarians, industry, academia and government agencies.

Keywords: Implementation of Surveillance, Institutional organization schemes; roles of institutions; tools for cooperation; collaboration, incentives.

Introduction
Effective animal health surveillance is a critical component of the infrastructure needed to sustain economically viable livestock and food production industries [2]. For trading nations animal health surveillance is essential; being indispensable for credibly documenting the disease or pathogen risk in the livestock and livestock products they make available for export [3]. Animal health surveillance is vital for livestock industries and individual producers to manage trans-boundary, emerging, endemic and zoonotic disease risks. Benefits of animal health surveillance extend beyond individual livestock producers. Mitigating disease risks reduces uncertainty and brings needed stability to livestock industries, strengthening rural economies and providing increased security of the food supply; benefiting society as a whole [2].

For these reasons, animal health surveillance may be most effective and sustainable when it is a participatory collaboration between many stakeholders, including the producers and businesses participating in livestock based food supply chains, veterinarians and others delivering animal health care, and animal and public health governmental agencies at both provincial/state and national levels.

This paper provides a brief description of the approach taken for sustainable farmed animal health surveillance in Alberta with a focus on Alberta's cattle population.

Materials and methods
The AVSN was designed to enable early detection and rapid effective response to emerging and re-emerging diseases of all livestock in Alberta. While the focus of this presentation is cattle surveillance, similar approaches and programs are in various stages of development for other farmed livestock and poultry. Cattle surveillance is used as an example because it is the most developed.

The AVSN is not a single surveillance effort. It is a group of coordinated activities that enable effective animal health surveillance in Alberta.

The AVSN is defined as:
An infrastructure (people, processes and technology) for systematic, continuous observation of Alberta livestock and poultry, and collection and analysis of data from many varied sources for:

1. rapid detection (or identification) and timely, appropriate response to important livestock, poultry, food safety and public health events and:
2. production and communication of valid information and knowledge about the health and disease status of Alberta livestock and poultry and safety of their products

Detection
Potentially important animal health events occurring in the province are identified through different methods depending on the pathogen, disease or hazard, and the livestock commodity or production group in which it occurs. However information comes into the AVSN and important events are detected through one of two routes: 1) by analysis of animal health data, or 2) by reports of unusual or important animal health events communicated to AVSN.

Important or suspected important disease events can be reported to the AVSN directly or through the Office of the Chief Provincial Veterinarian (OCPV) for Alberta [4]. Many reports are voluntary and rely on the vigilance, concern and participation of a broad spectrum of society. Farmers, veterinarians, diagnostic laboratorians, physicians, meat inspectors, public health officers or inspectors, wildlife officers, or any member of the public can report an unusual animal health event to the AVSN or the OCPV, usually by telephone.

For certain important diseases, especially those that may be threats to animal health, public health, food safety, and the economic interests of a livestock industry there is Provincial legislation under the *Animal Health Act* [5] requires by law that occurrences of these named diseases are reported to the OCPV. There are two types of diseases covered by this legislation: "Reportable" diseases, which are deemed of great enough importance to require intervention,

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ranging from removal from the human food chain to quarantine to implementation of control measures or eradication, and "Notifiable" diseases which are of lesser importance and are reported only to monitor changes in their frequency or distribution. Nomination of diseases to the Reportable and Notifiable lists was through a consultation process between the OCPV and Alberta livestock industry groups. Diseases on these lists are not permanent, but are expected to change through consultative, interactive processes as the needs of industry, government and society changes.

AVSN has adopted a number of collaborative approaches for detecting important livestock disease events using animal health data. For emerging disease surveillance of cattle, a real-time web-based Veterinary Practice Surveillance (VPS) [6] application was designed and implemented on a secure, controlled access web-site. Veterinary practices that service the Alberta cattle industry (cow-calf, dairy, feedlot and back-grounding production groups) were canvassed to voluntarily participate by entering data into the AVSN database via the web-site for all the disease and non-disease related services they provide to their cattle clients. Participants are paid for their efforts. The data entry web-site was designed initially by AVSN surveillance veterinarians and improved through a consultation between participating veterinarians and AVSN surveillance veterinarians. Currently the data entry web-site is almost entirely a point and click application with only a few fields requiring typing. Data collected include: number on farm, number affected, type of cattle (cow-calf, dairy, feedlot, and back-grounder), age group, clinical syndrome, clinical diagnosis, laboratory diagnosis, and other data. Data are collated, reported daily and analyzed automatically to detect potentially important disease events. Producer identities are not reported by veterinarians who act as gatekeepers; both protecting the confidentiality of their clients and in the case that a potentially important disease is detected, providing the only access between the AVSN and the producer for disease investigation or other responses.

VPS applications similar to the cattle system have been developed and are being tested for small ruminants and poultry.

Surveillance for Bovine Spongiform Encephalopathy (BSE) [7] is conducted in Alberta in collaboration with the OCPV and the Canadian Food Inspection Agency (CFIA). Under this program practicing veterinarians submit the obex from qualifying dead or euthanized cattle to Provincial or CFIA laboratories within the Province for BSE testing. Textual information about the clinical signs and the veterinarian's clinical diagnoses that is present on laboratory submission forms is text mined to allow for data extraction and analysis providing information of value for BSE surveillance and to enhance disease surveillance for emerging and endemic diseases of cattle. The program is voluntary and relies on the support and collaboration of both cattle producers and their veterinarians. Both farmers and their veterinarians are paid for their efforts.

A different approach was developed for collecting data for surveillance of Alberta swine for emerging and endemic diseases. A collaboration between the AVSN and a group of swine veterinarians resulted in the development of a functional swine practice management application that also serves as swine surveillance data collection application. When complete this application will support a strong linkage between private veterinarians and the AVSN that will automatically transmit surveillance data to a secure AVSN database. A similar approach is being adopted for veterinary practice surveillance of Alberta poultry.

Event detection is not limited to one surveillance initiative per livestock species. For example, surveillance of cattle in Alberta is accomplished using veterinary practice surveillance, text mining of BSE surveillance submissions, voluntary reporting of unusual disease events and mandatory reporting of reportable and notifiable disease legislation.

Data Analysis

AVSN has adopted a collaborative approach to event detection method development, engaging specialists from private industry and several academic domains including mathematics, computer science, and engineering. Methods have been adapted from public health event detection, time series analysis and modeling, process control, artificial intelligence, data mining and computational intelligence.

Investigation

Investigative capacity is essential for surveillance and is the first response of AVSN to all potentially important disease events, regardless of how they are indentified. AVSN has two investigative components; investigative pathology and outbreak investigation. Both of these components have discretionary funds available, allowing investigators and diagnosticians the ability to respond quickly to unusual or important disease events. AVSN has developed engagement criteria for both components enabling investigators and diagnosticians to make decisions and to move quickly when needed, without requiring higher level approvals.

The Livestock Pathology Consultation Program (LPCP) of the AVSN is comprised of a team of veterinary pathologists who work in cooperation with private practitioners to investigate livestock or poultry problems; or unresolved health issues in Alberta's livestock and poultry. LPCP fosters a team approach and may call upon assistance from private diagnostic laboratories and/or from a wide range of experts, for example epidemiologists, toxicologists, theriogenologists, and other specialists, both internal and external to AVSN.

The Livestock Disease Investigation Network (LDIN) of the AVSN is a team of veterinarians, epidemiologists, pathologists and other veterinary specialists that works with private veterinarians to conduct field investigations of complex, unresolved livestock health issues. LDIN works with private veterinarians who act as a liaison between LDIN investigators and producers, and are often contracted to assist with investigations.

Response

For important or unresolved disease problems and suspected reportable diseases, investigation is the initial response. For confirmed reportable diseases, responses can include quarantine of animals or premises, removal of animals or animal products from the human food chain and destruction of animals with compensation for destroyed animals.

Communication

Automated daily cattle disease reports and alerts generated from VPS cattle data are produced and sent by email to AVSN surveillance practitioners. Submitting veterinarians are contacted by telephone or email by an AVSN team member if an unusual disease event is identified.

Quarterly reports containing collated cattle disease information are distributed to participating practices. Unusual disease occurrences or changing disease patterns are communicated by articles in the Animal Health Forum, a publication distributed to all veterinary practitioners in Alberta, the Alberta Veterinary Medical Association's monthly newsletter and for more important disease events, by email notices sent directly to practicing veterinarians in Alberta.

Federally reportable diseases are reported to the CFIA as they are detected. BSE surveillance data is reported automatically via the Internet to the Canadian Animal Health Surveillance Network (CAHSN) of the CFIA.

Results

The AVSN's web based VPS cattle surveillance system has been operational and stable since 2005. It has collected data from between 3,400 and 4,500 farms per year with a total yearly cattle population ranging from 1.3 to 2.0 million cattle.

LDIN and LPCP investigated 684 cases since Jan. 1, 2006. Investigations were either suspected emerging diseases, diseases that had significant morbidity or mortality or that were provincially reportable diseases. Species investigated included cattle, sheep, goats, bison, deer, elk, reindeer, poultry and horses. A wide variety of infectious pathogens including: infectious laryngotracheitis, *Salmonella spp* outbreaks in poultry and cattle and toxic exposures such as lead toxicity were investigated. A number of syndromes were also investigated, including sudden death in adult cattle, toe tip necrosis in cattle, poor pregnancy rates, abortions, non-viable neonates, calves with pneumonia, diarrhea, cataracts in calves, conjunctivitis, infected eyes, excessive mortality of lambs, congenital chondrodysplasia and joint laxity and other conditions were also investigated.

Information was presented to producer at conferences and in industry journals, and to veterinarians through conferences and scientific and professional journal articles.

Discussion

AVSN has successfully engaged practicing veterinarians in many surveillance activities, ranging from providing data about their day to day activities, to reporting suspect emerging diseases, investigating diagnostic dilemmas and provincially reportable diseases and assisting with outbreak investigations. Actively engaging private veterinarians in a variety of surveillance activities has been essential for the long term sustainability of the AVSN and contributes to the economic viability of rural communities. Providing even "token" remuneration for their participation acknowledges their value and contributes to a strong collaborative relationship between the AVSN and practicing veterinarians in the province.

Important animal health events, such as disease outbreaks that cause significant morbidity, mortality, reduced production or reduced reproductive performance will always make themselves known to producers, veterinarians and disease control agencies. However, early detection of these events is essential for reducing the harm they cause. A primary goal of the AVSN is early detection before outbreaks become widespread enabling early and more effective responses. Working with private practitioners is essential. Private veterinarians develop strong working relationships with their clients. They are often the first responders for important disease problems on the farm and for this reason they can provide early information about disease outbreaks to surveillance systems. The trusting relationship they develop with their clients and the knowledge they have of their client's facilities and capabilities makes private veterinarians an obvious choice for leading field outbreak investigations.

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A modular simulation tool to help designing epidemics surveillance: Work in Progress

B. Bonté[1*] and R. Duboz[1]

Abstract

There is nowadays a need of new surveillance systems, lighter, cheaper and quantitatively evaluated. Hence, new statistical tools are being developed and new surveillance systems are being designed. Then, raise the issues of evaluating these new surveillance systems and build a clear view of their implementation, shared by researchers, actors and decision makers. In order to address these issues, we are building a modular and multi-formalisms simulation tool that allows simulating both the disease spread, and its surveillance. This simulation tools is a framework that can be used in two ways: Firstly to visualize at the same time epidemic spread and surveillance on didactic interfaces; and secondly to perform intensive simulation plans in order to test surveillance protocols in different scenarios. This is a work in progress; the basic structure has been implemented using Discrete Event System specification and the Virtual Laboratory Environment software system. Future work will be to implement a case study and to introduce the disease control component, which is essential to surveillance evaluation.

Keywords: Modeling, Simulation, DEVS, Surveillance.

Introduction

Designing new surveillance systems is a challenge. Sampling strategies, as well as data analysis must be optimized and evaluated but experiments on the field are very expensive and irreproducible. Furthermore, evaluation is an issue because we can't compare the result of surveillance with the unknown real epidemiological state. For these reasons we are building a simulation tool dedicated to surveillance systems designers. Contrarily to real experiments, computer simulations are cheap and reproducible. Moreover, we can know the real epidemiological state if we simulate it. Hence, this tool must allow simulating both, the **sampling performed by the surveillance system**, and **the epidemic spread**, in order to:

- **quantitatively evaluate** the adequacy between surveillance system estimation and real epidemic in **different scenarios**;
- optimize the **sampling process parameterization**;
- present the surveillance system sampling strategy in a didactic and/or contextualized way in order to discuss it with every actor of the surveillance.

Materials and methods

Our simulation tool simulates coupled models of disease spread and of surveillance monitoring. These models are specified using Parallel DEVS specification [1] and are implemented in the open source Virtual Laboratory Environment (VLE) software system [2].

The Parallel Discrete Event System Specification (DEVS) has two advantages. Firstly it allows multi-formalisms: we can specify dynamic systems models using different formalisms such as automaton or differential equations. Secondly, it is modular: A Parallel DEVS model (representing the global system) is composed of several Atomic DEVS models (representing sub-systems) coupled together. So we can take a sub-system and replace it by another one. Hence, we can simulate a model of an epidemics formalized as a differential equation system, coupled with a model of surveillance activity formalized as an automaton performing regular observations. Thus, we can keep the same model of epidemics but coupled with different models of surveillance in order to assess which surveillance gives the best results.

The VLE software system suite provides a set of tools to implement and simulate DEVS models. Beside other features, it provides an interface with R software system [3] that we use to explore and analyze models by running simulation plans (several simulations); and visualization plug-ins that we use to visualize the results of a single simulation, facilitating discussions.

Simulation tool presentation

Disease spread modular model: Literature in epidemiology proposes huge amount of epidemiological models [4]. Obviously, using different models implies making different hypothesis and simplifications that will have an impact on simulation results. For that reason, we are building the surveillance package as a modular and scalable tool in order to both, be able to test different hypothesis and assess the impact of different simplifications.

However, we think that the disease spread models we consider must be spatial and dynamic to allow an accurate description of the surveillance system that will monitor it. Therefore, the disease spread model has a basic structure. It is built as a set of “places” linked together by an “infectious contact network”. The infectious contact network is represented by a directed graph either valued or not if some infectious links are supposed to be stronger than others. The places are situated both in a 2D space and in the infectious contact network. The epidemic dynamics is then specified in the “places” models which are coupled together using the “infectious contact network” in order to constitute the disease spread model. Hence, we can test different disease spread models in the same network.

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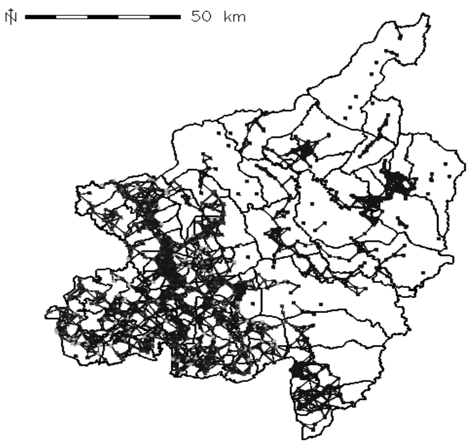
Surveillance modular model: The surveillance model is a set of surveillance components coupled with the disease spread model. We identified two different kinds of surveillance components. The first ones are event-based surveillance components that automatically receive information events any time the epidemiological state changes. And the second ones are pro-active surveillance components that must request for information events.

A surveillance component is then specified by three features: an observation policy (what to observe and when?); a perception error (is the information damaged?); and an analyze feature (How informations are aggregated?).

Simulation Tool outputs

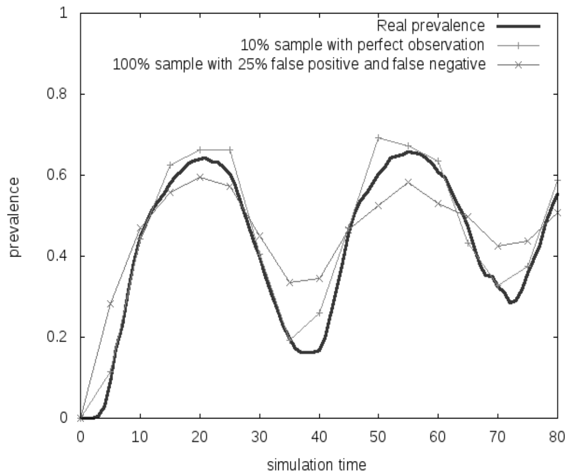
Visualization of a single experiment: In figures 1 and 2, we present two kinds of simulations outputs that can be produced by the simulation tool. In this toy simulation, a hypothetic disease spreads through the villages of the Phitsanuloc Province in North Thailand. Villages have an epidemiological state that can be susceptible, infectious or recovered. Then, an infectious contact network has been arbitrarily generated according to villages distances one to another (see Figure 1). At the same time two surveillance components are monitoring the epidemics and estimating prevalence at a regular time step of 5 time units. The first one observes all villages but have a 0.25 probability of a false positive observation and the same probability of a false negative observation. The second one observes a random sample of 10% of all villages with a perfect observation (see Figure 2). Hence, simulation outputs can be visualized both as dynamic maps, as shown Figure 1, and as charts, as shown Figure 2.

Figure 1: Epidemic spread output (snapshot during simulation).
Visualization of disease spread in toy simulation where disease spreads in villages network. Villages (dots) colours indicates epidemiological state (Blue=Suceptible; Red= Infectious, Green=recovered)



Building and analyzing experimental plans: The main interest of our simulation tool is that it can be used to quantitatively evaluate sampling strategies. As we said, performing real experiments on the field is hardly possible. Using simulations allows us to repeat virtual experiments and hence to test many possible scenarios. Interface between VLE and R software gives us access to many statistical tools in order to explore parameters space and then to analyze simulation results. Experimental plans distribution feature of VLE allows us to perform intensive simulation plans on computer clusters.

Figure 2: Surveillance monitoring visualization
Visualization of prevalence monitored by different surveillance components during simulation of Figure 1.



Future work

Implement a case study on HPAI in SEA: HPAI subtype H5N1, is nowadays endemic in several countries in eastern-south Asia. Surveillance of the virus circulation in poultry remains a challenge: Exporting countries must prove a minimal prevalence in their poultry production chain to be declared free of the virus. To do that, they must prove the quality of their surveillance system. At the same time, the surveillance system must be able to perform early detection and allow controlling disease spread. Classical surveillance systems are expansive and not efficient. Hence, there is a need of new surveillance systems, lighter, cheaper and quantitatively evaluated. In this case study we will evaluate if Capture-Recapture analysis [5, 6, 7] would have helped in the context of the 2004 epidemics of HPAI in northern Thailand (see map Figure 1.).

Add a model of disease control: A surveillance system is often associated to a disease control system. For two reasons we must consider the associated control system when evaluating a surveillance system. The first reason is that the surveillance system is often supposed to perform early detection in order to control the epidemics. Thus, surveillance evaluation must include an evaluation of the couple surveillance/control capacity to limit the spread of the disease. The second reason is that an observation performed by a surveillance system will have an indirect feedback on the disease spread, trough eventual control actions, thus the two systems "surveillance"/"disease spread" can't be considered separately but must be simulated as two coupled systems in interaction trough a control system. We will now work on the introduction of a control model component in our simulation tool.

Conclusion

We built a general framework of a generic and modular simulation tool meant to help surveillance system design. Designers can use this tool to evaluate quantitatively new sampling strategies and to present and discuss these new strategies using didactic visualization features such as dynamic maps.

The tool is still at a prototype stage but the modeling formalism (DEVS), as well as the open source software used for its development make it modular and scalable. It means that any case study developed with it from now on will participate to improve it and complete it.

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Poultry market contact networks in Ethiopia: implications for disease spread and surveillance

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Abstract

Like in other species, spread of disease in backyard poultry population could be potentially affected by movements. Therefore this study was conducted to understand the poultry markets contact structure in market chains from Shashmene to Addis Ababa in Ethiopia during two seasons representing the high (season_1) and low peak (season_2) in poultry movements. During each period data on weekly poultry trade was gathered via structured questionnaires administered to 215 and 109 traders, respectively, on the day of visit. Study revealed networks with weak connectivity. Nevertheless, few markets emerged as more central in the networks and could be focused for targeted surveillance. Equally important is the need for observation at some rural markets, used by farmer-producers for re-stocking, that could also plays role in maintaining disease spread cycle.

Keywords: contact network, market, poultry, Ethiopia;

Introduction

In Ethiopia about 96% of poultry are kept as indigenous chickens in a backyard system [4]and serve as food and source of income for many rural households. Large scale commercial production systems represent less than 2% of the national poultry population. Hence, the bulk of live poultry for marketing comes from the backyard system where chickens are directly supplied by producer-sellers to markets and sold either directly to consumers or to traders who sell them at other markets. Religious festivals periodically shift local demand, prices and quantity of live poultry at the markets [1].

The role of animals movement in disease spread has been demonstrated [6, 7] using network studies, a method which has been used extensively in human epidemiology for predicting the spread of infectious diseases like SARS and AIDS [2, 3]. The method has been also used for poultry movement in Cambodia [9], Vietnam [8] and UK [5]. Understanding of live poultry trade patterns at markets could help in the design of targeted surveillance and could have implication in disease control by facilitating application of policies and strategies to manage risk and prevent spread of highly infectious poultry diseases such as Newcastle Disease (NCD) and Highly Pathogenic Avian Influenza (HPAI).

This paper describes patterns of poultry trade and the application of network analysis methodologies to understand the contact network of poultry markets in the selected study area in Ethiopia during two different seasons of the year 2010.

Materials and methods

The study was implemented on poultry markets in the mid-rift valley areas south of Addis Ababa, down to Shashemene and was complementary to ongoing epidemiological, virological and serological studies on one of the most important poultry diseases, Newcastle Disease.

Questionnaires data collection

A cross-sectional survey was conducted in markets in the South East Arsi, eastern Shoa and eastern parts of Gurage and Silte zones of Ethiopia to evaluate the weekly trading practices during two different season of the year, representing the peak for poultry movement (season_1, around Ethiopian Christmas) and low season (season_2, during extended two month fasting season for Ethiopian Orthodox characterized by abstention from all animal products) in order to appreciate the spatial and seasonal variability of the contact structure (change in the network structures). All the markets were visited within a period of 2-3 weeks to capture representative data for each season.

All traders present at each market on the day of the visit were interviewed. Respondents were asked to provide information on their trading practices: frequency of doing business (regular, occasional), type of poultry products involved (live birds, eggs or both), purpose of visit to that specific market, biosecurity measures practiced at home with poultry and where they sourced and sold poultry during the previous one week period to avoid/minimize recall bias. In addition each market was described in terms of number of producer-sellers and traders present, estimated number of live birds and eggs supplied on the day of visit, and geographic coordinates.

The social network method was used and directed valued networks were drawn using Netdraw in UCINET (Software for Social Network Analysis. Harvard, MA: Analytic Technologies) and parameters were computed in R (R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/). In the networks markets represented the nodes, poultry movements the links between the nodes, and quantity of poultry moved as the value of the link.

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Data analysis

Data on the trade characteristics and market were summarized and presented descriptively. For data on source-destination pairs the quantity of chicken moved via traders was aggregated and an adjacency matrix was built for each of the two seasons (networks). A preliminary analysis of each network in terms of size (number of nodes, number of directed links, and diameter), centrality measures (degree, betweenness and average geodesic distance) and network cohesion/connectedness (density) was done.

Result

Trader characteristics: During the high peak period 215 traders were interviewed, of which 56 (26%) were occasional traders who did chicken and chicken product trading activity for that specific period of time to get a certain profit margin. During the second season of the survey (fasting season) the number of traders present was reduced by half (109 traders were interviewed) (Table 1).

Table 1: Number of traders and trader characteristics during the two seasons of interview

Description		*Number of traders interviewed*		*% trader*	
		Season 1	***Season 2***	***Season 1***	***Season 2***
Traders		***215***	***109***		
Sex	***M***	***192***	***88***	***89.3***	***80.73***
	F	***23***	***21***	***10.7***	***19.27***
Frequency of activity	***Regular***	***147***	***109***	***68.37***	***100***
	Irregular	***12***	***-***	***5.58***	***-***
	Occasional	***56***	***-***	***26.05***	***-***
Product traded	***Chicken***	***156***	***74***	***72.56***	***67.89***
	Eggs	***8***	***8***	***3.72***	***7.34***
	Both	***51***	***27***	***23.72***	***24.77***

N:B: Regular = poultry trade is frequent activity
Irregular = does but not frequently
Occasional = only does the practice during holidays

12.6% and 14.7% of the traders in the two seasons, respectively, were interviewed at least twice in different market places. The average number of traders per market was 7 (range 2-23) and 4 (1-11) respectively. Comparison between seasons using paired sample t-test showed a significant difference (P<0.001) for the two seasons.

Interviews on biosecurity measure concerning whether the traders kept unsold stock at home revealed that 63.2% brought live chickens purchased, or unsold chickens, back to their homes before taking them again to market, usually l-4 days later. Of these, 9.6% reported to have poultry breeding at home. Poultry were usually moved on trucks in batches from the source markets to the selling markets.

Network data analysis: Using the data collected during the two seasons, valued and directed networks were constructed with 55 and 43 nodes and 115 and 82 links respectively (Table 2). 12 nodes were identified as isolate during the 2nd survey. The weekly number of chicken moved through the network for the two seasons was 16,182 and 5,088 respectively, and the average link value was 140 (6-1612) and 62 (2-269) chickens respectively. The network parameters for the two networks are presented in the Table 2.

Table 2: Description of network parameters for the two seasons

Parameters	Season_1	Season_2
Size	**55**	**55***
Number of links	**115**	**82**
Density	**0.039**	**0.027**
Average geodesic distance	**1.57**	**1.73**
Diameter	**4**	**4**
Average degree	**4.18**	**3.8**
Average betweenness	**2.15**	**2.74**

* 12 nodes are isolates (not captured in season_2)

Preliminary analysis showed that the networks had similar diameter but relatively different density, average degree and betweenness. Qoshe, Alemtena and Meki were markets with high betweenness in both seasons while Meki market had the highest out-degree with respect to other markets in the network for both seasons. Markets at Aarsi negele and Ziway also had a high value of betweenness. Akaki, Shashemene and Debrezeit had highest in-degree values during both seasons. Apart from that, there is a bulk of live chicken which are going from markets identified in the network to the capital Addis Ababa, making it also a node with high in-degree values.

Discussion

Approximately twice as many traders were present and were interviewed during season_1 compared to season 2. This is due to low demand for poultry and poultry products during season_2, when traders are not encouraged to do business at full scale moving among all possible markets. This period was also reported as period of low chicken sale and consumption [1].

The networks in both seasons showed low connectivity, having density of 3.8% and 2.7%, respectively. This might be attributed to the fact that there is less movement contact between smaller markets supplied only by farmers, i.e. many small markets are observed to be connected to bigger markets than among themselves in the networks. The network also revealed a higher number of links during season_1 that could be attributed to an increased number of traders in the network diversifying and travelling further than usual to other markets to get more chickens to satisfy demand. The additional occasional traders (26%) during season_1 could have also contributed to the intensification of the links. In season_2 traders were observed to move between markets near to each other, except for a few traders which usually supplied consumers in bigger towns such as Nazreth and Addis Ababa.

The poultry market chain in the study area showed a flow pattern from rural producers to nearby rural markets and then urban markets. Similar movement pattern has been observed in Cambodia [9]. The bulk of the poultry movements end in big urban centers such as Shasmene and Nazreth which were attended by higher numbers of traders and lower numbers of farmer-producers. During interviews process the survey team observed some farmers attempting to get chickens for restocking directly from traders at markets or buying from one another. In addition, we observed also traders buying chickens intended for retail at other markets, for selling to producers for breeding or ritual purposes. These types of practices could have implications for disease spread from market to market and then from market back to villages. In fact, we recorded several claims that some of the poultry disease outbreaks in villages were suspected by farmers to be caused by poultry introduced from markets at a household in a village, and we are investigating this further.

When infectious poultry diseases occur in catchment areas of a specific market, markets with the highest out-degree could serve as points for the spread of these diseases. For the markets sending more chickens to terminal urban markets where they will be slaughtered, implication for disease spread, especially into the backyard production system, is limited. However, markets with out-degree that ends at other markets where producers may buy chicken for re-stocking could have significant implication in disease spread. Ziway is an example of such market, where producers also buy chickens for restocking.

The movement distance for the traders increases during high peak seasons to get access to markets nearer to rural producers, with higher supply and cheaper buying prices. This may facilitate disease spread over longer distances than usual, and the introduction of different strains of viruses to another area. Traders who breeds their own chickens and who are also bringing unsold chicken at home are at higher risk, given low biosecurity practices, and could also serve as source of disease infection to their respective area.

The fact that traders keep poultry together after purchase and during transportation would enable transmission of disease among chickens within batches should a single affected chicken be sold by producers from an outbreak area. The risk of this is intensified during holidays when larger numbers of chickens are coming from villages.

In epidemiological study done under the same framework we have detected NCD virus antigen, through qRT-PCR techniques, from apparently healthy chicken at some of these markets. Virus isolation and characterization is underway. This implies markets are potential sources of the disease and movement via trade can easily take infection from one area to the other.

Therefore, in addition to targeting markets with high in-degree and betweenness as revealed in the network analysis, surveillance should not be neglected at smaller markets (with less out-degree in terms of movement between markets), where producers may also obtain chickens for re-stocking, thereby perpetuating the infectious disease cycle.

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Surviving strategy: a practical guide

K.H. Clift[1]***,** B.R. Gould[2] and P.M. Stevens[3]

Abstract

Strategy development is an essential skill and provides opportunities for us to make a lasting impact through our work. However, this is often not an area of expertise for veterinarians and science based professionals. This paper summarises our experiences in developing a biosecurity surveillance strategy for New Zealand.

Keywords: Strategy, Surveillance, Collaboration, Role of government.

Introduction

As veterinarians and science based professionals working within animal health, we are highly skilled technically - specialists in epidemiology, statistics, disease control and surveillance methods. However, the solutions to the issues we face are not purely technical. We are increasingly required to branch out into new areas of expertise, such as strategic thinking, policy development, legislative change, stakeholder engagement, and strategy development – the focus of this paper. Strategy development is an essential skill and provides opportunities for us to make a lasting impact through our work.

There is no one size fits all approach to strategies and strategy development. But by sharing our experiences in developing a biosecurity surveillance strategy for New Zealand, we hope to assist your approach.

Discussion

Do I need a strategy? Good strategies fulfill a number of purposes; establishing common vision with stakeholders, defining mandate, roles and responsibilities, providing principles for consistent decision making, shaping long term direction and approach, and forming the foundation for action. Some strategies may also include an action plan. The process of strategy development can also be a useful vehicle for enhancing the profile and value of surveillance, gaining high level endorsement for change, and an opportunity to develop and build upon relationships with stakeholders. Strategies are most useful when setting a new direction and undertaking significant change that requires engagement from a wide range of individuals, groups or organisations.

Where do I start? There is never an ideal time to develop a strategy; there are always reasons to defer – more pressing priorities, impacts of other organisational initiatives, lack of resources, *etc*. But the reality is – change or be changed. Strategies provide the opportunity for you to shape the destiny of your organisation and ensure it meets current and future needs.

Strategies are not developed in a vacuum – there are likely to be higher level strategic documents, stated government priorities and policies that will shape and inform your strategy. There may have been previous reviews of your subject area. If a recent review is not available then this is an essential first step, as the review will provide the foundation for the strategy. It also fulfills a critical role of building a common understanding of the problems and the need for change, giving momentum to your efforts and bringing concerned parties together. The review could follow the commonly used S.W.O.T analysis and may include assessment of current and future trends and drivers. The review should be as honest and open as possible. If there are no opportunities for improvement then there is little point in developing a strategy. The challenge in carrying out any review is that it can be problematic for public servants to expose any flaws in current practice. A potential way to manage these risks and any perceptions of bias is to have the review undertaken by external consultants, who are not so constrained, and to include perspectives from your key stakeholders, who will generally not hold back on criticism of the status quo.

Am I up for it? Strategy development requires a commitment and strong leadership. It requires strengths in areas that many technically focused people can struggle with – dealing with ambiguity, managing change, being politically savvy, managing conflict, working across boundaries and also requires adaptability and willingness to admit mistakes. However, this provides a great opportunity for personal growth and development. In addition, you need to infect your team and those that you work with, with the same passion, enthusiasm and commitment as you have. If your team is largely from a technical background, they may also have capability gaps and so you will need to coach, mentor and support your people as they develop new skills. For example, we identified that meeting facilitation, especially for meetings with external parties, was a critical skill for developing the strategy but one where our team lacked confidence. To develop our skills, we organised a dedicated training session with a facilitation expert and matched people's skills and comfort level to their roles in the workshop *e.g.* greeters, facilitator, note takers, main speaker, *etc.*

What's in the strategy? There are a number of key items to consider initially to inform your approach to developing the strategy and the content.

Time frame: How long do you expect this strategy to be current – 5, 10, 25 years or longer?

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Scope: Is this an internal business unit or organisational strategy or is it system wide? What do you do and what do you want to do? Are you focused on farm animals, or does your mandate include wildlife, aquaculture or zoonotic diseases? What is the core purpose of your surveillance function – early detection of exotic diseases, monitoring of endemic diseases, identification of emerging diseases and trends?

Inter-relationships: Surveillance is generally not an outcome by itself – surveillance produces information for action – how does your surveillance relate to other biosecurity areas such as investigation, emergency response, diagnostics, long term disease control?

In terms of content, many strategies follow a similar pattern.

Vision and values: this is an aspirational statement about how the organisation wants to be or how it wants the world in which it operates to be. Describe the values that underlie this vision and what you expect of those individuals, groups and organisations that participate in the work you do.

Context and drivers: specify the factors behind the need for change and how this strategy relates to other initiatives. This needs to be targeted to your audience and also to identify and describe their role.

Goals and expected outcomes: Your earlier review identified the key areas for change that will inform the goals and expected outcomes. These goals will be specific to the challenges you face and the future you want to achieve. For our strategy, the critical areas were leadership, roles and responsibilities, coordination and partnerships, decision making, resourcing, prioritisation, surveillance design and delivery, science and research, information management, engagement and communication. Goals should be attainable but sufficiently different to now. It may be appropriate to have stepped goals with more easily achievable goals sooner, that contribute to later difficult to achieve goals.

Action plan: Strategies must be easily translatable into action plans. The most consistent feedback that we received was, that it was essential to include a high level action plan within your strategy for stakeholders to see how tangible change will be achieved. Without an action plan, the best strategy risks gathering dust on a bookshelf.

The overall look: Strategies should be concise (no more than 100 pages and preferably much less!) and easily readable – a professional editor is essential. People also absorb information in different ways and a mixture of content including text, case studies, pictures and diagrams, high level statements and detail will maximise the impact.

Future proofing: Strategies need to be adaptable – will it stand the test of time? It is essential to get the principles and approaches within your strategy right as these will be the cornerstones that enable consistent decision making, even when there have been significant changes.

How do I manage the work? This is a project and so needs to have a plan, project team, and resources (both dollars and people) allocated. Your organisation may have its own methods for managing projects, but if it doesn't then we would still advocate that taking a project management approach will greatly enhance your ability to deliver the strategy. From our experience, it is particularly critical to demonstrate your commitment and the importance of this work by making the resources available – other work will need to be reprioritised. Be realistic with timeframes and then meet them. The pace needs to be appropriate to the resources that you have and the quality you want in the end product. For example, our initial project plan stated that the strategy would be completed within a 12 month period. However, after we had completed the detailed planning this was extended to 2 years and the strategy was actually delivered in 2½ years.

In addition to the usual components of a project plan, it is especially critical for strategic work that there is a communications and stakeholder engagement plan and effective risk management. There will be successes and failures throughout the project. It is necessary to capture these "lesson's learnt" during the project so that they can be communicated and applied to future work.

Appropriate governance arrangements will need to be put in place. For example, a steering committee. A well set up governance arrangement can be a valuable sounding board and source of advice, championing the work and communicating the change widely, assisting in resolving any barriers or risks and ensuring that the final strategy is fit for purpose.

You are not doing this alone – who is your project team? This may include surveillance experts, project managers and administrators, communications and policy advisers - the larger the project team, the more complex the project management tends to become. The project team may cross boundaries and include people from across your organisation or even outside. There will be times when you need specific expertise and rather than have these as a core part of the project team, it can be more effective to bring in this expertise when required. From our experience it is best to "own" the strategy within the business. Outside consultants can provide valuable assistance but no matter how good, they do not have the depth of understanding, commitment and the long term vision that your team can bring. Involving your team in developing the strategy will result in a much greater commitment to the change and delivering the vision.

Who else needs to be involved and how will I involve them? Firstly, start as you mean to go on. If you need to work much more closely and collaboratively with those outside your organisation then they need to be involved in the development of the strategy. Stakeholder engagement can be exhausting, for your stakeholders and your team – but done well, it can be efficient and highly effective in delivering a strategy that actually will make a difference.

The first step is identifying who these people are, for instance other government agencies, local government, industry bodies, non-governmental organisations, universities, *etc.* Stakeholder analysis will help identify the key players, and their importance to this work and level of influence. How supportive are they now and where do you need them to be in the future for the strategy's vision to be fulfilled? It can also be useful to map out how your stakeholders relate to one another or other projects your organisation is involved in. This provides the basis for developing a specific engagement approach for individual or groups of stakeholders. Some may need only to be kept informed; others may be actively involved in the development of the strategy. We found that the use of small focus groups of key stakeholders was a really effective way of testing the strategies direction and approach before going out for wider consultation.

Be aware of the organisational and political processes that may apply – for instance many governments have specific requirements around public consultation. If you really want to capture people's input then you need to be quite flexible - you may hold workshops or send out consultation documents. Be prepared to also capture informal discussion and feedback. Set aside sufficient time and have the right expertise to assist with the analysis of all the inputs. Stakeholder comments will be contradictory and therefore you need to apply discretion to which changes are made, based on the input. It is a reality that you may receive little positive feedback – most comments will focus on what people disagree with. In meetings and in discussions, be prepared to represent your whole organisation. You may want to talk to a group about your specific strategy, but they may have their own interests and do not easily separate this specific piece of work from other initiatives or issues your organisation is managing. For example, at the same time as our strategy was being developed, there was concurrent consultation occurring on a very controversial initiative. In meetings we needed to manage the questions that arose on both initiatives, while bringing the focus back to the strategy we were developing.

While focusing your efforts on managing your relationships with stakeholders outside your organisation, you need to also keep in mind those that work in areas closely related which may be impacted by your strategy – how are you involving them?

This will be an iterative process – there is no point undertaking consultation if you are not prepared to change the strategy based on the input received. However, you need to decide when enough is enough.

In addition to specific consultation, how do you keep those interested up to date? This could involve a website, newsletters or other communication approaches. For example, we had a progress update table on our website and in our regular newsletters that contained the major milestones of the project and planned completion dates. This was updated as the milestones were completed and we received very good feedback from our stakeholders, as this demonstrated momentum continuing, even if there were few tangible outcomes for months at a time.

The strategy's done – what next? Congratulations - celebrate your success. Hold a launch that provides the opportunity for you, your team and your stakeholders to celebrate this significant milestone.

Implementation planning should be running concurrent to the strategy development. Momentum may be lost if you wait until the strategy is complete before developing the implementation plan. In the plan, it is important to identify "quick wins" – the small tangible changes that can occur quickly and build a record of success that makes implementing larger changes later easier. The implementation may require significant resources – where will these come from? It may be necessary to reprioritise existing activities to undertake new work, gain new funding, increase efficiency in current activities or sharing resources and decisions with partners.

What will be the ongoing governance arrangements that provide oversight and guidance to the implementation of the strategy? This may be quite different to the governance that you put in place for the strategy development and so you need to consider the representation and roles.

In conclusion, the approach taken to developing a strategy is crucial to deliver a fit for purpose strategy that will form the foundation for changing the way surveillance is led, developed, implemented and communicated.

Useful further reading

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REPAMO: A French network for the surveillance of mollusc health

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Abstract

The REPAMO is a French Network for the surveillance of Mollusc diseases that notably meets the obligations of the European Directive 2006/088/EC. It is entirely funded by the French State. The coordination of this network entrusted to the Institut Français de Recherche pour l`Exploitation de la Mer since 1986 aims at monitoring the notifiable endemic diseases, detecting the emergence of exotic or new pathogens and ensuring a minimum level of surveillance of the general health condition of molluscs. Beside IFREMER, different partners are involved in the surveillance of mollusc health at the national level: the Departmental direction for territories and sea who are the local representatives of the competent authority and the producers who have the obligation to notify any suspicion or any abnormal mortality.

The network REPAMO thus relies on active and passive strategies. It collects and manages data related to laboratory tests and information concerning sampling that is recorded in a national not open accessible database (also named REPAMO) to respect confidentiality of some data. Results are analysed and edited at least annually under a report format which is sent to all the network partners.

The test results allow mapping the geographic distribution of targeted pathogens including notifiable ones and have highlighted certain spatio temporal trends in mortality outbreaks.

The network adapts its strategy according to the epidemiological context, the evolution of the production in terms of organisation, quantity and diversity of species, the evolution of the regulation and the knowledge of the diseases it deals with.

Keywords: Surveillance, Mollusc, Pathology, Network.

Introduction

France is one of the first European country producing molluscs. This production relies on more than 3700 businesses [1]. The REPAMO (French Mollusc Pathology Network) is the largest shellfish surveillance network in Europe (in terms of national coverage, total number of tests, number of people involved, and number of species monitored). It was set up in 1986 and is a surveillance network for mollusc health along the coastlines of France, living under farmed or natural conditions. This surveillance mission is carried out by the Institut Français de Recherche pour l`Exploitation de la Mer (IFREMER). It fulfils some of the requirements of the European regulation (Council Directive (CD) 2006/088/EC dated 24 October 2006, 2).

The network functions independently, its funding being ensured entirely by the State. The 55,000 private leases and hundreds of thousands of tonnes of shellfish and natural populations are thus monitored only by public-sector agencies.

The objectives of this network are (i) to monitor the course of notifiable diseases affecting molluscs and present in France (*Bonamia ostreae* and *Marteilia refringens*) (ii) to detect the appearance of emerging or exotic diseases, and then follow their course (iii) to ensure a minimal level of surveillance of the general health of molluscs.

In response to this third objective, two strategies have been adopted.

The first one is active and is based on a routine monitoring of main mollusc species, main diseases and aims at describing the health status of these animals outside mortality outbreak. This monitoring can be planned in advance and since 2004, it has targeted one mollusc species and one disease for two years.

The second strategy to ensure a minimal level of surveillance of the general health of molluscs is passive and is based on the monitoring and investigations of increased mortality which cannot be planned. According to the CD 2006/088, any increased mortality should be notified by the farmer to the competent authority. In the Directive, increased mortality is defined as “unexplained mortalities significantly above the level of what is considered to be normal for the farm or molluscs farming area in question under the prevailing conditions. What is considered to be increased mortality shall be decided in cooperation between the farmer and the competent authority” [2]. This definition suggests the need of having a reference picture of the normal mollusc health situation.

After explaining how the network operates, we will present the types of data collected and give example of results obtained through the network. Lastly, taking into account huge mortality outbreaks that the French oyster production has faced since three years, we will draw some perspectives in order to have a network adapted to this new situation.

Materials and methods

Sampling: A health zoning plan regarding diseases affecting flat oysters has been established for French coastal regions. The zones have been determined according to different criteria: frequency of transfers; hydrological coherence; administrative decision-making unit; data on production of the species; data on

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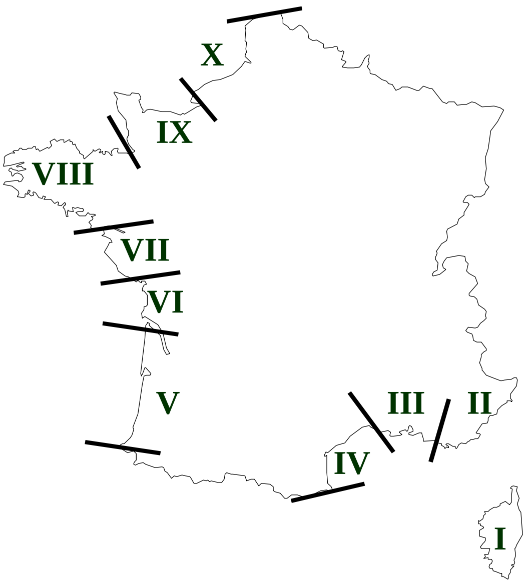
variations in the prevalence of infectious agents; compatibility with control activities. Ten production zones have been used as a starting point for sampling, and then adjusted for each mollusc species (Figure 1).

The epidemiological unit may be a zone, a part of a zone, a concession or an oyster bed, or a wild population. All epidemiological units may be the subject of sampling, depending on the circumstances.

Sampling will depend on the objectives defined above. In order to monitor health status, a minimum sample of 30 individuals per epidemiological unit was defined in the first instance, for each species, age category, and for each major coastal zone. The minimum temporal frequency required for this sampling has been fixed at twice a year, at the end of winter and during the summer, because of seasonal physiological changes. Rises in temperature and the summer reproductive period correspond to a period of increased vulnerability in many molluscs, from which numerous infectious agents profit.

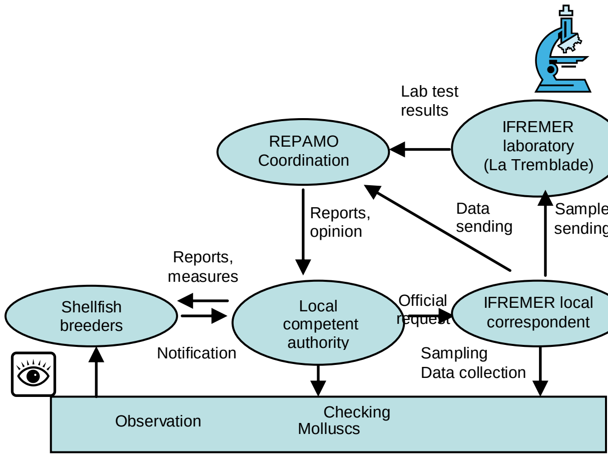
Figure 1: French mollusc production zones where REPAMO sampling campaigns are carried out for the surveillance of bonamiosis and marteiliosis



The study of abnormal mortality is adapted on a case-by-case basis. As a general rule, the greater the suspicion of infection, the more samples will be collected. The sample includes a minimum of 30 individuals.

Operation: The competent authority with respect to mollusc health is the Ministry of agriculture and locally the Departmental directions for territories and sea (DDTM), which calls upon IFREMER for its expertise in this area. The IFREMER coordinates the REPAMO network in response to the objectives fixed by the European Commission, thus ensuring the surveillance of notifiable diseases, routine monitoring of the principal species of commercial interest and study of cases of increased mortality. In addition, IFREMER ensures the testing of all samples collected in the context of the network. If the test results so justify, it is the Prefect for the region who takes the decision to close a production zone.

Figure 2: Operational flow chart for the REPAMO network



The functional relationships between partners in REPAMO are presented in Figure 2. DDTM participate in estimating mortality and collecting samples for the REPAMO network. Within IFREMER 14 coastal units, including 11 coastal IFREMER laboratories, are involved in the activities of the REPAMO network. Within each coastal laboratory, a REPAMO correspondent ensures the collection of samples and background information (using standardized questionnaires), in the context of continuous monitoring and in cases of increased mortality. All test results are centralised by the IFREMER laboratory at La Tremblade. The network also benefits from the application of new diagnostic techniques and advances in knowledge on mollusc diseases achieved by the research team at La Tremblade.

Data collection: The data collected in the context of this network are of two types: the results of laboratory tests, and information concerning sampling collected through standardized questionnaires including estimated mortality rates, production conditions and environmental parameters. Data from the questionnaires and laboratory test results, are stored in the national REPAMO database. Some of this information is subject to confidentiality rules. Data on sampling sites can be transposed onto a geographical information system.

Data diffusion: Local authorithies receive individualised reports. Monthly national bulletins and annual national reports are sent to all the partners of the network including representatives of shellfish breeders. In addition, annual meetings bring together all participants in order to standardise the methods used to collect data at a national level. This meeting includes general information on mollusc pathology, and more practical sessions aimed at ensuring the satisfactory operation of the network. Finally, efforts are made by IFREMER and the authorities to explain the work of the network to producers and thus increase their awareness of mollusc health.

Results

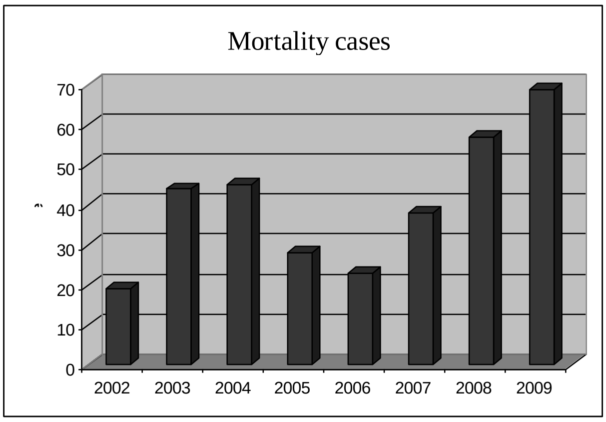
The network produces test results on between 2,000 and 4,000 shellfish a year. The number of tests carried out notably depends on the number of mortality cases notified each year. The number of mortality cases investigated by the network has particularly increased since 2008 (Figure 3) reflecting the crisis affecting the French production of Pacific cupped oyster, *Crassostrea gigas*. The tests performed in the context of the network have allowed to determine the status of the ten zones regarding *Bonamia ostreae* and *Marteilia refringens*. These two protozoans have been detected in all the zones except in zone X. Test results have also in some cases made it possible to discover infectious agents that are associated with mortality (*e.g.* OsHV-1 and *Vibrio* strain in *C. gigas*) or to demonstrate the presence in France of infectious agents previously considered to be exotic (*Bonamia exitiosa*).

Network activities also permit the collection of isolates to test new diagnostic tools, and increase the availability of equipment to establish pathogen taxonomy (*e.g. Vibrio* strains, 3).

Moreover, the work of this network has highlighted certain trends in mortality outbreaks and notifiable diseases:

- potential spatial trends, with summer mortality occurring along the French coastline according to a South-North gradient [4].
- greater susceptibility of flat oysters *Ostrea edulis* to bonamiosis with age [5];
- presence of *Perkinsus olseni* in four clam production areas in France [6].

Figure 3: Number of mollusc mortality cases investigated by the REPAMO between 2002 and 2009



Discussion

The REPAMO was set up in 1986, that means before the implementation of the first EU regulation related to aquatic animal health surveillance (Council Directive 91/67/EEC). Since that time, the context has changed. Close links with research are essential notably to improve the diagnosis of targeted pathogens; Local epidemiological studies are necessary to optimise the sampling strategy and enable a clearer understanding of the results generated by the network. Shellfish production is developing rapidly, and the numbers of live animals shipped within, and outside, the EU for re-immersion are constantly growing, as is the share of hatcheries (in addition to natural capture) in the production of spats. In this context, the network also needs to evolve, by applying an appropriate strategy to prevent the propagation of serious mollusc diseases in all French coastal regions through the transfer of infected animals, as has happened in the past.

In the summer of 2008, 2009 and 2010, severe mortality events in cultured Pacific oyster were reported from France and other main European producing countries. The available evidence suggests that infection with the Ostreid Herpes virus type 1, and especially the variant OsHV-1µvar, is a necessary cause but may not be a sufficient cause [7]. The network REPAMO was highly involved in the epidemiological investigations carried out to better understand this crisis.

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Surveillance for ISAV HPR0 Occurrence in Maine USA: The Sufficiency of Imprecise Data

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Abstract

An apparently non-pathogenic variant of Infectious Salmon Anemia Virus (ISAV), termed HPR0, is known to occur in many salmon farming regions worldwide. Internationally, certain ISAV surveillance programs have evolved to include methods with greater sensitivity for HPR0 detection. However, HPR0's significance to the epidemiology and spread of ISA disease is a topic of current debate. We examined data on HPR0 occurrence in the Quoddy Region of Maine, United States (U.S.) to infer its apparent distribution, its potential significance to ISAV control, and the need for modification of ISAV surveillance strategies to improve detection of HPR0. We conclude with evidence of a hydrographic pattern to HPR0 spread; and recommend further research, but not enhanced surveillance, on HPR0 in the shared waters of the Quoddy Region in the U.S. and Canada.

Keywords: value of surveillance, infectious salmon anemia, spatial analysis, aquatic animal disease.

Introduction

An apparently non-pathogenic variant of Infectious Salmon Anemia Virus (ISAV), termed HPR0, is known to occur in many salmon farming regions [1, 2, 3]. HPR0 has been detected during surveillance secondary to outbreaks; it has also been found in regions that have not yet experienced an outbreak. Whether HPR0 occurrence follows infection, is a precursor to infection, or is an entirely separate event, is unclear. Internationally, certain ISAV surveillance programs have evolved to include methods sensitive to detection of HPR0. However, HPR0's significance to the epidemiology and spread of ISA disease, and thus the value of any modifications to surveillance, is a topic of current debate.

ISAV surveillance in the Quoddy region of northeastern U.S. and Canada is targeted and very effective at early detection of pathogenic genotypes. Though focused on moribund fish, RT-PCR detections of a non-pathogenic HPR0 genotype do periodically occur within this system. However, concurrent virus isolation or clinical disease is a necessary for confirmation of ISA per U.S., Canada or OIE Aquatic Animal Health guidelines, neither of which is yet demonstrated for HPR0. And, other than increased monitoring, detection of a non-pathogenic genotype does not typically initiate a control response.

Given that ISAV surveillance methods are not honed to HPR0, it is likely that HPR0 occurrence is under-represented in this region. However, modifying sampling and diagnostic protocols to improve HPR0 sensitivity would add uncertainty (additional suspect findings) as well as additional cost to the ISA surveillance program, with unclear advancement in control. To explore rationale for expanded surveillance, we examined data on HPR0 occurrence in the Quoddy Region of the U.S. to infer its apparent distribution and potential significance to ISAV control. We consider the sufficiency of HPR0 under-representation in the U.S. surveillance program; and whether surveillance should be modified in the U.S. and Canada to ensure more sensitive detection of HPR0.

Materials and methods

Surveillance data from all U.S. sites in the Quoddy Region stocked with Atlantic salmon at any time from May 2002 to end November 2010 were included in this analysis. Surveillance data, including sites visited, samples collected and test results, are routinely compiled at the ISA Program offices. Exact stocking and final harvest dates are known with less certainty, but can be inferred from the dates of 1st and last veterinary inspection. Veterinary inspections of active Atlantic salmon marine farms are required on a monthly basis. At each inspection, kidney samples from up to 10 moribund fish are submitted for ISAV diagnostics. Diagnostics include RT-PCR on all samples, with archived IFAT smears reserved for confirmation testing. Tissue samples for virus isolation are collected on re-test visits following positive RT-PCR findings. Two tests positive on two fish from any given cage constitutes confirmation of ISA infection and leads to mandatory depopulation of the infected cage. Infected sites, sites near to infected sites, or suspect sites with less than the requisite number of positive results, are re-sampled on a weekly or biweekly (rather than monthly) basis.

This strategy has contributed to the successful control of ISA outbreaks in Maine and New Brunswick [4]. However, the strategy's value in HPR0 detection is uncertain. Gill tissues, preferred for HPR0 detection [3], are specifically excluded from U.S./Canada surveillance plans, as positives can result from surface contamination. RT-PCR primers targeting segment 6 are only used as follow-up to segment 8 detections, which are not as sensitive to HPR0. Similarly, weak positive RT-PCRs are sequenced when possible to confirm or refute HPR0; though, often HPR0s do not produce a strong enough copy number to sequence.

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[2] USDA APHIS Veterinary Services, Infectious Salmon Anemia Program, Maine, U.S.A.
[3] New Brunswick Department of Aquaculture and Agriculture, 107 Mount Pleasant Rd, St. George, New Brunswick, Canada E5C 3S9.

Consequently, we presume that the current methods detect only a fraction of probable HPR0 occurrence. However, the frequency and quantity of surveillance data in the Quoddy region, presuming there is not a bias in selection strategy, should allow consistent predictive patterns to emerge over time.

Tidal excursion models are available for the U.S.-Canadian (Quoddy) region [5]; tidal excursion models are not, however, available for sites further south and west. We conducted a proportional hazards survival analysis (SAS Version 9.2, SAS Institute, Cary, N.C., USA) on surveillance data from the U.S. side of the Quoddy region to examine hydrographic clustering of HPR0 occurrence and potential predictive relationships with pathogenic ISAV. Upstream variables were created to denote whether any sites linked hydrographically, i.e., within one tidal excursion, were found ISAV positive at any time during an overlapping production cycle. Spatial groupings were represented by hydrographic patterns modeled and described elsewhere [5, 6].

Considered predictors of time to HPR0 occurrence included samples submitted per month, pathogenic ISA upstream occurrence, HPR0 upstream occurrence, and pathogenic occurrence on site. Considered predictors of pathogenic ISAV occurrence included samples submitted per month, pathogenic ISA upstream occurrence, HPR0 upstream occurrence, HPR0 occurrence on-site. ISAV occurrence variables were dichotomous, representing whether the named genotypes occurred at any during the production cycle in question. We forced inclusion of the monthly submission variable to address detection bias introduced by variability in sampling effort across sites and production cycles. Other predictive variables were retained or removed by a process of backward elimination. Dependent variables representing HPR0 occurrence and pathogenic ISAV occurrence were evaluated separately.

Result

Detections of HPR0 are fairly broadly distributed across the coast of Maine; pathogenic ISAV findings, in contrast, have been limited to the northeast region abutting Canada (Figure 1).

Though HPR0 occurrence is widely distributed geographically in Maine, survival analyses were limited to the Quoddy region where tidal excursion data are also available. The U.S. Quoddy region dataset totals 24 year-class/site Atlantic salmon cohorts for survival analysis.

Survival analysis results suggest a hydrographic pattern of spread for both pathogenic and nonpathogenic genotypes in the U.S. Quoddy region. However, current data do not indicate whether either genotype strongly influences the other's occurrence. Specifically, a site is more likely to be HPR0 positive if upstream sites are also HPR0 positive at any time during its active (stocked) period. Similarly, a site is more likely to be confirmed pathogenic ISAV positive if upstream sites are also pathogenic ISAV positive during its active period. However, although univariate analyses suggested a significant association between on-site pathogenic and on-site HPR0 occurrence, this effect was lost in combined analysis with other predictors. Rather, in the full multiple variable model, correlation between nonpathogenic and pathogenic genotype occurrence is not significant. This is the case whether sample volume is or is not included as a covariate, though correlation between genotypes is stronger when sample volume is excluded.

Figure 1: 2002-2010 summary of the spatial distribution of ISAV HPR0 and pathogenic genotypes in Maine. HPR0 is widely distributed. However, pathogenic ISAV genotypes have only been found in the northeast section of Maine, abutting Canada, termed the Quoddy region. Yellow circles represent sites of HPR0 detection; green triangles represent sites of confirmed pathogenic ISAV findings; black dots denote Atlantic salmon sites unaffected by either genotype.

Table 1: Maximum Likelihood Estimate results from proportional hazards analysis of HPR0 survival data. Upstream pathogenic occurrence and on-site pathogenic occurrence were removed from the full model (p values > 0.2).

Predictive variable	Hazard Ratio	Chi-sq	P value
Samples per month	1.1	2.4	0.12
HPR0 upstream	7.1	4.6	0.03

Table 2: Maximum Likelihood Estimate results from proportional hazards analysis of pathogenic ISAV survival data. HPR0 upstream occurrence and on-site HPR0 occurrence were removed from the full model (p values > 0.2).

Predictive variable	Hazard Ratio	Chi-sq	P value
Samples per month	1.1	9.3	< .01
Pathogenic ISA upstream	5.1	3.8	0.05

Discussion

The current analysis depicts a hydrographic pattern to HPR0 spread. A previous study of ISA outbreaks found hydrographic patterns in pathogenic ISA spread [6]. The previous study, which did not include HPR0 findings, predicted a relatively short lag period (within 1 month) for hydrographic spread of pathogenic ISAV; likely in part due to the rapid removal of pathogenic ISAV-affected cages. We allowed for a longer period of influence (the entire production cycle) in the current analyses, as HPR0 findings are both under-represented with the current detection methods and do not result in depopulation. The relatively broad spatial occurrence of HPR0 (yet confined occurrence of pathogenic genotypes), the data sufficient in quantity to detect hydrographic patterns, and a concurrent absence of a clear association with ISA disease outbreaks, provides preliminary support for the conclusion that HPR0 is not a key factor in ISA disease control.

However, while the analyses suggest hydrographic patterns in HPR0 occurrence, the sensitivity and power (sample size) of the current dataset limit our ability to detect predictive relationships of lesser strength. Consequently, analyses of greater breadth, volume or sensitivity may detect associations not apparent in the current analyses. We intend next to combine U.S. and Canada data to expand this analysis to a broader region. Similarly, an expanded surveillance effort, modified to improve HPR0 sensitivity, could also provide stronger evidence to support or refute these preliminary conclusions. However, enhancing surveillance to improve HPR0 detection would likely increase the volume of tests, tissue types and number of suspect sites requiring up-scaled monitoring, without tangible improvement in disease control.

Ultimately, the need for more precise HPR0 data depends on the objectives of the surveillance effort. Over the long term, the accumulated data available from routine surveillance in the U.S. appears sufficient to provide baseline knowledge of HPR0 occurrence. It is also likely that current surveillance efforts are sufficient to monitor for large-scale changes or drivers in HPR0 occurrence, as exemplified by the hydrographic relationships suggested in this analysis. Further, as the current ISAV surveillance system is already very successful at early detection of ISA disease, any enhancements to improve HPR0 detection are unlikely to facilitate disease control.

However, it is possible that additional efforts to detect HPR0 would improve epidemiologic understanding of ISAV risk pathways and details of spread. And, although the current analyses do not demonstrate a predictive relationship between HPR0 occurrence and eventual disease, the association of both types with sample volume may confound interpretation. Furthermore, the potential for deletion or insertion events to lead to new ISAV genotypes is well recognized [1, 2]. Consequently, while we conclude that the current surveillance strategy is sufficient for ISA disease detection and control, we recommend that HPR0-specific investigations are conducted on a limited or periodic basis to address research questions or regional concerns.

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Epidemiology Informs Policy Regarding Surveillance of a Notifiable Disease of Salmonids

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Abstract
A surveillance scheme supporting an eradication programme for Bacterial Kidney Disease from Scottish salmonid aquaculture has been investigated. A scheme to control rather than eradicate the disease is being adopted as a result of the review.

Keywords: *Renibacterium salmoninarum*, Bacterial Kidney Disease, rainbow trout.

Introduction

Bacterial Kidney Disease (BKD) is an infectious, chronic, and systemic condition of the Salmonidae with the potential to cause high mortality. The causative agent, the gram positive bacterium *Renibacterium salmoninarum*, can persist subclinically for at least many months and possibly years. The occurrence of BKD in Scotland has changed from being a disease of wild atlantic salmon (*Salmo salar*) when first discovered in 1930 to being a disease of farmed salmonids as aquaculture has developed. A review of BKD including epizoology and control is available [1].

The United Kingdom (UK) was granted ‘additional guarantees’ for BKD in 2004 for a limited time on the condition that an approved programme to control and eradicate the disease was implemented in those territories, which included Scotland, where it was known to occur (European Union Commission Decision 2004/453/EC). It is likely that BKD can be controlled by identifying populations as they begin to show symptoms of the disease. In contrast eradication may have to focus on identifying infected populations before disease symptoms become apparent.

Marine Scotland Science, formerly Fisheries Research Services, has investigated the surveillance scheme used in Scotland prior to the expiration of the current additional guarantees. Disease control and eradication can only be justified if the commercial and welfare benefits exceed the costs of an eradication programme which are borne by both industry and government. While many of our results are being disseminated in specialist publications this conference offers an opportunity to bring them together to show how they are being used to inform a policy decision.

Materials and methods

Farmed fish investigation: The results are based on a single rainbow trout (*Oncorhynchus mykiss*) cage culture farm located in a freshwater loch. The farm, which used a continuous production cycle, had been subject to statutory movement restrictions for many years following occasional outbreaks of BKD. The results of a preliminary screen a month before the start of the study indicated that the farm was still infected with *R. salmoninarum* although, to the best of our knowledge, no outbreak of BKD had occurred while any of the fish used for the study were on site. Kidney tissue from 2700 fish from seven cages was sampled and tested using procedures based on bacterial culture, the enzyme–linked immunosorbent assay (ELISA) and the quantitative real-time polymerase chain reaction (qPCR).

Wild fish investigation: Kidney tissue from a total of 1,332 wild salmonid and non-salmonid fish caught from the loch in which the study farm was situated was tested for *R. salmoninarum* using qPCR. Escaped rainbow trout are not included in the analysis.

Results

Diagnostic test sensitivity and specificity: Asymptomatic fish were tested individually and in grouped pools of five. The individual level tests have high diagnostic specificities which range from greater than 98.9% for qPCR to greater than 99.9% for culture and an intermediate value of 99.9% for ELISA. Diagnostic sensitivities range from 9% for culture to 94% for qPCR with an intermediate value of 23% for ELISA.

The pooling of fish into groups prior to testing is likely to be more cost efficient when surveillance is intended to detect infected populations. Pooling samples may also improve the diagnostic specificity of testing at the population level. Estimates of diagnostic sensitivity for fish pooled into groups of five were estimated for the ELISA and qPCR test procedures; culture is carried out on individual fish only. The process of pooling is likely to result in a substantial dilution of the molecules detected by each test. This is because the estimated prevalence of infected fish on the farm is low (≈2.5%) and, given that the infected fish are asymptomatic, pooling is random. There is a linear relationship between the ELISA optical densities (OD) of pools and expected values based on the OD of constituent individuals with a gradient of 0.959±0.009. Pooling therefore reduces the chance that the OD of a pool containing an infected individual will exceed the threshold required to identify it as positive. The diagnostic sensitivity of the ELISA test procedure for the study farm was reduced to 6%.

In theory the response to dilution of qPCR should not be as marked as for ELISA. The polymerase chain-reaction process involves the repeated non-destructive replication of a target DNA molecule resulting in an exponential increase in signal. The diagnostic sensitivity of the qPCR test procedure for this farm was reduced to 36%. This reduction appears to be associated with stochastic variation around the detection threshold.

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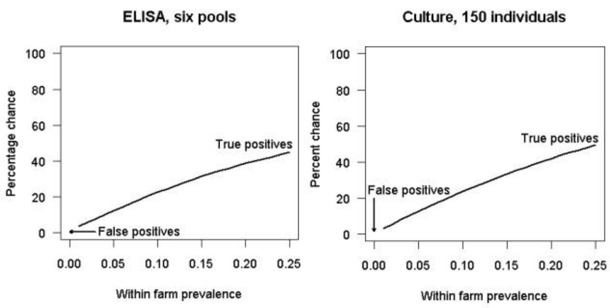
Sensitivity of the surveillance scheme: Farms infected with *R. salmoninarum* but not experiencing BKD are identified using samples taken from 30 fish once every two years. These samples are pooled into groups of five and tested using ELISA. One or more positive ELISA tests raises a suspicion of infection and the temporary suspension of live fish and gamete movements on and off the farm. Samples from a further 150 fish are then collected and tested individually using bacterial culture. Movement restrictions are removed if these tests are negative but are confirmed if *R. salmoninarum* is successfully cultured. A farm has to eradicate *R. salmoninarum* before confirmed movement restrictions can be revoked. A more detailed description of the surveillance scheme is available [2].

There have been 1096 visits to 483 farms involving statutory testing for *R. salmoninarum* since additional guarantees were granted in 2004. Confirmed movement restrictions were imposed on five farms which were not previously covered by restrictions at the introduction of additional guarantees and for which there was no suspicion of disease prior to the visit.

Graphs illustrating the sensitivity of the ELISA and culture test procedures for a range of within-farm prevalences are presented in Figure 1. The estimates of sensitivity for the ELISA test takes into account the change in dilution of the antigen as well as the probability of one or more positive test results as prevalence increases. A positive result for both ELISA and culture are needed before movement restrictions are confirmed. The probability that movement restrictions would have been confirmed on the study farm at the time of our study, if they had not already been in place, is approximately 2%. This suggests that the surveillance scheme is sub-optimal.

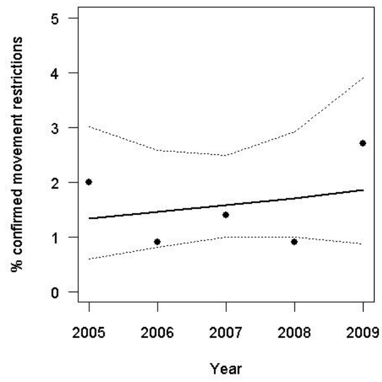
Figure 1: Sensitivity and specificity of the ELISA and culture test procedures as used in the surveillance scheme



In contrast 16 confirmed movement restrictions have been imposed following suspicion of disease over the same period. It is likely that the surveillance scheme is substantially better at detecting farms affected by BKD than asymptomatic *R. salmoninarum* infected farms.

Confirmed movement restrictions imposed over time: A reduction in the proportion of new confirmed movement restrictions imposed each year would be consistent with progress towards eradication. The percentage of inspected farms issued with a new confirmed movement restriction each year is presented in Figure 2. Only complete years are included because BKD is seasonal with the majority of outbreaks occurring in the spring. Predicted values and 95% confidence intervals from a logistic regression are also plotted. There is no evidence of a change in the proportion of newly imposed confirmed movement restrictions over time (estimate of 0.08±0.17). While the time-series is short the result is consistent with a lack of progress towards eradication but with control of the disease.

Figure 2: Confirmed movement restrictions imposed as a percentage of farms undergoing inspection each year



Infection in wild populations: Two *R. salmoninarum* qPCR positive pools were obtained from non-salmonid species caught in the loch in which the fish farm is located. Positive *R. salmoninarum* screenings for wild salmonids and non-salmonids in the UK have also been recently reported [3]. These observations raise the possibility that there is a reservoir of *R. salmoninarum* infected wild fish which could infect farms, although evidence that this actually happens is not available.

Discussion

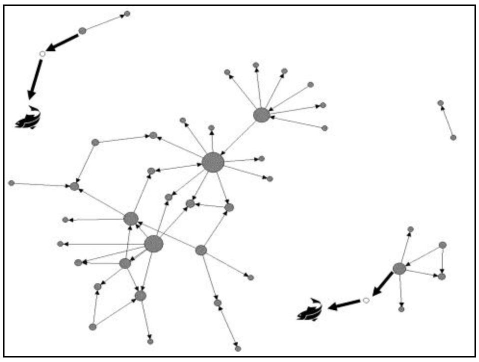
The surveillance scheme implemented to conform to additional guarantees was based on previous schemes for Viral Haemorrhagic Septicaemia and Infectious Haematopoietic Necrosis as specified by the European Commission (European Communities Commission Decision 2001/183/EC). The number of fish sampled appears to be based on sample sizes estimated in 1973 on the assumption of a within farm infection prevalence of 10% and a diagnostic test sensitivity and specificity of 100% [4]. It is unlikely that the surveillance scheme used for BKD eradication would have detected infected fish on the study farm at the time of sampling because the:

- prevalence of infected individuals on this farm was considerably lower than 10%;
- diagnostic test sensitivity is considerably lower than 100%.

An important question for any study based on a single rainbow trout farm is the extent to which the results can be generalized to salmonid aquaculture in Scotland. Although infected with *R. salmoninarum* the study farm was not experiencing an outbreak of BKD at the time of sampling. It is unlikely that this farm was sufficiently different from other infected but asymptomatic rainbow trout farms as to seriously underestimate the sensitivity of the surveillance scheme for farms undergoing a statutory inspection. It is likely, however, that the probability of detecting a rainbow trout farm undergoing an outbreak of BKD is higher than described in this report. This could be because of either a higher bacterial burden experienced by clinically affected individuals and/or a higher prevalence of infected individuals on such farms. It is also possible that the sensitivity of the surveillance scheme for salmonid species other than rainbow trout is different.

At the very least these results suggest that infected asymptomatic rainbow trout may compromise efforts to eradicate BKD. Infected rainbow trout farms represent a reservoir of infection which could infect other salmonid farms. This could occur through fish movements between farms and/or the sharing of watercourses. First, an analysis of fish movements between farms in Scotland [5], a part of which is shown in Figure 3, suggests that although there are relatively few connections between rainbow trout and atlantic salmon farms, the possibility of infection being transmitted between the species cannot be discounted. Second, although *R salmoninarum* is not thought to be a normal part of the aquatic environment it does have the potential to survive outside fish for a limited time (reviewed in reference 1). This raises the possibility that infection could be transmitted between rainbow trout and atlantic salmon farms if they share a watercourse.

Figure 3: Network of movements for 45 rainbow trout farms in 2003 (adapted from reference 5)



- ● rainbow trout farms
- ○ mixed rainbow trout and atlantic salmon farms
- atlantic salmon farms

There are two ways of solving the problems of this surveillance scheme. The first is to change the surveillance scheme so that it is sufficiently sensitive to allow progress towards eradication. Changing the surveillance scheme so that 150 fish are sampled during a statutory inspection and testing individuals (rather than pools) using qPCR and ELISA would increase the diagnostic sensitivity to approximately 55%. While this is a substantial improvement in diagnostic sensitivity it is not certain that it would lead to eradication, there may be an increased risk of false positives, and it could increase costs to both industry and government. The possible presence of infected wild fish may also undermine attempts to eradicate BKD since re-infection from wild stock cannot be discounted. The second option is to adopt a policy of disease control rather than eradication. This would involve surrendering additional guarantees since they are only available for programmes intended to eradicate disease. Discussions are ongoing with stakeholders to agree a suitable surveillance scheme to allow control rather than eradication.

This work demonstrates that ongoing research is a necessary part of the surveillance process. Surveillance schemes are designed using information and guidelines available at the time of their inception. Improvements in knowledge are able to inform both the rationale and design of such schemes.

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Prioritization of animal disease surveillances using a positioning map

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Abstract

Japanese animal health authorities maintain nationwide animal disease surveillance programs targeting 20 animal diseases currently. The recent increased concerns against food safety have demanded intensive surveillances for many animal diseases including zoonoses. On the other hand, due to the limitation of budgetary resources, rationalization of surveillance programs by prioritization of targeting diseases becomes crucial issues for animal health authorities. The purpose of the present study is to propose transparent and logical framework for prioritizing surveillance diseases using a positioning map.

In order to evaluate the relative importance of surveillance diseases, we modified the positioning map by considering two dimensions (evaluation axes), "importance of disease" and "surveillance efficacy". Then evaluation facotrs were developed using analytic hierarchy process (AHP) through the investigative committee with experts consisting of prefecture veterinary officials and researchers on veterinary epidemiology. Pairwise comparisons are conducted for determining a weight for each evaluation factor. Reflecting these weights of the factors, relative comparison of the surveillances was made possible on the positioning map.

Although there still needs more consideration on validation methods, we believe that the developed approach is highly transparent and could be utilized by the decision makers reflecting the opinions of different stakeholders.

Keywords: prioritization of surveillance, analytic hierarcy process, positioning map.

Introduction

The onslaught of livestock infections disease (hereinafter referred to as "infectious disease") and its spread within a country affects not only the related industry, but also have a major impact on local economy, environment, and human health. The recent foot and mouth disease outbreaks in Asia and Europe affected not only farmers but inflicted great social and economic losses. Furthermore, the occurrence of zoonoses, such as bovine spongiform encephalopathy (BSE) and highly pathogenic avian influenza (HPAI), highlighted the issues from the perspectives of public health and food safety, attracting social attention. On the other hand, as the global migrations of people and goods have increased today, the risks of disease spreading across borders in a short time have also increased. Therefore, the surveillance has been gaining its importance.

While the significance of surveillance is getting acknowledged, the financial resources and personnel of active surveillance are limited. Because of this, there is a need to prioritize and optimize the overall surveillances by developing strategies, such as allocating resources in accordance to the priority level. In doing so, different factors need to be considered in a comprehensive manner, including economic loss of farmer, impact on local industry, public health concerns, and social concerns in addition to factors relating to surveillance design.

Often companies develop strategies on how to invest with limited funds to promote continuous business growth. Positioning map and analytic hierarchy process (AHP) are the primary methods used to develop such strategies. Positioning map is a method that uses two axes to illustrate the relative position of the business in the market and its growth prospect. This makes it possible to develop future business strategies by clarifying the needs to be focused or selected. AHP, meanwhile, is a decision-making method developed in the social science and is useful for solving complex issues consisting of the multi-criteria structures[1)-3)].

This study aimed to develop a framework that comparatively evaluates surveillances by applying the positioning map and AHP to build an appropriate surveillance strategy. By creating a positioning map, the relative relationship between surveillance with higher priority and surveillance needed to be improved can be clarified. The AHP method was used to achieve the quantitative evaluation of the characteristics of surveillance. The AHP gives an overall assessment of a wide range of factors including cost of surveillance, items such as precision and effectiveness, effects of disease on farmers and related industries, and effects on human health. Using this framework, an experimental evaluation of the infectious disease surveillances currently conducted in Japan was carried out for the validation.

Materials and methods

An investigative committee was organized to create the present framework for evaluating active surveillance. In order to reflect opinions of different sectors, members consisted of prefectural veterinary officer in charge of control measures on the field, researchers in animal health or veterinary public health, and those from a private think-tank. The members were explained the goal of this study and the existing surveillances managed by the government in advance in order to equalize the degree of knowledge.

First, the two evaluation axes of the positioning map were discussed in the investigative committee. The items of the axes were decided based on the objective to create a two dimensional (2D) map that could

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adequately evaluate the usefulness of the current surveillances and the necessity of the continuation of ongoing surveillance. Furthermore, the characteristics of each quadrant divided by the two axes were interpreted.

In order to quantitatively evaluate the two axes, factors that construct each axis were set hierarchically using AHP. During this process, considerations were given so that the factors in the same hierarchy level were independent each other. In order to prioritize the set factors of evaluation according to their importance, a pairwise comparison of all the factors in the same hierarchy level was performed. This pairwise comparison was practically performed by each member of the committee. Then along with the results, evidence was submitted to the authors. The authors organized and reviewed them to come into an agreement at the following committee. Finally, a value was decided for each comparison and based on it each factor was given a wight. Finally, the lowest hierarchical factors were scored by a 5-level evaluation. The scoring results will be expressed on the 2D positioning map reflecting the weight. In order to investigate the usefulness of this framework, several surveillances currently conducted in Japan were evaluated and the validity of its placement on the map was investigated.

Results

The investigative committees for constructing the framework were held twice, November 2010 and January 2011, while there were frequent exchanges of opinions through email in the time between. The evaluation axis of the positioning map was decided on two items, "the importance of the disease" and "surveillance efficacy". Of the four quadrants on the positioning map, the surveillances, which were evaluated high on both quadrants (the importance of the disease, and the efficacy of the surveillance) were classified as "surveillances that should be continued". The surveillances which were evaluated high on importance of the disease, but low on the surveillance efficacy were classified as "surveillances that should be continued after making improvements on their method", and the surveillance which were categorized as low on importance of disease but high on surveillance efficacy were classified as "surveillances that should be preferably maintained according to the budget". The surveillances that were evaluated as low on both importance of disease and surveillance efficacy were classified as "surveillances that should be discontinued".

The following three factors were set for evaluating the axis item "importance of the disease": the effect on farms, the effect on consumption and related industry, and the effect on the international society. For the item "surveillance efficacy", the following three contents were set: operating costs, precision, and effectiveness. Furthermore, in order to evaluate each of the factors, two to three sub-factors were set. The structure of the present framework including the axes and factors along with the weights calculated by the pairwise comparison are shown in Figure 1.

Figure 1: The structure generated by AHP for the evaluation of surveillance.

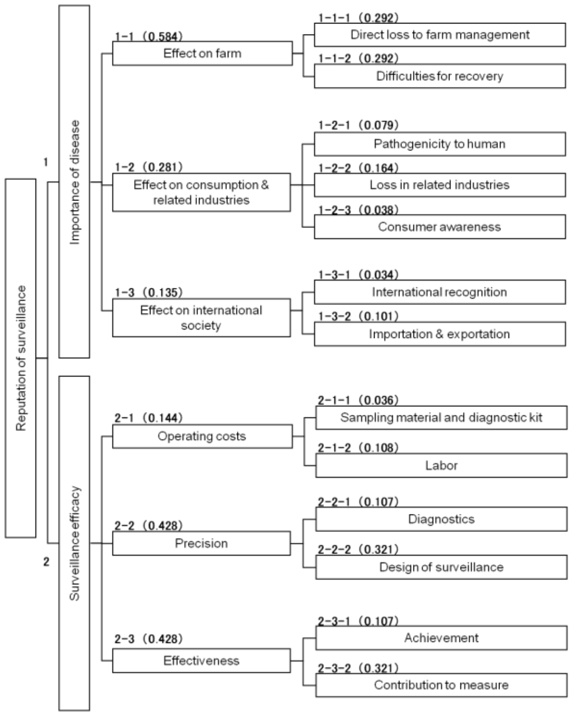
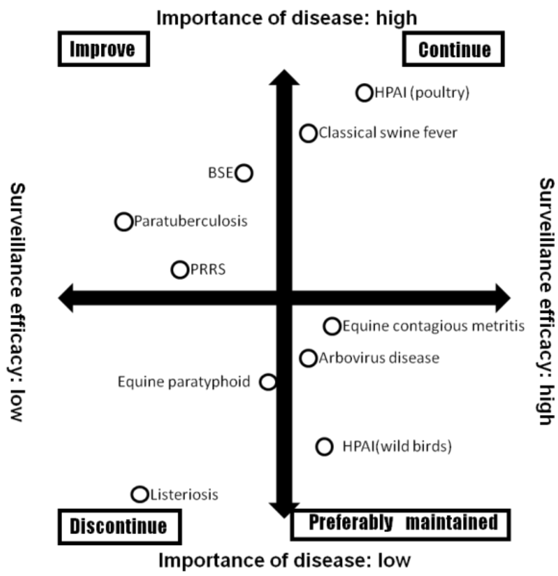


Figure 2: The composition of the positioning map and the positioning results of several surveillances.



The results of evaluation for several surveillances currently conducted in Japan are shown in Figure 2. The "importance of the disease" for HPAI and classical swine fever was evaluated as high, and the surveillance system currently used was evaluated as highly efficient. However, the surveillance on BSE, paratuberculosis and porcine reproductive and respiratory syndrome (PRRS), which were categorized as highly important diseases, were evaluated as needing improvement in the surveillance method. On the other hand, effective surveillances were conducted for diseases that were relatively less important - equine contagious metritis, arbovirus infections, and HPAI in wild birds. It was evaluated that the implementation of these surveillances should be reviewed, in accordance with the financial situation or any rational demands. Surveillances on equine paratyphoid and bovine listeriosis were evaluated to be both low in importance and efficacy. Therefore, it was evaluated as not having sufficient reason to continue with the current methodology. Although there were some rooms for discussion on the distance from the origin to each point given to the surveillance on the map, it is considered that valid results were earned from the quadrants placed.

Discussion

The framework that was developed for this study was designed to assist the optimization of current surveillance system in Japan. By creating a positioning map utilizing two axis items including the importance of the disease and the surveillance efficacy, a visual representation of the relative relationship of the surveillances became possible. The advantage of utilizing a positioning map is to clarify the target to select and to focus. With those surveillances that were evaluated as low efficacy and not cost-effective, in particular, this method can determine that they need urgent improvement strategy reviews. In fact, there is a large budget being invested in the surveillance of BSE and paratuberculosis. It is believed that in the future, investigations on increasing the efficacy of these surveillance systems, based on improvements in diagnostic method and risk assessment, will be needed. In addition, the surveillances that were evaluated as low in importance and efficacy must be considered for reduction or discontinuation while incorporating the opinions of the stakeholders.

In this study, social scientific approach was adopted, where the evaluation was conducted based on the expertise of the participants (knowledge, experience, intuition). Therefore, the selection of the experts who will be involved in the decision making process became important. When evaluating an animal disease surveillance, veterinary knowledge, such as the characteristic of diseases and the pathogenic agents, method of surveillance, and sampling methods, are essential. Furthermore, when there is a outbreak, it is essential for the expert to have knowledge in damages that a farm may receive, the effect on related industries and society, and health effects on humans. In this study, as experts who satisfy the above categories, veterinarians and researches were selected. In the future, if we were to aim to establish a consensus formation from a larger scope of viewpoints, there may be a need to select for various stakeholders, such as from administrative officers in charge of disease prevention, representative of from a producer's group, and representative of general consumers.

It is essential that those who participate in the discussion have basic knowledge of infectious diseases and those surveillances. One must also keep in mind that in the early stage of the decision making process, the participants tend to be more concerned on the topic that are relevant to them. For an example, a veterinarian who is working in the disease control of the animal health field will be more concerned on effects on farms. Public health experts will be more concerned about the human health effects. Therefore, when conducting AHP, it is important for evaluators to strengthen mutual understanding. In order for evaluators to make appropriate judgment, it may be beneficial to provide objective data as background information.

It is difficult to make the most optimal decisions when conducting evaluation on infectious disease prevention, including surveillance, because the requirement of knowledge on animal health, public health, and social economy are needed and various stakeholders are involved. The framework that was developed in this study was effective in establishing shared awareness between participants by making visual representations using positioning maps, as well as visualizing the organization of the relationships between factors and the stratification of the evaluations using AHP. Clarifying the relative position of the surveillances on this map can provide information for making decisions on how to allocate limited resources (funding, human resources) effectively. Therefore, the evaluation framework constructed for this study will become a useful tool to support the construction of a surveillance strategy.

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Monitoring and surveillance in the Progressive Control Pathway for Foot and Mouth Disease

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Abstract

Monitoring and surveillance are at the heart of the Progressive Control Pathway for Foot and Mouth Disease (PCP-FMD). The PCP-FMD is a set of 5 stages that assist in planning and management of efforts to increase the level of FMD control to the point where an application to the OIE for official recognition of freedom from FMD with or without vaccination may be successful and sustainable.

As countries move along the pathway, the focus of monitoring and surveillance systems (MOSS) shifts from analyzing trends to early detection and prompt response. In early stages, disease monitoring data is combined with information about livestock production value chains to identify feasible and effective control measures. As control measures are applied, MOSS are needed in management to measure the impact of the control program. In later stages of the PCP-FMD, countries are approaching eradication of FMD and the focus of MOSS will be on early detection and quick response to outbreaks.

MOSS provide the information required to enhance and improve national and regional FMD control programs and progress through the PCP-FMD. As the PCP-FMD is applied in FMD-endemic countries around the world, the resultant information about the global distribution and epidemiology of FMD will be extremely relevant to inform international risk assessment and develop risk mitigation measures to prevent and/or minimize the impact of FMD incursions into free countries.

Keywords: Foot and mouth disease, Monitoring and surveillance systems, Value chain analysis, Risk analysis.

Introduction

Foot and mouth disease is endemic in many parts of the world, and its distribution roughly mirrors economic development. Wealthy countries have eradicated FMD but to date less prosperous countries generally lack the resources to do so.

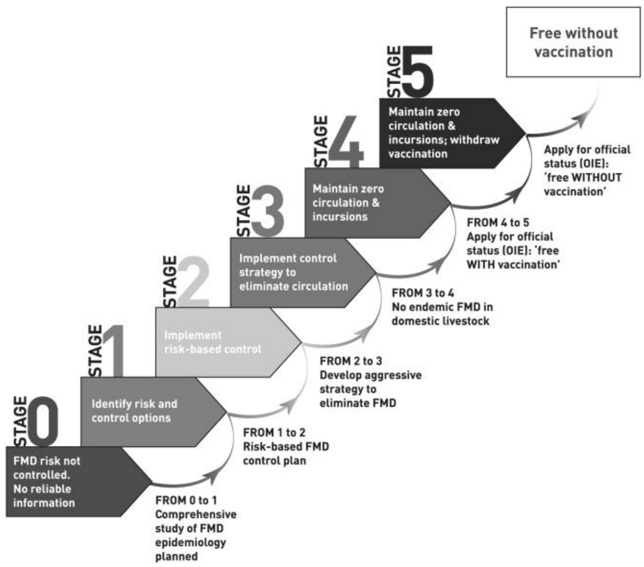
The Progressive Control Pathway for FMD (PCP-FMD) was developed in 2008 by the European Commission for the Control of Foot-and-Mouth Disease (EuFMD) and the Food and Agriculture Organization (FAO) to assist countries where FMD is still endemic to progressively reduce the impact of FMD. The PCP-FMD has since been adopted as a working tool in the design of FMD country (and some regional) control programs and is expected to become an important tool in the Global FAO/OIE Strategy for the Control of FMD that is under development.

As they progress through the PCP-FMD, countries develop an understanding of the local characteristics of FMD infection. This information is applied to develop an effective control strategy that employs limited resources most effectively. In FMD-free countries, this information is also critical because risk assessment to inform preparation and prevention for an FMD incursion is often constrained by lack of systematically collected data in potential "source" areas. MOSS are at the heart of the PCP-FMD, and the resulting information is applied to maximize the effectiveness of the scarce resources available to FMD prevention and control, nationally and internationally. In this paper we describe the PCP-FMD with emphasis on MOSS.

PCP Stages

The PCP is made up of 5 Stages (Figure 1), that range from FMD risk not controlled with no reliable information being collected (Stage 0) to official recognition by the OIE as 'free from FMD without vaccination' (final step of Stage 5, completion of the pathway). Along with progressively advanced levels of FMD control, monitoring and surveillance activities become increasingly comprehensive along the pathway.

Figure 1: The Stages of the Progressive Control Pathway for FMD



The focus of Stage 1 is "To gain an understanding of the epidemiology of FMD in the country and develop a risk-based approach to reduce the impact of FMD". To achieve this, countries should combine disease data with analysis of the production (husbandry) systems

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and livestock marketing network to arrive at a working hypothesis of how FMD virus circulates within the country. "Disease data" will include the distribution patterns, main mechanisms and drivers of transmission, high risk populations, seasonality and the characteristics of circulating viral strains. This hypothesis is used as the basis to develop a risk-based control strategy, in which resources are targeted where they will have the most impact. It is important to note that, in early stages of the PCP, 'impact' may not equate to reduction in FMD incidence, but might instead reflect protection of the most valuable industry such as the dairy industry.

The focus of Stage 2 is "To implement risk based control measures such that the impact of FMD is reduced". Monitoring of circulating strains and risk in different husbandry systems is ongoing. Building on Stage 1, the MOSS activities of Stage 2 additionally measure the impact of the control program. Depending on national circumstances, a country may decide to stay (temporarily) in Stage 2 or progress to Stage 3.

The focus of Stage 3 is "Progressive reduction in outbreak incidence followed by elimination of FMDV circulation in domestic animals in at least one zone of the country." This represents a shift in the strategic objective from FMD *control* to *eradication*, in at least part of the country, and also a potential shift from focusing on one livestock sector to addressing all livestock sectors in order to control FMD in the area. In Stage 3, there is a shift from monitoring to surveillance ("information for action") as there must be a mechanism in place to respond to all detected outbreaks. Outbreak investigation plays a more important role, and the source and spread of outbreaks should be identified as much as possible. Over time, analysis of this data should allow identification of the remaining transmission risks that have not yet been mitigated effectively.

In Stages 4 and 5, the focus is "To maintain 'zero tolerance' of FMD within the country/zone and eventually achieve OIE recognition of 'FMD free'" with and without vaccination for each Stage respectively. FMD is no longer circulating in domestic livestock. Thus, the objective of MOSS shifts from assessing and responding to FMD as an endemic disease to early detection and prompt response to any FMD incursions.

PCP application

Since its introduction in 2008, the PCP-FMD approach has been applied in West Eurasia (14 FMD endemic countries from Pakistan to Turkey, including central Asian states), several countries in Africa, the Andean region of S. America and South Asia (Bhutan). The PCP-FMD Stages allow comparison between countries, and have been used by FAO in development of short and longer term regional co-ordinated efforts ("Regional Roadmaps") in Africa, West Eurasia and the Andean countries. In the Roadmaps, the expected national PCP progress to 2020 has been charted, based on assumed levels of national investment and regional technical support [3].

In West Eurasia, epidemiological studies and control activities consistent with the PCP-FMD approach are ongoing in most countries, mostly supported by national funds. Technical support, provided through the FAO Global FMD Unit and EuFMD, focuses on the design of monitoring programs, enhancing diagnostic capacity, and support for national strategy development. In 2009, five countries in West Eurasia progressed to the next Stage of the PCP, primarily through undertaking epidemiological studies required to support strategy development. An obvious momentum can be seen in which control strategies are enhanced or targeted based on FMD monitoring results. In at least two countries, epidemic waves of FMD detected in 2009-10 have led to re-evaluation of preventive measures and recognition that critical gaps in immunity and high risk animal movements must be addressed. One common finding from these monitoring programs is that FMD incidence is often far higher than previously recognized. This has underscored that, given the epidemic nature of the disease, several years of monitoring may be needed to reliably assess the impact of control measures.

To be perceived as useful at all levels, the PCP-FMD approach emphasizes the collection of information directly relevant to managers who are confronted with issues of vaccination program coverage and impact. In some countries, national FMD task forces are being supplemented by local task forces whose role includes improving local prevention (and response) activities.

The PCP-FMD has been developed for global use and as such it is outcome-oriented rather than prescriptive. It recognizes that for different country situations different methods have to be applied to achieve the required outcomes. For example, a change in FMD occurrence could be assessed using data from clinical disease reporting (active and/or passive surveillance) or through the careful interpretation of serological surveys. In practice however, vaccination can mask FMD clinical signs. Further, in many countries there are obstacles to reporting that lead to biased estimates; therefore serological surveys are the preferred method to measure FMD incidence.

One of the important outputs of the PCP-FMD is to provide information for use not only nationally but also internationally. Monitoring viral circulation to detect the emergence of new viral strains and the detection of epidemics that threaten to spread beyond the country of origin are of both regional and global importance. The implementation of the PCP-FMD would improve the information base for regional efforts (in which vaccine appropriate to the regional threats are usually essential) as well as the likelihood of early reaction to threats.

In FMD-free countries, knowledge about the global distribution and epidemiology of FMD can be used to improve risk mitigation measures to prevent FMD incursions. This information is also critical to maximize preparedness in case of an incursion, for example by ensuring that the most relevant antigens for vaccine production are stored in vaccine banks.

To provide useful information both nationally and internationally, the results of serological surveys and virus characterization must be interpreted in the context of survey design and results must be adequately disseminated. To this end, a network of national and international epidemiologists has been formed in West Eurasia to discuss issues related to survey design, data analysis and interpretation of results, to promote information sharing and to identify training and capacity building needs. Annual meetings can provide an important forum for presenting country progress in the PCP-FMD and identifying problems requiring co-operation to address. A survey to assess progress at national and regional level has been conducted during an annual meeting in West Eurasia, with the country or zone assigned to the appropriate PCP-FMD Stage on the basis of evidence presented.

Value Chain Analysis

MOSS in the PCP-FMD are not limited to FMD incidence but also include trends in animal husbandry practices that increase the risk of FMD entry and/or spread. Livestock movements pose the most obvious risk, but there might also be risk associated with other practices (eg swill feeding pigs, manure disposal, carcass disposal, milk collection, *etc.*). Livestock movements are usually associated with marketing, but also include movements associated with transhumance and nomadic peoples.

Methods to monitor the risk associated with husbandry and marketing practices are still being developed. A promising tool is a framework that combines value chain analysis with risk analysis to link the characteristics of livestock production with epidemiology [1]. The value chain is a description of livestock production from input suppliers (feed, veterinary care, *etc.*), through producers of animals, to the marketing system, processors and consumers, and includes information about socio-economic drivers and governance to understand *why* the chain operates as it does. Combining understanding about the value chain plus the FMD epidemiology allows for the identification of risk hotspots: points in the value chain where the combined effect of the probability and the consequences of FMD entry/spread are greatest. Interventions to mitigate the risk at hotspots can then be assessed. Knowledge of the value chain should be widely discussed with stakeholders to evaluate the probable impact and feasibility of candidate interventions, because if there are serious negative financial or social consequences, the intervention is unlikely to be widely adopted.

Ongoing monitoring of FMD incidence in the context of the value chain over time is essential both to assess the impact of any intervention and also because husbandry and marketing practices are dynamic and can change quickly. Research is needed to understand the drivers for change, which might be used to facilitate this monitoring. For example, surrogate indicators such as regional differentials in meat prices might be used to predict livestock movements, a method analogous to syndromic disease surveillance. Further development of practical methods to best combine the value chain and MOSS data is needed to identify risk hotspots and feasible control options.

Discussion

To date the response to the PCP-FMD has been overwhelming positive from both FMD endemic countries and the international community. Evidence of enthusiasm includes the ongoing participation in Regional Roadmap meetings, and proposals to adapt the PCP approach to control of peste des petit ruminants, classical swine fever and brucellosis.

It is relatively inexpensive to initiate the PCP-FMD and progress to Stage 1 and sometimes onto Stage 2. However, progression beyond Stage 2 could require significant and ongoing investment, particularly if large quantities of vaccine are required. The international community stands to benefit from reduced FMD incidence globally and thus there is a good argument for continuing donor international investment. However, money from donors is often short term and this can lead to problems with sustainability. There is likely to be more ‘buy-in’ and ownership of the program should some of the funding come from the participating country itself, but for this to happen convincing incentives to reduce the incidence of FMD are required. One promising avenue to motivate continued participation in the PCP-FMD is that it provides a benchmark by which countries might compare themselves to other countries. If the health status is similar then doors could open for new bilateral trade opportunities. Secondly, economic studies are revealing that FMD is not only an important disease because of the limitations it poses on trade but that it also has a significant economic impact in endemic countries related to loss of production [2]. The socioeconomic and value chain studies inherent in the PCP-FMD will elucidate the importance of these losses further and can provide justification for national governments to invest in FMD control.

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Epidemiological Models for Designing and Evaluating Animal Disease Surveillance Systems

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Abstract
An Internet search for articles about models for design and evaluation of animal disease surveillance was conducted. Three general groups of models were identified: models for surveillance planning, for evaluating systems and models to evaluate control or eradication programs. Epidemiological models have been shown to be valuable tools to optimize existing or planned animal disease surveillance systems.

Keywords: Surveillance, planning, evaluation, epidemiologic models.

Introduction

An epidemiological model is a logical or mathematical representation of the epidemiology of disease and associated processes. It takes what is currently known about the disease situation, and uses that information to help one make an educated guess about what may happen in the future, or under different conditions. It allows users to ask "what if..?" questions and compare the results of different actions.

Epidemiological models range from simple to very complex, depending on the situation. All types can be useful, as long as the model is appropriate to the question being asked. Models may be deterministic, where input values are specified as point estimates, and the results of the model are the same each time it is run. Or they may be stochastic, where input values represent a range of values rather than one value. In stochastic models, one value from within the range is selected by the model for each input during the simulation. Each time the model runs the result can be different. These models are usually run many times, and the outputs are analyzed looking at the full range of outcomes. Stochastic models are used where a distribution is needed to capture the variation in the input value, due to either biological variability or uncertainty.

According to the Terrestrial Animal Health Code [1] three aims of surveillance are:

- Documenting the absence of *disease* or *infection.*
- Determining the frequency or distribution of *disease* or *infection.*
- Demonstrating/detecting the presence of exotic or *emerging diseases* as early as possible.

Models have been designed to assist in fulfilling all these aims and other related activities. These are not only necessary for internal and technical reasons, but may be important in political and trade-related issues when demonstration of preparedness, competitiveness, and transparency is needed externally and internationally. The following sections will briefly describe some models for each application and will refer to others with similar function.

In addition to aiding in fulfilment of the aims of surveillance listed above, epidemiological models are used to:

Plan surveillance systems by:

- Visualizing potential outbreaks of disease, and using that information to develop a surveillance plan.
- Identifying where and how to target surveillance activities – locations, herd types or sizes where enhanced surveillance would be especially useful.
- Calculating sample sizes and estimating sensitivity for targeted or risk-based surveillance.

Evaluate existing surveillance systems by:

- Visualizing potential outbreaks of disease, and using that information to evaluate a surveillance system.
- Examining the influence of enhanced surveillance on the magnitude of potential outbreaks.
- Assisting in estimating sensitivity of a surveillance system, expressed as the probability of successfully detecting the disease, if present.

Evaluate control or eradication programs by:

- Assisting in evaluating the effectiveness / adequacy of a surveillance system
- Estimating the value of surveillance, in terms of disease outbreak consequences that are averted (biological, economic, social, *etc.*)
- Evaluating changes in the incidence or prevalence of diseases for which surveillance data are available

Results and Discussion

A total of 60 articles published between 2000 and 2010 were obtained with Internet searches. The models were categorized according to scheme above. However some models fit into more than one category.

Many models have been used to assist in the planning of surveillance systems [2-15]. Stochastic simulation models are commonly used to calculate the sample size for surveys. They are especially useful for calculating the sample size required for risk- based or targeted surveillance and when disease prevalence and test characteristics are uncertain [7, 11, 13, 14, 15]. Models are very useful for comparing the likely performance of several different sampling strategies [2, 3, 8, 9] diagnostic tests [10] and combinations of the two before the actual implementation, thus, potentially saving time and money.

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Stochastic simulation models are commonly used to evaluate the sensitivity and specificity of surveillance systems [15-18], evaluate the effects of different sample collection methods [19], sample sizes [20] surveillance or eradication strategies [22-29] serological tests [10]. The number of positive tests expected in different sized IBR infected or non-infected clusters of animals was simulated. Receiver operator curves and likelihood ratios were used to determine if a survey result would be likely to occur if a country or region were infected at a given prevalence or free from infection [15]. The effect of different sampling collection conditions for testing for IBR were evaluated with a simulation model [20]. A simulation model was used to determine that the sample size for an abattoir–based survey was too small to estimate a true prevalence of Scrapie of 1% with an accuracy of ±0.5% [21]. Simulations have been used to evaluate specific surveillance systems.

The North American Animal Disease Spread Model (NAADSM) when applied to a non-endemic disease, will assist in evaluating the ability of a surveillance system to detect the disease. The disease spread that will occur prior to detection can be estimated, and different surveillance systems can be compared [30]. Disease transmission models work at many levels, and can be used to look at disease spread in a herd of animals. Additional models that incorporate disease progression, sampling probability, test sensitivity and specificity, and other aspects of surveillance, can be applied to the results of the transmission model. With the information obtained, the user can evaluate the effectiveness of a surveillance system in use, or one that is proposed. Changes in the assumptions about any aspect of transmission or detection, or changes in the surveillance plan, can be input into in the model. The results can be compared and evaluated, and the information can be used to guide decisions about the surveillance system.

The deterministic BSurvE model can be used to evaluate and compare alternative surveillance strategies for BSE surveillance [31-32]. The BSE surveillance system evaluation described in the OIE Terrestrial Animal Health Code uses a simplified version of BSurvE.

Surveillance for livestock diseases already present in the country can be evaluated *e.g.* Salmonella in Denmark [34-35], Brucellosis in the UK [36] and BVD in Switzerland [37].

Improved surveillance in this context involves measures that reduce animal mortality, increase feed efficiency, and reduce veterinary expenses. A second surveillance analysis deals with reducing the risk of foreign animal diseases from entering the country and becoming established. In this case as well, mortality is reduced by surveillance, and adverse consumer reactions and trade restrictions are also limited. These benefits can be considered when evaluating the value of surveillance. An evaluation of value will also need to take into account the social effects related to the biological and economic benefits of surveillance, since avoiding negative social consequences are also an important part of the value of a surveillance system

Epidemiological models can be used to estimate the probability that disease is absent in a population or herd [17, 21, 38-49]. *It is impossible to prove that a population is free from disease or infection without testing each and every animal in that population.* However, with models using sample data one can estimate the probability that a population is free of the disease or infection, as well as the confidence in the probability estimate. Models can allow the user to account for uncertainty in the test performance, sampling accuracy, the clustering of animals in herds, or any number of other factors. Risk-based or targeted surveillance are commonly used to increase the probability of detecting infected herds/animals [1, 2, 4, 8, 9]. Models can be used to calculate sample sizes for random surveys or risk-based surveillance in order to obtain a given level of confidence that the disease level is below a pre-defined threshold value ("the design prevalence"). An additional advantage is that modelling can take into account the complexity of disease transmission, as well as the uncertainty and biological variability that needs to be considered when evaluating surveillance for documenting freedom from disease

Epidemiological models can be used to estimate the prevalence of a disease in a population or herd. Simple formulas can be used to estimate the prevalence of disease in a herd or population, based on sampling and evaluation of results. However, stochastic models can allow a more complex evaluation of the sampling results, allowing the user to account for uncertainty in the test performance, sampling accuracy, the clustering of animals in herds, or any of a number of other factors [13, 14, 22, 30, 31, 50].

Early detection of exotic or emerging diseases is an important aspect of surveillance [6, 51-61]. The sooner the disease is detected, the sooner disease management can begin and the sooner the disease may be eradicated or controlled, thus decreasing economic and other societal losses. Early detection of exotic or emerging diseases often depends on passive surveillance, participatory surveillance or syndromic surveillance. Some detection methods involve models *e.g.* hidden Markov models (HMMs) or statistical techniques (Farrington algorithm, C-sum technique, logistic regression, *etc.*) that identify quantitative aberrations in clinical observations, routinely collected animal health or production data, time series data, spatial and temporal data or disease incidence. Such early warning systems have been developed in several countries. Some of these are:

- Rapid Syndrome Validation Project-Animal (RSVP) in the United States [6];
- "émergences" in France [52];
- Bovine Syndromic Surveillance System (BOSSS) in Australia [53];
- Monitoring and surveillance system (MOSS) in Belgium [54];

- Veterinary Practitioner Aided Disease Surveillance (V-PAD) in New Zealand [59];
- VetStat in Denmark [60].

The models described above, as well as others, can be used in various ways to estimate the value of surveillance. As described above, the effect of different surveillance systems on the ultimate size of a disease outbreak can be identified by whatever standards are appropriate (such as number of herds affected, number of animals dead). Those biological benefits can be used to estimate the economic benefits of surveillance by combining agricultural sector economic models with epidemiological results. Changes in variables and parameters associated with improved surveillance cause changes in market quantities and prices that generate differences in economic welfare.

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The mandatory bovine health visit in Guadeloupe: a tool to monitor the health control in cattle

C. Sala[1]*, G. Gerbier[2], P. Hendrikx[3] and D. Calavas[1]

Abstract

We analysed 1, 224 mandatory bovine health visits (BHV) carried out in 2008 and 2009 in Guadeloupe (French West Indies FWI). This analysis contributes to the valorization of BHV as a surveillance system and to its coordination. Additionally it allows feedback with veterinarians and positive evolution of BHV.

Keywords: health surveillance, cattle, Guadeloupe, population structure.

Introduction

Since 2005, a yearly mandatory bovine health visit (BHV) has been implemented in all cattle farms in mainland France to assess their level of global health risk management. In 2007, BHV became biennial and was extended to veterinary public health matters in order to constitute a surveillance and preventive system of health risks. Complementary aims of BHV were helping to program official health controls and reinforcing links between cattle farmers and field veterinarians.

Guadeloupe is a French island of the West Indies with tropical climate, vector-borne and parasitic endemic diseases and a majority of small cattle holdings. The BHV was adapted to the particularities of the local cattle farming practices and included five sections: cattle health protection linked with animal movements, farm equipment, management of cattle health, management veterinary drugs and management health documents. Each section leads to an assessment of the quality of the farmer's management. In the context of Guadeloupe, the analysis of the BHV may improve the knowledge of local farm practices and contribute to the surveillance system coordination.

Materials and methods

We analysed 1,224 BHV carried out in 2008 and 2009 in Guadeloupe. The consistency between answers was assessed using cross analysis of questions and multiple correspondence analysis (MCA). Additionally, a hierarchical ascendant classification (HAC) based on MCA results allowed drawing the typology of surveyed farms [1].

Results

The method allowed us to identify three farm groups: traditional, intermediate and professional. The variables used for classification and characteristics of each groups are detailed in Table 1. Figure 1 shows the distribution of variables and individuals on the two first axes of the MCA:

- Traditional farmers were characterized by small number of animals (less than 7), no breeding material and poor respect of cattle regulation;
- Intermediate farmers had intermediate number of animals (7 to 39), few breeding material but satisfactory respect of regulation.
- Professional farmers were essentially characterized by the size of herds (more than 39 animals), the good level of breeding equipment and the pasture with free grazing animals.

This farm typology drawn from health and livestock farming data was consistent with previous studies based on larger datasets [2, 3].

Most farmers had a satisfactory assessment for the various points evaluated, except for the management of health documents (Table 2). This characteristic had been previously observed when analyzing the French continental BHV [2].

Table 1: Main characteristics of farm groups resulting from the hierarchical ascendant classification and MCA

Variables used in CMA (name)	Values	Farm groups (proportion of surveyed farms)		
		Traditional (40.5%)	Intermediate (53%)	Professional (6%)
Pasture (Animal)	*FREE/ROPED*	ROPED	-	FREE
Number of bovines owned (Nb_bov)	*<7,7-13,14-22,23-39,>39*	< 7	7 to 39	> 39
Building for animals (Building)	*YES/NO*	NO	NO	YES
Materials to manipulate animals (Manip_mat)	*YES/NO*	NO	NO	YES
Origin of pastures (Pasture)	*OWNED/RENTED/LENDED/MIS**	LENDED	RENTED	-
Number of pasture sites (Pasture_sites)	*1/ >1/ELSE*	1	>1	-
Identification of animals (Identif)	*ALL/ADULTS/ELSE*	ADULTS/ELSE	ALL	ALL
Notification of animals movements (Notif_mv)	*YES/STME**/NO/MIS**	NO/STME/MIS	YES	YES
Occupation	*FARMER/ELSE*	ELSE	FARMER	-
Global health management (trend)	*S/TI/NS****	TI	S	S

MIS: MISSING, **STME: SOMETIMES,*S: SATISFACTORY, TI:TO IMPROVE, NS: NON-SATISFACTORY*

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Figure 2: Projection on the two first axes of MCA of the surveyed farms and active (blue) and passive (brown) variables.
To improve reading of the figure, MCA variables (except the number of bovines) have been slightly moved on the first axis and only positions on the second axis are exact.

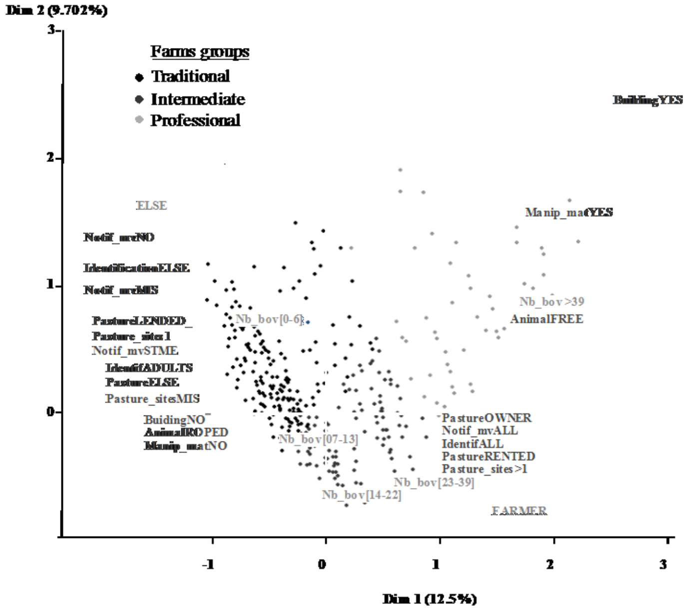

Table 2: Assessment of the five sections of the BHV and the global level of health risk management

Section	Assessment (in proportion, 100% per row)			
	Satisfactory	To improve	Non satisfactory	Missing
Health protection	73.4	21.8	3.5	1.3
Farm equipment	69.4	11.4	17.7	1.4
Health management	62.4	29.8	3.5	4.2
Veterinary drug management	86.7	9	2	2.4
Health documents	31	48.1	18.8	2
Global health risk management	56.4	34.6	6.5	2.6

Discussion

Adaptation of BHV to Guadeloupe situation improved the interest of BHV and knowledge of local farming practices.

Globally, the level of health risk management was satisfactory even if cattle's breeding is not the main economic resource for most of farmers in Guadeloupe [3]. However, the farm selection was not exhaustive as in continental France. The surveyed farms represent probably the part of cattle owners which is the most in accordance with health regulations.

Analysing only the assessments of the sections of BHV, as previously done for continental BHV [4], limits the interest of BHV as tool for health management. Only a detailed analysis of BHV may contribute to the valorisation of such a surveillance system and to its coordination, identifying points of improvement. Additionally it allows feedback with veterinarians and positive evolution of BHV. Knowing that only 25.3% of the farmers have contact with a veterinarian at least once a year, BHV is also a tool to improve the link between farmers and veterinarians on the one hand and on the other hand between private veterinarians and veterinary services. It is therefore a tool for active surveillance and helps to the enhancement of the animal health network in Guadeloupe.

Based on the same system, health visits for poultry and porcine farms are under development in Guadeloupe.

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Decision support models for risk communication to stakeholders

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Abstract
Decision support models for five endemic diseases were developed to simulate control and/or eradication options for these diseases. Based on bi-yearly prevalence surveys and new developments, the models are adapted. The model results facilitated risk communication to stakeholders. The process is illustrated with the results for BVDV.

Keywords: decision support, simulation, prevalence, economics, BVDV.

Introduction

Since 2004, a monitoring system is conducted in the Netherlands in which the prevalence of several endemic diseases is monitored every 2 years in dairy and in non-dairy farms. The diseases for which this monitoring system was put in place are Bovine Viral Diarrhoea Virus (BVD), Salmonella, Infectious Bovine Rhinotracheïtis (IBR), Leptospirosis and Neosporosis. The results of these prevalence studies gave information about the evolution of these endemic diseases in time and offered the opportunity to develop decision support models.

In these decision support models the prevalence and subsequent economic consequences of the endemic diseases can be calculated for the current situation and can be simulated for coming years. In addition, these models provide the opportunity to add several scenarios in which the effect of control and eradication strategies on both the prevalence and economic consequences can be simulated.

With this information from the decision support models, stakeholders can make better decisions on the industry level whether they want to take actions to reduce the prevalence of the endemic diseases.

Decision support models were developed for each of the monitored endemic diseases in cooperation with field experts for each endemic disease. For every endemic disease, the prevalence and economic consequences were estimated based on, amongst others, results of prevalence surveys. The future prevalence and economic consequences were simulated for a period of 10 years. In addition, together with the experts and stakeholders a number of control and eradication scenarios were added to the decision support models. In this paper, the development of the simulation model for BVDV in dairy herds will be described as example for all five decision support models that were constructed.

Material and Methods of the BVD model

The BVDV decision support model consisted of two modules. The first module calculates the prevalence and incidence of BVDV per month from 2007 until 2016 and the second module describes the economic consequences. The results from the epidemiological module served as input for the economic module.

Epidemiological module

In the epidemiological module an S (susceptible) I (infected) R (recovered) model on herd level was build. The probability for an average herd to evolve from state S to state I was depending on three known risk factors (purchase of cattle, over the fence contacts and raising young stock at other farms), a basic risk from other dairy herds and a risk from other types of cattle farms (small scale, cow-calf operations, *etc.*). An I herd could evolve back to state S by removing the infected cattle shortly after introduction and could evolve to state R when the first introductions lead to multiple infections in the herd and when no infectious cows were left. Finally, herds could evolve from state R to state S when the proportion of antibody positive cattle had declined to such levels that the herd had become susceptible for a new BVDV outbreak. Information about the BVDV prevalence in the Netherlands that was obtained from the prevalence studies, information from literature and information from expert opinion were used as input for the epidemiological module.

Economical module

The economic consequences of BVDV were based on the losses caused by BVDV in a herd in which BVDV emerged, the costs for the control and eradication of BVDV in infected herds and the costs of a voluntary BVDV eradication program in which part of the herds participate.

Control and eradication scenarios

Six control and eradication scenarios were added to the model to evaluate if the prevalence of BVDV in the Netherlands could be reduced and if so, the effect on the economic consequences. The scenarios included compulsory or voluntary contingency plans with and without vaccination. The six scenarios that were added were: 1) all dairy herds are obliged to test their bulk-milk 2 times a year with a PCR test and they have to track and remove BVDV carrier cows when the milk appears to be PCR-positive. 2) all dairy herds are obliged to enter a BVD-free program in which all carriers are traced and removed and in which the 'free' status of the herds is monitored. In addition, farmers are free to vaccinate if they want and it is assumed that 33% of the farmers will vaccinate. 3) all dairy herds are going to vaccinate. In addition there is no tracing and removing of BVDV carrier cows. 4) all dairy herds are going to vaccinate and carrier cows will be traced and removed. 5) scenario 2, without vaccination. 6) tracing and removing BVDV carrier cows and vaccination in the first three years.

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General remarks concerning the model

The decision support model is a dynamic stochastic model that was built in @Risk and MS Excel. For each scenario 1000 iterations were carried out and combined to a final result.

Results of the initial developed model

The results of the basic model showed that currently there is an endemic equilibrium for BVD with a constant prevalence. The economic losses for the dairy cattle sector in the Netherlands will be approximately 40 million euros per year (Figure 1).

The effect of the different scenarios were estimated, with and without a risk from non-dairy cattle herds representing whether non-dairy herds were participating or not. The results for the prevalence of the dairy herds show that contingency plans are most effective when all types of cattle holdings are participating (Figure 1).

Figure 1: Epidemiological (1a) and economic (1b) results of 6 scenarios for dairy herds when the risk of BVDV introduction from other than dairy cattle holdings is ignored.

Figure 1a.

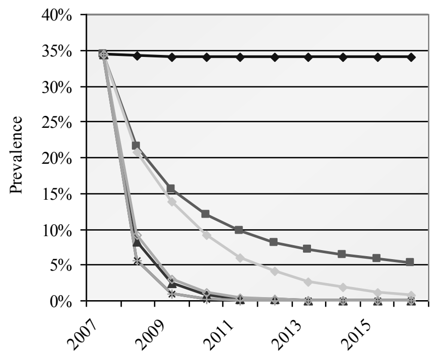
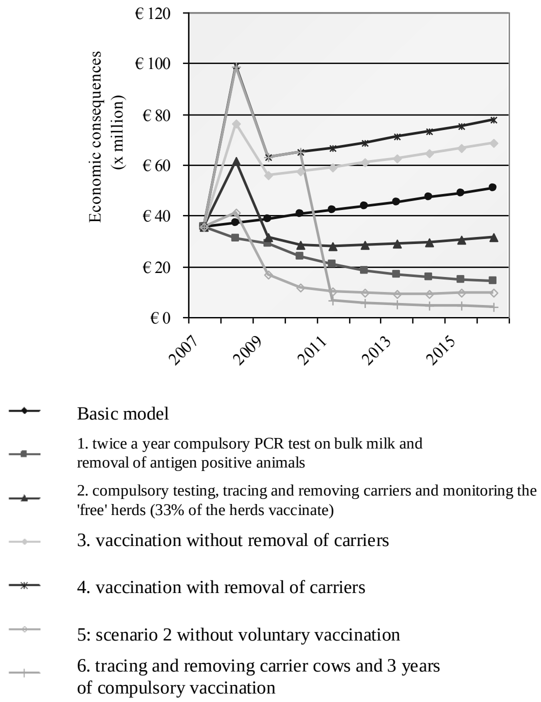


Figure 1b.



In this situation, the 5th scenario is most favorable because it is very effective in bringing down the prevalence against the lowest costs. When the risk of BVD introduction in dairy herds from other types of cattle holdings is not ignored, the prevalence will decrease but will only go to 0% with scenario 4, which is the most expensive scenario (Figure 2).

In this case the most favorable scenario is also the 5th scenario. In this scenario, the prevalence can be reduced to 5.7% in 10 years against the lowest costs.

Figure 2: Epidemiologic (2a) and economic (2b) results of 6 scenarios for dairy herds when there is a risk of BVDV introduction from other types of cattle holdings

Figure 2a.

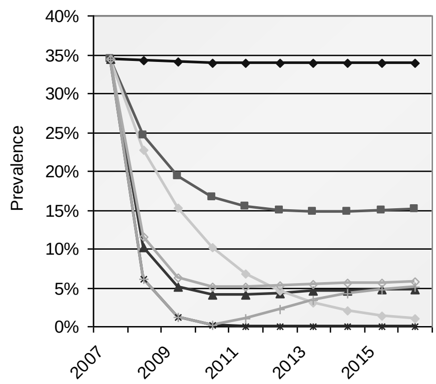
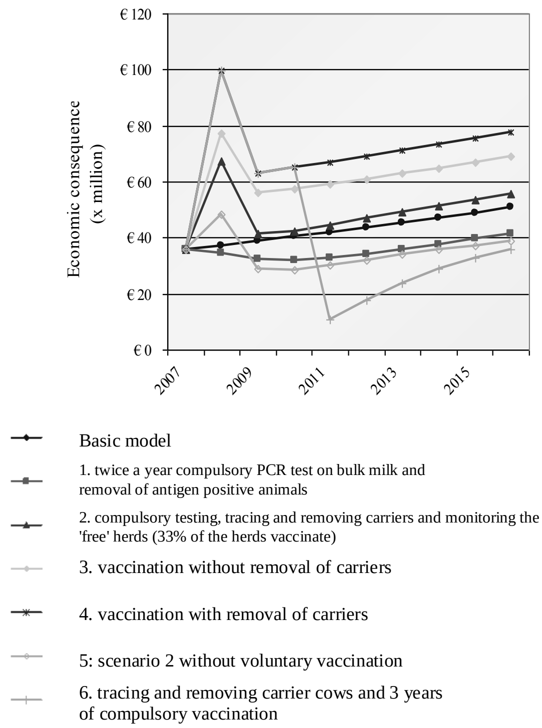


Figure 2b.



Evolution of the decision support models

The decision support models for endemic diseases are adapted every other year when new information about the prevalences comes available. In addition, new developments (*e.g.* new diagnostic tests) are included in new scenarios and added to the model. For example, lately there were many developments on BVDV control and eradication in Europe. Neighboring countries surrounding the Netherlands decided to start BVDV eradication programs based on tracing and removing carriers by means of testing all newborn calves with ear notch samples. Furthermore, it appeared that the prevalence of BVDV was slightly declining due to changing attitudes of Dutch dairy farmers. Therefore, in 2010, it was decided to evaluate the BVDV model and to add two scenarios with compulsory contingency plans. In these scenarios the costs and effects of contingency plans involving eradication of BVDV using ear notch sampling of new born calves were estimated. The results of the adapted model with the two additional scenarios were presented to the decision makers.

Discussion and conclusions

The developed decision support models gave insight of prevalences and economic consequences for five important endemic diseases (IBR, BVD, Leptopirosis, Salmonellosis, Neosporosis) in the Netherlands.

The models are relatively simple in that they model the average herd in the Netherlands and only include known risk factors. Unknown risk factors for transmission are modeled in an aggregated variable, the basic risk. Thus, the model is a theoretical reflection of the field situation. In reality, the situation is more complex than in the model herds. The models are not suitable for modeling extreme situations or specific farm situations but give a good impression about the effects of control programs for the dairy industry in the Netherlands. The absolute figures for prevalence and economic consequences may be an approximation, but this will not affect the relative values and the ranking of the different scenarios.

Although several assumptions have to be made in the development of the decision support models, the models gave the opportunity to quantify the costs and benefits of several contingency plans. The results of these models support decisions from the stakeholders on the control and eradication of endemic diseases and give insight which contingency plan is most effective at the lowest costs. Until this moment, the stakeholders have used the information from the models in their decisions to control Salmonella. It might be that the results of the models will also be used in decision making of the control of the other endemic diseases.

The models that were developed in the Netherlands are evaluated every two years and if necessary, they are updated. In addition, on request of the stakeholders, new contingency plans can be added. The simulation models increase the value of the prevalence data that is obtained with the 2-yearly surveys. The decision makers greatly value the information that they obtain from the models and use them in policy adaptations.

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A private initiative to monitor cattle health in dairy herds using routinely available data

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Abstract
The assessment of dairy cattle health is often obtained during farm visits, which are time consuming and inspection by many experts can lead to classification bias. This study shows how uniform routinely available data were used to develop a screening instrument for detecting dairy herds with prolonged cattle health problems. The paper discusses the process in which all stakeholders, *e.g.* the dairy cooperation, food safety authority, farmers, veterinarians and epidemiologists were involved.

Keywords: Stakeholders, routine data, monitor, dairy cattle health.

Introduction

During the last decade, several systems have been developed to assess cattle health in dairy herds. These systems are all based on information obtained during farm visits. However, farm visits are often time consuming, cattle health is assessed at only one point in time and inspection by many experts can lead to classification bias.

More and more countries are aware of the importance to register cattle health parameters in central databases. A main advantage of such routinely available data relative to farm visits is that they are uniformly gathered and registered throughout time. That makes comparison between dairy cattle herds possible and can result in opportunities to develop reliable tools for assessing cattle health based on routinely available data.

The goal of this study was to develop a monitoring system to detect prolonged cattle health problems in individual Dutch dairy herds based on routinely available data. The involvement of the stakeholders and the different steps in the development of such a system are described and discussed.

Development of the cattle health monitor

First, data were selected from different organisations that had to meet the following conditions: 1) data had to be registered in a uniform way across herds and had to be available over a 2-year period and 2) data had to be available for the majority of dairy herds. Eligible data concerned on-farm movements, mortality, bulk milk quality, milk production, udder health and herd status for infectious diseases such as salmonellosis and bovine virus diarrhea (BVD). Information was converted into cattle health parameters per herd and per quarter of a year.

Secondly, expert opinion was used to select cattle health parameters that could be defined on the routinely available data and that they deemed necessary to assess cattle health sufficiently.

Third, an exploratory factor analysis was carried out to examine the interrelationships among these cattle health parameters. This resulted in a weighted scoring system (Continuous Cattle Health Monitor (CCHM)) based on an annual moving average (average of four quarterly scores). Thresholds for each parameter were set, based on the distribution in the Dutch dairy herd population and weights were based on expert opinion and were reflecting the importance of the association with cattle health. Based on the distribution of the annual moving average from Dutch dairy herds, two cattle health statuses were distinguished: <60 points=insufficient cattle health status, and ≥ 60 points=sufficient cattle health status.

The fourth and last step was a meeting with 219 farmers to discuss the CCHM. To increase farmers' appreciation, quarterly results were included in the CCHM as these were considered useful management information. This was confirmed by a questionnaire, in which 87.5% of the farmers indicated that the CCHM reflected cattle health of their herd and 73.9% of the farmers indicated that the CCHM contained useful information for management purposes.

Involvement of the stakeholders

The initiative of the study came from a dairy co-operative in the Netherlands. Their aim was to obtain a farm-specific monitor that guaranteed that the milk was produced by a healthy herd, was affordable and provided useful information for farmers. Private veterinarians were seen as the natural partners in this project because they should be able to assist the farmer to improve the health of a herd. Farmers were involved to help design and test the new monitor. The Food Safety Authority had to certify the new monitor. Epidemiologists from the Animal Health Service carried out all the modeling.

A project team was formed, which included people from the dairy co-operative, farmers, veterinarians and epidemiologists. The new monitor was applied on a group of volunteers that were members of the dairy co-operative.

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The results were discussed with all participating farmers in a one-day workshop. Some adaptations were made accordingly. In parallel, the results were discussed with the Food Safety Authority. The focus in these discussions was how well the new monitor was able to detect herds with prolonged health problems.

The new monitor that was eventually obtained was supported by the farmers and veterinarians. The Food Safety Authority requested a formal validation on a random sample of herds. The results of the validation on a random sample of dairy herds is described by Brouwer *et al*. [2010] and is submitted as a separate paper for the ICAHS.

Discussion

It was concluded that routinely available data can be used to develop an effective screening instrument for detecting herds with prolonged cattle health problems. Our approach for developing this monitoring system seemed successful because all stakeholders were involved. The development of similar tools in other countries seems possible because many countries have similar data in central databases. Then, a reliable comparison of health parameters between dairy herds across countries would be possible.

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