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Syndromic surveillance using laboratory test requests: A practical guide informed by experience with two systems

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ABSTRACT

Syndromic surveillance systems can enhance early disease warning, endemic disease monitoring, or help to accumulate proof of disease freedom. In order to provide immediate feedback to achieve these goals, the health data sources scanned should be acquired continuously, in an automated fashion, and should be stored electronically. Recognizing that data from diagnostic test requests often meet these requirements, two systems designed to automatically extract surveillance information from animal laboratory databases have been developed and are described in this paper. These systems are designed to contribute to early disease detection, as well as the timely management of epidemiological information, in a province of Canada and in Sweden, the areas served by the diagnostic laboratories concerned. Classifying in-coming requests into syndromes, the first step, was the most time-consuming and the least portable step between the two systems. The remaining steps were more easily adjusted from one system to implementation in the other. These steps included: retrospective evaluation of data to create baseline profiles following the removal of excessive noise and aberrations; the identification of temporal effects; prospective evaluation of detection algorithms; and finally real-time monitoring and implementation. Building upon the institutions' existing data management software, all steps to use those data for the purposes of syndromic surveillance were set up using open source software; as a result this approach could be readily adopted by other institutions. Relatively straight-forward development and maintenance is expected to lead to the incorporation of these systems into each institution's surveillance processes, becoming an indispensable tool for diagnosticians and epidemiologists, as well as stimulating further technical development of such systems.

1. Introduction

At the turn of the millennium Doherr and Audige (2001) pointed out the changing demands in animal health surveillance, as disease control and eradication around the globe have increased the demand to deal with rare events and provide evidence of disease freedom. The authors highlighted their role in the early detection of emerging (or re-emerging) diseases, calling attention to the need to develop and implement "scientifically based approaches

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that use the resources (and data) available". Over the intervening decade technological infrastructures and the health data available within them have developed rapidly, disease prevalence has reduced for some diseases in many areas, and general awareness of the need for early disease detection has grown as a result of publicity around major disease outbreaks such as pandemic influenza as well as the concern regarding bioterrorism events (Buckeridge et al., 2005a; Shmueli and Burkom, 2010).

This has led to rapid developments in the field of syndromic surveillance. In human health, syndromic surveillance has been used not only for the early detection of diseases, but also for real-time monitoring of outbreaks (situational awareness (Fricker, 2011a), monitoring of disease trends, and to provide reassurance of disease freedom (Henning, 2004; Katz et al., 2011). It is a tool to extract surveillance information from continually changing health data sources, in as timely a manner as the rate at which data are gathered in electronic formats. Timely collection and computerization were among the reasons highlighted by Ma et al. (2005) to consider the use of laboratory order data in syndromic surveillance, together with the fact that such data often exhibit high population coverage. The scarcity of centralized electronic collections of clinical data in veterinary medicine further motivates the use of laboratory data in animal health surveillance (Dórea et al., 2011).

After a decade of syndromic surveillance development, the focus today is on developing holistic biosurveillance systems which work in parallel – rather than as substitutes – to help inform and complement other types of surveillance (Fricker, 2011a; Buckeridge, 2011). Authors, who in the last decade researched the potential of data sources and the use of different aberration detection algorithms, now highlight the need to continue research into system design and implementation. They also point out the need to compare methods developed under different conditions and to document their performance, fomenting the sharing of experience in order to enhance syndromic surveillance utility (Fricker, 2011b; Morse, 2012).

The objective of this paper is to present a structured approach to the design and implementation of syndromic surveillance systems using laboratory test request data, based on research at two animal health laboratories with high population coverage. These laboratories were the Animal Health Laboratory in the province of Ontario, Canada and the laboratory at the National Veterinary Institute in Sweden. The latter system is still in its development phase, but comparisons between the two data sources will be made as well as an assessment of the portability of the system and the challenges of working with each data source. The focus of this paper is not on the results of each system particularly, but on the development process.

2. Methods

An overview of the process (assuming the availability of animal health on a structured tabular format, such as laboratory data) is presented schematically in Fig. 1. Details of each step are described below with references for more in depth information. The two syndromic surveillance systems described here were developed in order to achieve the following goals. Firstly, to generate automated analyses of health data and to generate timely reports containing epidemiologically relevant information; and secondly, to provide a system for early detection of temporal changes in disease patterns that can be indicative of disease outbreaks.

2.1. Data sources

Two syndromic surveillance systems were developed on the initiative of the data owners, with all phases of data access, analysis and output generation developed inside the institution. The Animal Health Laboratory (AHL), part of the University of Guelph, is a full-service veterinary diagnostic laboratory that serves livestock, poultry and companion animal veterinarians in the province of Ontario, Canada. The AHL is the primary laboratory of choice for diagnostics in the province of Ontario. The Swedish National Veterinary Institute (SVA) is an agency under the Ministry of Rural Affairs and is the largest and only official laboratory in veterinary medicine in the country. Both laboratories provide diagnostic services to veterinarians, but also process samples collected as part of monitoring and surveillance programs, as well as commissioned research. Test requests are digitalized daily. At both locations, as in most diagnostic laboratories, data and operations are managed by a laboratory information management system (LIMS), the primary functions of which include reporting the results of diagnostic tests as well as administrative tasks, such as billing. The format of this information is therefore very structured. Most data fields which can be used for surveillance purposes – such as samples submitted and diagnostic tests performed – have a pre-set list of options and only limited amounts of free-text are entered.

These data can be extracted into two-dimensional tables using Structured Query Language (SQL) queries. In both projects a batch of data queried using the institutions' existing data management systems interface sufficed for all development phases. Four years of historical data were used in both cases (2008–2011 for the AHL, and 2009–1012 in Sweden). Only cattle data were used at the AHL, while data from all species are being included at the SVA.

The institutes' diagnosticians were involved in defining the data fields relevant for the extraction of surveillance information. Only data available at the time of submission were considered. Fields with information concerning animal owners and veterinarians were not included in the data extracted for reasons of confidentiality, however any fields that allowed for identification of different animals or herds within the same submission were considered. All fields that could contribute to the identification of the clinical problem were identified. Only cases submitted to the laboratories by field veterinarians requesting diagnostic tests were considered relevant for the purpose of syndromic surveillance, that is, samples submitted as part of regular and/or mandatory surveillance programs were not considered relevant as indicators of the disease burden in the population (Gibbens et al., 2008).