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SHORT COMMUNICATION

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Utility of examining fallen stock data to monitor health-related events in equids: Application to an outbreak of West Nile Virus in France in 2015

Géraldine Cazeau[1] | Agnès Leblond[2] | Carole Sala[1] | Marie Froustey[1] | Cécile Beck[3] | Sylvie Lecollinet[3] | Jackie Tapprest[4]

[1]French Agency for Food, Environmental and Occupational Health and Safety (ANSES), Laboratory of Lyon, University of Lyon, Lyon Cedex 07, France

[2]VetAgro Sup, National Institute for Agricultural Research (INRA), UMR EPIA, Animal Epidemiology, University of Lyon, Marcy l'Etoile, France

[3]ANSES, Animal Health Laboratory, UMR 1161 Virology, ANSES, INRA, ENVA, EURL on Equine Diseases, Maisons-Alfort, France

[4]Dozulé Laboratory for Equine Diseases, ANSES, Goustranville, France

Correspondence
Jackie Tapprest, Dozulé Laboratory for Equine Diseases, ANSES, Goustranville, France.
Email: jackie.tapprest@anses.fr

Abstract

Few studies about the use of quantitative equine mortality data for monitoring purposes are available. Our study evaluated the utility of monitoring emerging equine diseases using mortality data collected by rendering plants. We used approaches involving modelling of historical mortality fluctuations and detection algorithm methods to analyse changes in equine mortality in connection with the West Nile Virus (WNV) outbreak that occurred between July and September 2015 along the Mediterranean coast of France. Two weeks after the first equine WNV case was detected by clinical surveillance, detection algorithms identified excess mortality. The temporal distribution of this excess mortality suggested that it was related to the WNV outbreak, which may helped to assess the impact of the WNV epizootic on equine mortality. The results suggest that real-time follow-up of mortality could be a useful tool for equine health surveillance.

KEYWORDS
epidemiological surveillance, equine, mortality, syndromic surveillance, West Nile Virus

1 | INTRODUCTION

West Nile Virus (WNV) is an arbovirus mainly transmitted by mosquitoes to avian reservoir hosts, horses and humans. West Nile Virus infection in humans and horses is generally asymptomatic or associated with influenza-like illness; however, in some cases, the infection can lead to severe neurological symptoms and mortality (Hayes et al., 2005). The Mediterranean coast of France was affected by several equine WNV outbreaks between 2000 and 2006, and again in 2015 after nine years of silence (Bahuon et al., 2016; Beck et al., 2016). Few studies have evaluated the benefit of using mortality data from actual outbreaks in equine disease surveillance (Faverjon, 2015). In France, the main source of equine mortality data is the Fallen Stock Data Interchange database (FSDI) managed by the French Ministry of Agriculture. Recent evaluation of these data has demonstrated their potential and utility in epidemiological surveillance (Tapprest et al., 2016). The aim of our study was to evaluate the benefit of following up on equine mortality in the context of West Nile disease emergence in horses on the Mediterranean coast of France in 2015.

2 | MATERIALS AND METHODS

2.1 | Data sources

The weekly number of equine deaths originated from the 10,428 removal visits registered in the FSDI database from 2011 to 2015 for the Mediterranean coast of France (supplementary item). Within this area, WNV is considered a potential etiology for all equine clinical cases that include neurological symptoms, and occur between July and November. Equine suspect clinical cases were reported through local Veterinary Services or the French equine epidemiosurveillance network RESPE (Bahuon et al., 2016). Case confirmation during the 2015 WNV epizootics was based on laboratory findings, for example, positive screening by competition and IgM capture ELISA tests, followed by positivity in WNV virus neutralization assays. The weekly number of WNV notifications in the same region was provided by the French Reference Laboratory for equine diseases. The date of suspicion (date of clinical onset or date of blood sampling) was used as the date of disease occurrence.

2.2 | Data analysis

Classic time series analyses and detection algorithms were used to provide equine death predictions and excess detection (Dorea, McEwen, McNab, Revie, & Sanchez, 2013). A Negative Binomial (NB) regression model was used to obtain (a) a clean baseline for the 2011-2014 calibration period, and (b) the prediction values for the period of interest (2015). Different parametric assumptions regarding the trend (no trend, linear trend, quadratic trend), seasonality (annual periodicity) and auto-regressive processes over the last two weeks (AR1 and AR2) were tested. The best model was selected based on the lowest Akaike Information Criterion (AIC) (Wei, 2006) and the diagnosis of the residuals plots. The clean baseline was obtained by the replacement of the observed values above the one-sided 95% confidence interval (CI) by the 95% CI fitted value of the model (Tsui, Wagner, Dato, & Chang, 2001). The expected weekly number of equine deaths during 2015 was obtained by refitting the NB model on the clean baseline. Four methods were used to evaluate excesses mortality:

- The 95% CI of the NB binomial model
- A Shewhart control chart with a detection limit of one standard deviation
- A cumulative sums control chart (CUSUM) with a detection limit based on the upper limit of the 95% CI and a sensitivity parameter of 0.1
- An exponential weighted moving average control chart (EWMA) with a smoothing parameter of 0.25, and a detection limit of 2 standard deviations.

For all these methods, a signal was produced when the observed values or residuals exceeded the prediction. Signal detections were compared graphically to the change in the number of WNV notifications in order to discuss the possible causal relationship between the epizootic and the excess mortality. R software (R Core Team, 2016) version 3.3.0 (2016-05-03) was used for all data processing and statistical analyses (qcc and surveillance packages for control charts implementation).

3 | RESULTS

The model with annual periodicity, no trend and AR1 had the lowest AIC. Residuals plots indicated that the model fitted the data correctly. The results of the analyses and signal detection are provided in Figure 1. Excess mortality was found by all the methods between 24 August and 30 August 2015, two weeks after the first WNV case was identified (Figure 1).

4 | DISCUSSION

The analysis of FSDI data allowed us to highlight significant excess mortality occurring in the horse population along the Mediterranean coast of France at the end of August 2015. Although our approach does not demonstrate causality, the similar temporality of this excess and the epizootic curve are in favour of a link between excess deaths and the disease. The delay between the first notifications and the detection of excess mortality could be related to under-reporting of deaths by horse-owners, but also to the fact that many horses

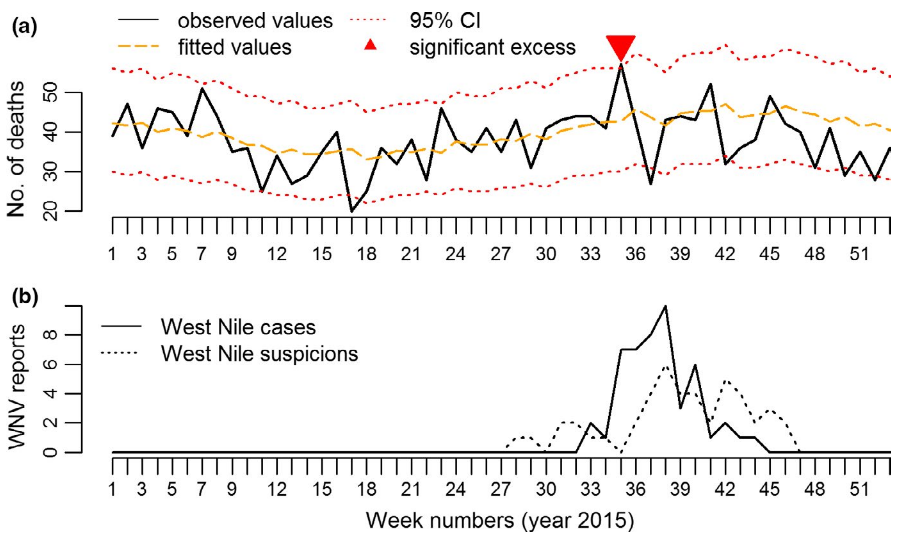

FIGURE 1 (a) Observed and predicted weekly number of death in 2015. The solid line indicates the number of deaths observed, the orange dotted line the values fitted by the model, the dotted red lines indicate the 95% CI. Excess mortality is identified by a red triangle. (b) Weekly number of WNV reports in 2015: the solid line indicates confirmed cases and the dotted line suspicions

probably recovered from the neuroinvasive forms of WNV. The lethality rate of 14.6% (6/41) quantified at the end of the 2015 WNV circulation period is clearly lower than the case fatality rate usually reported during WNV epizootics (20%–57%, Dauphin & Zientara, 2007). The 2015 WNV strain is a lineage 1 strain genetically close to the strain isolated in France in 2000 (personal data), which showed lethality of 34% in WNV neuroinvasive forms. Therefore, this finding of 14.6% lethality could be attributed to better vigilance of veterinarians, associated with an improvement in their therapeutic measures. Equine diseases with a higher mortality rate, such as eastern, western and Venezuelan encephalitis (Chapman, Baylis, Archer, & Daly, 2018), could probably be detected earlier by our system. The temporal monitoring of equine mortality in the at-risk zone is of benefit to reinforce awareness among veterinary practitioners and horse owners, and could help to detect an increase in the virulence of the circulating strain. The other benefit of monitoring equine mortality is the potential to detect the emergence of an unknown health event, an exotic disease or a disease whose reporting to the veterinary authorities is not compulsory, as mortality data are gathered before laboratory confirmation is available. Veterinary authorities may be able to respond earlier to outbreaks (i.e., implementation of survey) and thus reduce morbidity, mortality, as well as social and financial impacts.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

ORCID

Jackie Tapprest https://orcid.org/0000-0003-3159-3059

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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