

A proxy for ovine mortality: early warning, or is it a fluke?

TONGUE SC¹*, EZE JI¹, GOMES CG¹, BRULISAUER F², GUNN GJ¹

¹SRUC Research, Epidemiology Research Unit (ERU), Inverness, UK; ²SAC Consulting, Veterinary Services, Inverness, UK

*sue.tongue@sruc.ac.uk

Abstract

The practical implications of calls to use alternative data sources to contribute to livestock health and disease surveillance systems, especially for early warning of new or (re)emerging incidents and/or as syndromic surveillance are often not fully understood by those making the calls. We determine whether it is statistically feasible to analyse an incomplete, business-focused, alternative data source as a proxy for the mortality experienced in the Scottish sheep population. We transform the data, describe the temporal and spatial patterns, apply time-series methods and a temporal aberration detection algorithm (TADA). We extend our analysis to contemporaneous laboratory diagnostic submission data. Distinct annual and spatial trends plus seasonal patterns were observed in the three age groups investigated. The TADA produced an alarm at the point of an historic known departure from 'normal', in April 2013, for two age groups, across Scotland as a whole and in specific postcode areas. The contemporaneous laboratory diagnostic submission data analyses provided further insight, although did not fully explain observed events. There is potential for use of these data: as a proxy measure for mortality in the sheep population; as complementary components in a future surveillance system and in design of additional components. Some limitations could be addressed by improvements to data collection and provision. Others highlight the primary provider insight, epidemiological and industry sector knowledge that is required to turn data and analytical outcomes into useful information.

Keywords: *Surveillance, sheep, mortality, liver fluke*

Introduction

There is increased pressure, from policy-makers and industry, to make use of alternative data sources in livestock health and disease surveillance systems. To date, most research into possible indicators of the mortality experienced by livestock populations has investigated the potential for use of statutory, or mandatory, registers of cattle, or pig, populations. As there is no appropriate, comprehensive, register that can be utilised for British sheep, our primary aim was to explore an alternative; a data source designed for business purposes, with voluntary membership, derived from collections of fallen stock. The intention was to explore the challenges posed by this data source and determine if it has the potential to contribute to surveillance intelligence for the Scottish sheep population.

However, one of the major issues for any system that is

intended to provide early warnings, or to detect aberrations, is the need to be able to investigate any statistical alarm and determine whether it does represent an epidemiological alert. This requires further resources, potentially additional data sources, epidemiological expertise and industry knowledge. Our secondary aim was to explore contemporaneous voluntary laboratory diagnostic submission data, in order to determine whether they could, retrospectively, provide explanations for some of the patterns and alert signals observed in the fallen stock data.

In doing so, the intention was to assess whether difficulties with the data could be overcome sufficiently to make appropriate inferences and discover how the multiple sources of information could best be integrated, or otherwise utilised, and interpreted.

Materials and methods

The study period was limited by the data availability for the fallen stock collection data: January 2011 to the end of December 2014, inclusive.

Data on membership and ovine fallen stock collections were provided from the National Fallen Stock Company (NFSCo). The latter, the collections data, were aggregated at a full postcode level and by calendar month. Raw data provision was not considered (by the data provider) to be feasible due to a number of system constraints.

Contemporaneous voluntary laboratory diagnostic submission data were provided from SAC Consulting Veterinary Services' network of Disease Surveillance Centres (SAC C VS DSC). For this study, the focus was on data for one condition – liver fluke, *Fasciola hepatica*, as an exemplar. Diagnostic data for all diagnoses of liver fluke in sheep, during the study period, were extracted after careful consideration of how diagnoses were determined and recorded.

The NFSCo membership data were summarised and described over time for the country, as a whole, and by postcode area.

The NFSCo collections data were summarised and described over time for the country as a whole. They were originally collected for business purposes, such as invoicing and accounting, therefore they needed to be transformed into estimates of animal units before they could be analysed

meaningfully. This meant that a number of assumptions had to be made, e.g. How many dead lambs are there in a bag?. These assumptions were validated with industry representatives via established research-industry interface meetings.

The subsequent estimated animal units data were analysed for three separate age groups: 0-1 month old lambs; 2-12 month old lambs and sheep over 12 months of age. They were summarised and described over time for the country, as a whole, and by postcode area. Time-series methods were applied at a country level only. The TADA, based on the Farrington method, was implemented at both country and postcode area level. The reference period was the calendar year 2011.

Diagnostic submission data were summarised and described over time for the country, as a whole, and by postcode area. To be comparable with the NFSCo data, these data also had to be manipulated into estimated animal units, aggregated by full postcode and month, up into postcode area, the appropriate age group determined and, finally, stratified into acute and chronic fluke diagnoses. The same analyses were done.

Results

The data on membership was not suitable as a denominator dataset, although it did enable some insight into the geographical usage of this voluntary collection scheme and changes over time. These insights will need to be considered when trying to interpret the count data from the collections. Members could have collection points in more than one full postcode and a full postcode could contain collection points belonging to more than one member.

Distinct seasonal variations in the frequency of collections and subsequent estimated animal units of fallen stock were seen over the course of a calendar year. These corresponded to expectations, given the annual cycle of the sheep production-year calendar; with peaks for 0-1 month old lambs and sheep over 12 months of age around the lambing period and for 2-12 month old lambs later in the year. The geographical variation could be explained by the underlying uneven distribution of the density of sheep population and holdings, combined with the insights into membership of this fallen stock scheme and industry knowledge of other operators.

A significant alarm was raised for both 0-1 month old lambs and sheep over 12 months of age in April 2013, for Scotland as a whole and in specific postcode areas. This corresponded to a major weather event. Severe adverse weather conditions, snowfalls, occurred in a number of areas in Scotland, resulting in increased mortality at the peak of the lambing period.

Additional alarms were produced at postcode area level for a number of time-points, in differing age groups. A number of these related to 2-12 month lambs during the last quarter of 2012 and into January 2013.

The liver fluke diagnostic data consisted of just over 1000

submission records, of which less than a fifth were for acute fluke diagnoses. There could be multiple animal units per record. Again the geographic distribution varied, as did the annual number of submissions.

The seasonal and annual trend for acute fluke diagnoses were similar for both the age groups encountered: 2-12 month old lambs and sheep over 12 months of age. The peak seasonal effect occurred in the late autumn/early winter (October/November) and January; the peak annual effect in 2012. However, the peak seasonal effect for sheep over 12 months preceded that of the 2-12 month lambs, being in October and November, respectively. In both age groups alarms were raised in each of the four months from October 2012 to January 2013, inclusive, corresponding to those observed in the fallen stock animal units.

Not surprisingly, given the pathogenesis of liver fluke infection, the chronic fluke diagnoses were more variable, with 2013 being the year with peak annual effect. The alarms raised varied by age group: in an extended winter period for 2-12 month lambs from November 2012 to April 2013, then again in July and August 2013; while there were no winter 2012/13 alarms for sheep over 12 months, there were two in August and September 2013.

Discussion

Despite the constraints and limitations that exist with an incomplete, business-focused, alternative data source, we have demonstrated that – with sufficient background knowledge and expertise, plus careful interpretation – there is potential for use of the fallen stock data as a proxy measure for mortality in the sheep population.

As provided (monthly) it would not be of sufficient timeliness to act as an early warning system. However, if this and a number of other system constraints can be overcome – for which recommendations were made to the data providers – it is possible that timeliness could be improved and these data could become a component in a syndromic surveillance system.

In this study, the laboratory diagnostic submission data were analysed in a comparable manner, in order to be complementary to and assist in the retrospective explanation of historic events. Again, primary provider insight into the data was absolutely vital, along with epidemiological expertise and knowledge of the pathogenesis of the disease process, to be able to utilise the data appropriately and turn it into useful information.

These data could be utilised in a more timely, prospective manner and have the potential to provide early warnings of an emergent problem. If this were required then we would plan to trial different analytical approaches, due to the sparse nature of the data.

Liver fluke was chosen as the diagnostic exemplar in this study for a number of reasons: it is a disease that has known seasonal variation, acute fluke causes mortality in sheep and

2012 was a particularly conducive year for fluke (good for fluke; bad for infectious load and consequences for the sheep). Further diagnoses and clinical combinations remain to be explored. However, as it requires significant resource input from several skill-sets to investigate the utility of alternative data sources and to turn them, and any subsequent analytical outcomes, into useful information the key questions remain – is it worth it? Does the benefit outweigh the cost? Does the input required really add value?

Acknowledgements

The ERU project team was funded as part of the scientific deliverable to evaluate new methods and systems within

Work package 6.1 “Measurement and monitoring to enhance livestock health in Scotland” of the Scottish Government’s Rural and Environment Science and Analytical Services Division (RESAS) portfolio of Strategic Research 2011-16 RESAS Programme 2, Theme 6.

NFSCo data were originally supplied by Jane Rockingham on behalf of NFSCo (National Fallen Stock CIC) with the permission of Mr M. Seals on behalf of NFSCo.

SAC Consulting’s Veterinary Services (SAC C VS) data were supplied with the permission of Mr Brian Hosie, on behalf of SAC C VS.