Mapping of surveillance and livestock systems, infrastructure, trade flows and decision-making processes to explore the potential of surveillance at a systems level

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Abstract

Challenges resulting from trade globalization, changing food production patterns, disease emergence and climate change have resulted in a need for more effective and efficient animal health surveillance systems to avoid negative (economic) consequences resulting from animal disease. At the same time, many decision-makers face reductions in departmental budgets. Improved animal health surveillance does not only benefit animal health and welfare, but also society as a whole by promoting public health and sustainable food supply as well as a more efficient use of resources. We present an integrated assessment for informing surveillance design, based on mapping of surveillance system components in seven European countries and analysis of related demographic, production, infrastructure and trade characteristics as well as existing decision-making processes for resource allocation to surveillance.

Introduction

The past twenty years have seen European countries experiencing several animal health outbreaks (e.g. foot-and-mouth disease, bovine spongiform encephalitis), the shockwaves of which have been felt economically, socially and politically, thereby emphasizing the need for well-developed and adequately resourced health systems, including surveillance. While the need for effective animal health surveillance is widely recognized for the prevention and management of such threats, the currently used systems do not take optimal advantage of recent advances in epidemiological approaches and investment is being constrained due to significant financial budget reductions.

Decision-making for animal health surveillance is closely linked to the political economy that defines investments in animal health and drives factors impacting on mitigation programs, such as social and cultural acceptability (1). For example, the animal health strategy of the European Union (EU) for 2007-2013 aims at reducing serious threats to human health and the rural economy to a negligible level, and advocates the use of economic analysis to allocate limited resources efficiently. Any assessment of surveillance thus needs to explicitly take into account the wider decision-making context and the boundaries set by political and cultural realities.

Human and animal populations, protected via the implementation of surveillance and other mitigation measures, are embedded in complex supply chain systems involving activities from production to consumption including inputs (e.g. feed, veterinary drugs), primary production (e.g. livestock, fish), harvesting and processing (e.g. slaughter, food manufacturing) and finally the use of goods and services (e.g. livestock food products, pets as companions). These systems are served by a wide range of services and infrastructure (e.g. laboratory diagnostics, veterinarians), driven by consumer demands (including societal expectations about ecosystem services, such as recreational use), regulated by legislation and interlinked in a web of national and international trade.

While it is widely recognized that livestock sectors are not static, such information rarely features in surveillance designs. For example, the EU pig sector has undergone major changes in the past decade with a decrease in absolute sow numbers in the EU-27 accompanied by structural changes in certain countries in terms of concentration of sows on large farms, abandonment of sow farming, and re-structuring (2). The analysis of population and production data as well as infrastructure is critical to understanding the basic composition, characteristics, and functioning of the populations that surveillance systems are attempting to protect. For instance, distinct production systems (e.g. beef vs. dairy production) are expected to vary greatly in their farm management, herd size, husbandry, herd turnover, industry organization (e.g. membership of quality assurance schemes), and movement patterns (among other) – these factors may impact disease risk and consequently the need for surveillance.

Therefore, the aim of this research was to explore opportunities for a new generation of animal health surveillance at a systems level based on an integrated mapping of surveillance and related system components, i.e. demographic, production, trade and infrastructure data. These activities formed part of an EU-funded research project (RISKSUR) that investigates novel approaches for cost-effective surveillance in the EU and elsewhere.

Materials and methods

To understand the health systems and how populations and service providers are connected and embedded into current surveillance, primary and secondary data on surveillance systems, human and animal populations, trade flows, critical infrastructure, and decision-making processes were collected. Written data collection guidance was provided and a teleseminar was organized to discuss the data collection protocol and eventual questions with data collectors. The structure and guidance document was submitted to and approved by the ethics committee of the Royal Veterinary College, London (No. 2013 0071H: Ethical clearance for RISKSUR mapping).

Primary and secondary data collection in seven European countries: RISKSUR researchers in France, Germany, Great Britain, the Netherlands, Spain, Sweden, and Switzerland screened scientific literature, internet pages, government reports, and other informally published written material to describe all existing private and public surveillance system components (SSC) in the year 2011 in all animal species of economic value (companion animals, wildlife, livestock, fish, and bees). Both disease-specific surveillance as well as surveillance related to health-events (e.g. syndromic surveillance) were considered. Information was collected about the threat(s), disease(s) or health event(s) of interest; target population(s) and sector(s); sampling point; geographic focus (including NUTS code); potential integration into a program or organization; surveillance purpose; existence of legislation or regulation; management and coordination; private and public expenditures and cost-bearer; means of data acquisition; study design; case definition; use of risk-based surveillance; temporal changes; multi-objective nature; a short description of the surveillance component; and relevant references.

Further, data were collated on critical infrastructure, namely slaughterhouses, feed mills, livestock markets, livestock traders, livestock transporters, laboratories and post-mortem facilities, and veterinarians. Basic information to be collected included species or type of feed or services offered, total number of items, throughput, ISO-certification or quality standards.

In addition, interviews with decision-makers in private and public surveillance were conducted. The questionnaire contained closed and open-ended questions and was targeted at decision-makers responsible for allocating resources to surveillance. Questions referred to their role, how animal health surveillance was carried out, how resources in the private or public sector were allocated to animal health surveillance, and what the relevant processes were. The questionnaire further contained questions about public-private partnerships, cost-sharing, decision-criteria used, constraints perceived, and additional information desired for decision-making on surveillance.

All data were entered into a web-based shared Structured Query Language (SQL) database. Data cleaning was performed to remove duplicates, delete test entries, and standardize entries in free text fields. Following consistency checks and the development of further guidance, the dataset was double-checked by data collectors to ensure accuracy and consistency.

Secondary data collection in European countries: Data on livestock and bee holdings in Europe, human and animal populations, gross domestic product, and farm values were collated from Eurostat. Data on trade was obtained from the EU’s Trade Control and Expert System (TRACES) which records movements of live animals in the EU. This secondary data was used to create maps to visualize distributions and differences in human and animal population and holding densities as well as animal movements across Europe.

Data on animal populations and trade flows were combined with the data collected in the seven countries and analyzed descriptively. The distribution of human and animal populations (heads/km^2), animal holding densities (holdings/km^2) and holding size densities were mapped at NUTS2 level. Absolute trade flows of live animals and animal products illustrated between countries were broken down by species and purpose. The number of slaughterhouses, livestock markets, traders, transporters, laboratories, and veterinarians were compared to livestock demographics. Existing SSC were described in terms of target hazard, species, surveillance protocol and design, geographic focus, purpose, inclusion of risk-based sampling, multi-objective nature, coordination and expenditures. Finally, decision-making processes and key decision-making criteria used by the relevant stakeholders were characterized.

Result

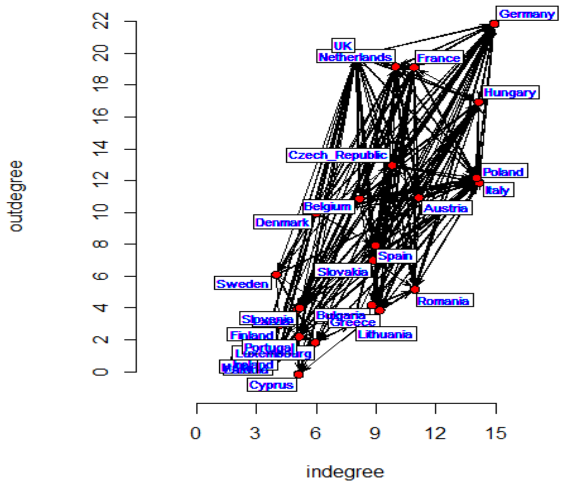
A total of 498 SSC from France, Germany, Great Britain, the Netherlands, Spain, Sweden, and Switzerland were recorded; of which 73% were active, 16% were passive and 11% were enhanced passive. Across all countries, the most frequently mentioned purposes for surveillance were “early detection or warning”, “to substantiate freedom from disease or infection”, and “to detect cases to allow specific actions to be taken in animals or holdings, which will facilitate control or eradication”. Species most frequently identified as targets for surveillance were cattle, pigs and poultry. The most commonly recorded hazards for surveillance were *Salmonella* (12%); *Brucella* (5%), avian influenza (4%); bluetongue (4%); bovine spongiform encephalopathy (4%); scrapie (3%); classical swine fever (3%); bovine tuberculosis (3%), enzootic bovine leucosis (2%), flaviviral infections (2%), and trichinella (2%); all other hazards were less than 2%. Most of the recorded SSC focused on the national level, and only a minority of these were restricted to sub-regional or local areas.

There were differences across countries in terms of private and public funding; in some countries nearly all surveillance components were publicly funded, while in other countries a considerable percentage was privately funded. A multitude of private-public partnerships was found ranging from sharing of testing costs, to outsourcing of the planning and implementation of surveillance to private bodies (but funded by government), to formal partnerships with 50:50 cost sharing of all surveillance costs.

The single most important decision criterion influencing surveillance mentioned by decision-makers and technical advisors was 'international legal requirement' (including EU obligations). In the group of decision-makers, economic decision-making criteria, namely 'cost-benefit measure', 'cost-effectiveness measure', 'expected costs', or 'expected benefits', respectively, were reported by ≥ 40% of respondents. Similarly, 'disease situation in the country' and an 'impact' related criterion (impact on animal production/national economy/human health) were also mentioned frequently for all programs and situations. 'National legal requirement' was reported by ≥40% for the question whether to conduct surveillance, but not for the question about how to conduct it. Criteria like 'timeliness', 'sensitivity', and 'practicality' of the surveillance system were relevant in relation to the question how to do surveillance.

Qualitative and quantitative analyses examining within and between country patterns illustrated the potential of using systems data to inform surveillance design. A network analysis was conducted to illustrate the trade patterns by species and production type. An example is given in Fig. 1, which expresses the import/export livestock trade linkages of poultry livestock units between European countries.

Figure 1: Trade linkages of poultry livestock units between European countries.



The X-Y location of countries in the chart provides information for surveillance design – countries in the upper right quadrant, for example, both import (in-degree) and export (out-degree) high numbers of livestock units, which means that they need to monitor both local production and imports so that they export healthy animals but also avoid introduction of disease. More importantly, countries can explicitly take into account the risk associated with the trade behaviors of the countries they are trading with. A country with low import quantities may still be at risk through being connected with another country that is an important hub for trade.

Discussion

This research aimed at bringing together key system attributes of selected EU countries allowing a comparison between countries and systems, as well as appreciating the impact of the linkages between systems and countries and the consequences for risk management.

Generally, there was very strong focus on disease centered surveillance with a small minority of programs that were generic in nature, such as syndromic surveillance. There were no components that reported higher-level surveillance of trends or changes in livestock populations, production systems or trade patterns and only very few components that reported health monitoring on farms (e.g. use of productivity levels as a surveillance indicator). However, it has to be acknowledged that private surveillance may have been underreported due to limited availability of publicly accessible documentation of private surveillance schemes. There is also a possibility that the event-based surveillance of livestock populations (e.g. sudden changes in trade patterns) was not reported, because it may be information used in risk assessment and not surveillance as such.

A suggested innovation is to design surveillance by considering the supply chain structure (e.g. populations, trade-flows, economics) on which the program applies. Markets and slaughterhouses, veterinary services, and laboratories do not only have an important role in service provision and contribute to the value of animal production, but they also are potentially useful sources of surveillance data. Further, information on populations and movements provides insights into how animal trade works within the EU and hence allows targeting surveillance more efficiently based on the trade between the various countries. Countries with vibrant marketing and movement of animals require good traceability systems which should be integrated into the surveillance systems. The results can be used to design novel risk-based SSCs that are scientifically sound and acceptable to relevant national and international stakeholders.

In conclusion, more integrated analyses of system characteristics within and between countries and the explicit inclusion of temporal and spatial system dynamics, such as changes in production systems and trade flows have the potential to promote the efficiency of animal health surveillance.

References

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