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A practical approach to designing syndromic surveillance systems for livestock and poultry

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ABSTRACT

The field of animal syndromic surveillance (SyS) is growing, with many systems being developed worldwide. Now is an appropriate time to share ideas and lessons learned from early SyS design and implementation. Based on our practical experience in animal health SyS, with additions from the public health and animal health SyS literature, we put forward for discussion a 6-step approach to designing SyS systems for livestock and poultry.

The first step is to formalise policy and surveillance goals which are considerate of stakeholder expectations and reflect priority issues (1). Next, it is important to find consensus on national priority diseases and identify current surveillance gaps. The geographic, demographic, and temporal coverage of the system must be carefully assessed (2). A minimum dataset for SyS that includes the essential data to achieve all surveillance objectives while minimizing the amount of data collected should be defined. One can then compile an inventory of the data sources available and evaluate each using the criteria developed (3). A list of syndromes should then be produced for all data sources. Cases can be classified into syndrome classes and the data can be converted into time series (4). Based on the characteristics of the syndrome-time series, the length of historic data available and the type of outbreaks the system must detect, different aberration detection algorithms can be tested (5). Finally, it is essential to develop a minimally acceptable response protocol for each statistical signal produced (6).

Important outcomes of this pre-operational phase should be building of a national network of experts and collective action and evaluation plans. While some of the more applied steps (4 and 5) are currently receiving consideration, more emphasis should be put on earlier conceptual steps by decision makers and surveillance developers (1–3).

1. Introduction

Animal health surveillance is no longer restricted to field personnel investigating animal health on farms, but has expanded to include epidemiologists who are "more in touch – electronically – with global animal health developments" and who carry out their surveillance duties on national or sub-national levels (Kellar, 2012). The political and economic drivers of cost-effectiveness and new technologies have fostered new approaches to surveillance systems. Syndromic surveillance (SyS) is one of them. Syndromic surveillance is not based on laboratory confirmed diagnoses of a disease, but on non-specific health indicators including clinical signs and other proxy measures (e.g. absenteeism, drug sales, decrease in animal production etc.) that are potential indicators (or "syndromes") of change in the disease status of a population (Triple-S definition: http://www.syndromicsurveillance.eu). Advances

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in electronic data capture, transfer, storage, analysis and visualization technologies during the past decade have made the collection and storage of large amounts of meaningful health and health-related digital data possible by non-specialists. This has created an opportunity for SyS implementation as SyS is often a secondary use of health-related data which are collected for other primary purposes (e.g. payment of subsidies, calculations of breeding values, managing veterinary practices etc.).

SyS systems have become relatively common in public health surveillance following 2001 when threats of bioterrorism on US soil motivated the creation of such systems (Reingold, 2003). Because SyS can use existing data, SyS may be a more cost-effective alternative for the detection of unexpected disease events when the diseases are believed to be absent in the population or at low prevalence. Studies have shown that SyS can complement traditional surveillance by detecting patterns not visible in passive diagnostic laboratory surveillance (Amezcua et al., 2013); or by detecting outbreaks earlier than conventional surveillance (e.g. Bluetongue in the Netherlands (Elbers et al., 2008)). It is unlikely that SyS will replace more traditional animal disease surveillance such as reportable disease programs, slaughter surveillance or repeated population based disease surveys. However, SyS has the potential to complement these methods by producing different health-related information. SyS can be adapted to data coming from almost any point on a livestock production chain or any point along the continuum from the introduction of a new to pathogen into a naïve population to the production of a disease epidemic (Dórea et al., 2011). SyS can therefore target points along the production chain or disease continuum that are not covered by traditional surveillance, filing in surveillance coverage gaps. Combining SyS and traditional surveillance methods into one system has the potential to broaden the overall coverage of livestock populations, potentially enabling earlier outbreak detection (Elbers et al., 2008).

While the interest in SyS is growing, it is only in the last 5 years that its potential application for animal health surveillance has been explored. Dórea et al. (2011) reviewed SyS systems based on the systematic monitoring of animal populations for outbreak detection and reported 11 animal health SyS systems from 7 countries (Australia, Canada, France, Netherlands, New Zealand, United Kingdom, USA). A more recent inventory of SyS in Europe (Dupuy et al., 2013), based on the wider Triple-S definition of SyS, identified 27 veterinary SyS projects. However, only 12 of these were operational, the rest being in the pilot or exploratory phase, as opposed to 22 (out of 33) active human SyS in Europe (Conti et al., 2012).

Despite the growing interest in SyS, there is little practical information to guide animal health SyS developers in developing and operating a SyS system. There are some publications describing methods for animal health surveillance in general that are relevant to SyS. These include: key terms and concepts for animal-health surveillance (Hoinville et al., 2013); key methods for surveillance (Salman, 2003); a conceptual framework for population health surveillance and foreign animal disease surveillance (El Allaki et al., 2012); surveillance to document freedom from animal diseases (Christensen, 2012) and methods for evaluating animal health surveillance (Hadorn et al., 2008; Hendrikx et al., 2011). The Animal and Plant Health Inspection Services (APHIS) from the US Department of Agriculture have also published standards focused on (1) key components, (2) data, and (3) information management for surveillance systems (Centers for Epidemiology and Animal Health, 2006). Similarly, the Department for Food and Rural Affairs (DEFRA) has published a list of surveillance system requirements for the UK (Defra, 2012). Many SyS resources are available from the public health surveillance sector that may have relevance to animal health SyS. For example there are methods available for the early detection of disease outbreaks (Wagner et al., 2006); recommendations for SyS systems for bioterrorism preparedness (Mandl et al., 2004); many approaches for selecting, fitting and evaluating event detection algorithms (Buckeridge, 2007); and methods for evaluating public health syndromic surveillance (Buckeridge et al., 2004).

To the authors' knowledge, no practical, animal health specific SyS guidelines have yet been published. This is likely because SyS in animals is relatively new and also because there is considerable variation among the approaches to SyS for livestock (Dórea et al., 2011; Dupuy et al., 2013). In this paper, we propose, a practical approach to designing a SyS system for livestock and poultry.

2. Proposed approach

Our 6-step proposed approach (Fig. 1) loosely follows the population health surveillance theory presented in (El Allaki et al., 2012). The latter is made of four sequential interrelated phases: phase (1) recognizing a trigger or a need for surveillance; phase (2) formulating the problem; phase (3) planning the surveillance system; and phase (4) implementing and evaluating the system. Population health surveillance is an activity that targets populations as opposed to individuals; produces information relating to specific diseases of importance (prioritizes diseases for surveillance), and is conducted by organizations of people, therefore requiring group-based decision making (El Allaki et al., 2012). Our process recognizes these attributes, and at the same time provides practical approaches that are specific to designing and implementing SyS for livestock and poultry.

2.1. Define the purpose and goals of a national livestock SyS

In the words of A. Reingold, "If SyS is the answer, what is the question?" (Reingold, 2003). Public health SyS was originally conceived and implemented for the purpose of early detection of a large-scale release of bioterrorist agent (Reingold, 2003). Current public health SyS goals reach beyond bioterrorism preparedness and include detecting the changing incidence of nonspecific mild illnesses (Mostashari and Hartman, 2003). Similarly, many livestock SyS systems currently focus on the early detection of emerging diseases; however other surveillance goals