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Using seasonal-trend decomposition based on loess (STL) to explore temporal patterns of pneumonic lesions in finishing pigs slaughtered in England, 2005–2011

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ABSTRACT

Enzootic pneumonia (EP) is responsible for considerable economic losses in pig production. This study analyses temporal variations of pneumonic lesions present in slaughtered finishing pigs utilising a novel analytical tool – STL decomposition. Using data collected over a 6-year period starting in July 2005, time-series analyses were conducted to identify trend and the presence of seasonal variations to support industry led measures to monitor and control this important respiratory disease. In England, the BPEX Pig Health Scheme monitors the occurrence of EP in slaughtered finished pigs by identifying its gross pathology, enzootic pneumonia-like (EP-like) lesions. For visual analytics, the monthly prevalence for EP-like lesions was modelled using STL, a seasonal-trend decomposition method based on locally-weighted regression. A binomial generalised linear mixed-effects model (GLMM), accounting for clustering at batch level, was used to test the significance of the trend and seasonality. A mean of 12,370 pigs was assessed per month across 12 pig abattoirs over the study period. A trend toward reduction in prevalence of EP-like lesions during the first 3 years of BPHS, followed by an increasing trend, was identified with STL. This feature was consistent with the presence of a statistically significant positive quadratic term ("U" shape) as identified using the GLMM inference model. November and December appeared in the STL explorations as higher seasonal peaks of the occurrence of EP-like lesions. These 2 months had a significantly higher risk of this disease (OR = 1.38, 95% CI: 1.24–1.54 and OR = 1.4, 95% CI: 1.25–1.58, respectively, with July taken as baseline). The results were reported back to the pig industry as part of the national monitoring investigations.

1. Introduction

Respiratory disorders are regarded as the most serious diseases in modern swine production world-wide (Sorensen et al., 2006). Particularly in Great Britain, enzootic pneumonia-like (EP-like) lesions have been reported as the most prevalent respiratory condition detected through pig abattoir monitoring (Sanchez-Vazquez et al., 2010a). Although EP-like lesions are not pathognomonic for a particular pathogen (Sibila et al., 2009), *Mycoplasma hyopneumoniae* is usually involved in this pathology (Sorensen et al., 2006; Meyns et al., 2011). Substantial economic losses have been attributed to this infection including reduced feed efficiency, reduced daily weight gain and increased production costs due to medication (Straw et al., 1989; Thacker, 2006). Since 2005 the BPEX Pig Health Scheme (BPHS) has monitored the occurrence of respiratory gross pathology in pigs slaughtered in England's main pig abattoirs. On a regular

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basis, swine veterinarians carry out detailed post-mortem examinations in parallel to the routine official food-safety meat inspections. BPHS offers consistent monitoring of the occurrence of EP-like lesions, which is used by the pig industry to evaluate the behaviour of national trends and to promote strategies leading to health recommendations aimed at addressing increasing trends, or to confirm favourable situations when the level of a disease is diminishing.

Understanding the temporal patterns of a disease is an essential step in learning about its epidemiology. Time-series analyses aim to provide a concise description of data correlated through time – serial correlation. Exploratory methods and graphical representations are integral to understanding the complexity of serially correlated data (Diggle, 1990). This is particularly true where the sample is equivalent to the population or a large sample size is available (where, for most practical purposes, the sample behaves approximately equal to the population), in which statistical inference is secondary in favour of descriptive methods. In this respect BPHS, with 6 years of consistent monitoring in English abattoirs, offers a unique opportunity to explore the temporal patterns of the occurrence of EP-like lesions. An exploratory method well-established in other fields is a seasonal-trend decomposition based on locally-weighted regression (loess) widely known as "STL" (Cleveland et al., 1990; Hafen et al., 2009). The STL method is straightforward to use, allows for flexibility in specifying the amount of variation in the trend and seasonal components of time-series, and produces robust estimates that are not distorted by transient outliers (Cleveland et al., 1990). In particular STL offers excellent data visualization – visual analytics – (Hafen et al., 2009). STL has been widely used in several disciplines including environmental science, ecology, epidemiology and public-health (Cleveland et al., 1990; Chaloupka, 2001; Silawan et al., 2008; Hafen et al., 2009).

This study analyses the 6-year trend of BPHS EP-like lesions and identifies the presence of seasonal variations, thereby investigating the progress (if any) made by the industry in controlling this respiratory disease. This paper presents a time-series investigation executed in two steps: firstly, visual analytics through STL are utilised to explore the temporal structure of this respiratory pathology; and secondly, an inference model, generalised linear mixed model (GLMM), is used to statistically test the significance of the temporal attributes. This paper is also intended as a reminder of the importance of data exploration in time-series analyses, and therefore places a particular emphasis on describing the graphical exploratory process executed with STL.

2. Material and methods

2.1. Data source

2.1.1. BPEX Pig Health Scheme

BPHS has monitored the occurrence of EP-like lesions across the largest pig abattoirs in England since July 2005. Veterinarians assess every second pig in a batch (up to 50 pigs assessed) for gross pathology. The scheme feeds back benchmarked results from abattoir inspections to the participating producers (i.e. those paying a fee to be part of the scheme). The inspections, however, include all the batches submitted to the abattoir on the assessment days regardless of their BPHS membership status. More detailed information about BPHS can be found elsewhere (Sanchez-Vazquez et al., 2011).

Fig. 1. Map of Great Britain showing England shaded, with dots representing the location of the 12 abattoirs included in the study.

2.2. Study sample

This study used all (members and non-members) BPHS records available from the 12 abattoirs that participated in BPHS from July 2005 to June 2011. The abattoirs are geographically wide-spread across England (see Fig. 1). A total of 890,654 pigs (from 20,874 batches) have been assessed over this 6-year period, submitted from 1541 herds. The study data are the combined set of pigs assessed by BPHS.

2.3. The EP-like lesion

EP-like lesions are reported for the following gross pathology: a red-tan-grey discoloration, collapse, and