Monitoring cattle abortion telephone notification calls as a health indicator in Great Britain

C COOK*[1], LA STRINGER[1], E WATSON[2]
[1]Animal and Plant Health Agency, Addlestone, United Kingdom; [2]National Milk Laboratories, Wolverhampton, United Kingdom

charlotte.cook@apha.gsi.gov.uk

Abstract
Timely detection of new and emerging threats to animal and public health is crucial to allowing decision makers time to implement control or containment policies. Routine automated data analysis can aid surveillance activities through rapidly screening multiple data streams for anomalies. Surveillance investigators' limited time is focused on the areas of the data where an unexpected observed result is present.

Many automated outbreak detection algorithms are used within animal and human health surveillance. They are designed to scan through time series data and raise alarms when observed data, for a given time point, exceeds an expected level.

This work describes the application of the Farrington algorithm (1) to the cattle premature calving or abortion telephone notification dataset held at the Animal and Plant Health Agency (APHA). Details of the number of cattle abortions reported have been collected since April 2009. The dataset represents an opportunity to monitor the health of the breeding GB cattle herd. New and emerging threats that affect cattle reproductive health may present in increases in the number of premature or aborted calves.

A monthly analysis report of the cattle premature calving or abortion notifications numbers is now included in the range of data routinely examined by the APHA Cattle Expert group. This group comprises a variety of experts and stakeholders, both within and external to APHA, focusing on surveillance for new and re-emerging animal health threats.

The report contains the results of the Farrington analysis with a graphical presentation of the data and supporting information.

Keywords: *Cattle abortion, early warning*

Introduction
Early detection of new and emerging threats aids disease control by enabling timely investigation, characterisation and management of the identified threat. The scanning surveillance programme in Great Britain includes a number of activities aimed at detecting, investigating, managing and mitigating risks and impacts arising from animal-related new and re-emerging threats. A key source of surveillance information is the diagnostic data derived from carcase and sample submissions to the geographical network of APHA laboratories and contracted private providers of diagnostic services. While these data are analysed on a quarterly basis to identify any anomalous trends in endemic disease and syndrome presentation, this approach may not be the timeliest for identifying potential threats.

Syndromic surveillance offers improvements through removing the requirement to wait for a diagnosis to be assigned to the submissions. Applying syndromic analysis to the cattle abortion notification dataset is thus a route to more rapid identification of possible threats to cattle reproductive health.

Surveillance for Brucellosis in GB requires that all premature calving or abortion events in cattle are notified to APHA. These statutory notifications are a component of wider bovine brucellosis surveillance. The record of telephone notifications of cattle premature calving or abortion provides a suitable syndromic data stream for regular monitoring, as the data are timely, due to prompt reporting by keepers, and the syndrome is unambiguous.

This paper describes the automated monitoring system that has been introduced to screen cattle abortion notifications in GB for anomalies on a monthly basis.

Materials and methods
The Brucellosis (England) Order 2015 (4) defines premature calving or abortion as calving less than 271 days after insemination or 265 days following embryo transfer. Where a premature calving or abortion has taken place in a herd, it is compulsory to notify the competent authority (APHA). Notifications are recorded within APHA disease monitoring databases, and a triage system determines whether follow-up sampling on farm is necessary. Data on the total number of notifications received in each month are extracted at the end of the calendar month for analysis. Information includes: the individual farm notifying and location, the date of the notification and the type of cattle affected.

The algorithm described by Farrington (1) has been applied to a number of other data sets within APHA (2), and is also used here. A brief description is given here with particular regard to the APHA datasets used, but for a full description of the algorithm please see the reference.

Individual records within the abortion notification dataset are converted to count data with a bin for each month. The dataset starts in April 2009, with additional data fields being added to the individual records over time. A data point is included in each bin where a notification has been received with the minimum required data-fields completed.

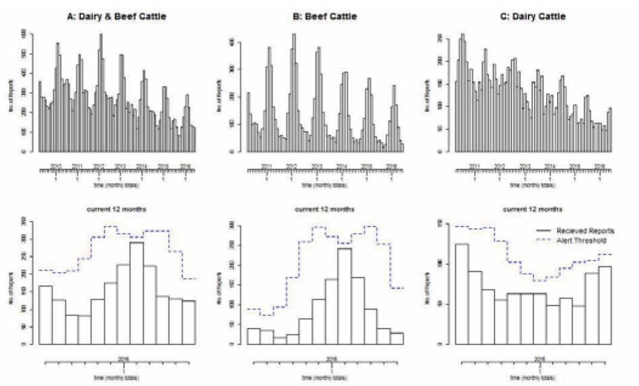
Data are analysed one month at a time, with a set of baseline data from the time series selected by taking the equivalent, preceding and subsequent month from all complete years in the dataset. The baseline data set is used within a regression step to produce a predicted threshold value for the month being evaluated. Where the observed value for the month exceeds the threshold a flag is raised.

The results of the analysis are displayed graphically within a report prepared every month. Reports are seen by species experts to confirm, and if required, investigate potential alarms raised. In addition to automated outbreak detection, a number of visual data exploration graphs of the cattle abortion dataset are produced, to aid the species expert group in identifying any trends present.

Results

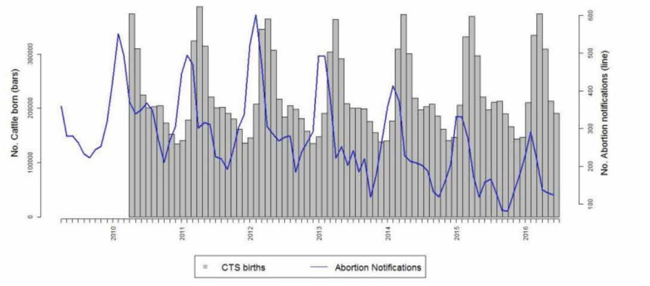
The report detailing the results of the Farrington algorithm is designed to be simple and easy to interpret. As the analysis will identify any anomaly in the data the results are given within the context of other supporting data in the form of the number of cattle birth registered for the same month. An example graphical output of the Farrington algorithm analysis is given in Figure 1. The report analyses all notifications (column A), and also beef and dairy cattle (columns B and C) individually to allow for different seasonal effects in cattle management. A complete time series of notifications is presented along with a detailed view of the current 12 month window. An alert will be raised when any of the monthly totals for the current 12 month period exceeds the calculated threshold (blue dashed line).

Figure 1. Example output from automated outbreak detection with Farrington algorithm analysing current 12 month window of abortion notifications received.



Supporting data exploration graphs are designed to help in interpretation of any alarms raised by giving the data in context. The example in Figure 2 shows a complete time series of the abortion notification dataset (grey bars) along with cattle births registered in the Cattle Tracing System (CTS) over the same time period (blue line).

Figure 2. Example of the supporting data graphical output produced for monthly reports based on cattle birth registrations.



Discussion

As the notification of cattle abortions is a legal requirement, the data set represents an opportunity to monitor the general health of cattle for new and emerging diseases which may impact reproduction. Abortion or premature calving can be an indication of many conditions including bovine viral diarrhoea virus, bacterial or fungal infections (5) and newly emerging infections such as Schmallenberg virus (6).

Regular and frequent monitoring of cattle abortion notification frequency offers the potential to see emerging trends in the data that may indicate an increase in abortion or premature calving over the GB cattle at a population level. This information, in conjunction with veterinary expertise, may provide early warning of an increase in conditions, endemic or new/re-emerging, that cause premature calving or abortion. The veterinary expertise is essential to confirming or rejecting alarm flags raised by the algorithm. Alarms may be raised for a variety of reasons, for example data entry errors in recording notifications may result in a seeming increase of cases rather than a true increase. In this way automated outbreak detection systems are able to supplement animal health surveillance expertise by automating a simple, but time consuming, part of the surveillance process. The automated monitoring of certain data streams can free up surveillance expertise by focusing attention to times when the data departs from what may be considered normal.

Data analysis can provide supporting evidence to animal health surveillance experts, such as confirming anecdotal observations on increasing, or decreasing, abortion trends at a local level. Inspection of the data on a regular basis can also reveal data issues that are not due to health status, such as recorded reduction in abortion notifications over time.

Changes to the database system used to record notifications in 2014 make it possible to extract more information about each individual case. Having more details, such as geographical location, make it possible to analyse the data with respect to localised distribution. If a pathogen is introduced in a small area the effect on abortion frequency may only be observable at a very local level. The analysis of the dataset at different geographical levels may increase the possibility of detecting clusters at a spatio-temporal level. In combination with the cattle population data areas of low or high incidence of premature calving or abortion can be easily identified.

Currently the monitoring has not flagged any months as anomalous for GB as a whole. Monitoring of the dataset continues and efforts to increase the number of data streams that can be monitored in such a way are continuing.

References

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