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Assessment of Several Algorithms for Outbreak Detection using Bovine Meat Inspection Data for Syndromic Surveillance: A Pilot Study on Whole Carcass Condemnation Rate

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Objective

The objective of the work was to assess the performance of several algorithms for outbreak detection based on weekly proportions of whole carcass condemnation

Introduction

The majority of farmed animals are sent to slaughterhouses, making them a focal point for potential collection of health data. However, these data are not always available to health officials, and remain under-used for cattle health monitoring. Meat inspection data are mainly non-diagnostic (condemned portion and reasons for condemnation) and cover a large population. These characteristics make them a good candidate for syndromic surveillance. Whole carcass condemnation rate is linked to acute infections which reduces the dilution bias due to the variable period of time between cattle infection and the detection of lesions at the slaughterhouse.

Methods

Data from 177,098 cattle slaughtered in one French slaughterhouse from 2005 to 2009 were used (proportion of whole carcass condemnations: 0.97%). The method for outbreak detection covered three steps as previously explored by Dórea et al. on laboratory test data [1]: i) preparation of an outbreak-free historical baseline over five years, ii) simulation of over 100 years of baseline time series with injection of artificial outbreak signals with several shapes, durations and magnitudes and iii) assessment of the performance (sensitivity, specificity and precocity) of several algorithms to detect these artificial outbreak signals. The tested algorithms were the Shewart p-chart, one-sided confidence interval of a negative binomial regression model, and EWMA and CUSUM control charts on residuals of a negative binomial model. Age and sex were taken into account because of their known effect on whole carcass condemnation [2].

Results

The highest sensitivity was obtained using negative binomial regression and the highest specificity using CUSUM or EWMA (Table 1). EWMA sensitivity was too low to select this algorithm for efficient outbreak detection. CUSUM showed complementary performance to negative binomial regression.

Conclusions

The use of whole carcass condemnation data for syndromic surveillance is more complex than monitoring counts because we need to take into account the denominator (number of cattle slaughtered) as well as age and sex. The recent deployment of a national meat inspection database in France will enable prospective investigation of this indicator on real data. The Shewart control chart could be used as a first step considering its high sensitivity and simplicity of implementation followed by the negative binomial model and CUSUM on residuals of the negative binomial model when historical data becomes available.

Summary statistical values of performance indicators for all age-sex categories

Outbreak shape algorithm	Sensitivity Median (min-max)	Specificity Median (min-max)	Precocity Median (min-max)
Spike			
Shewart	0.85(0.48-1.00)	0.93(0.90-0.96)	/
CUSUM	0.82(0.30-1.00)	0.95(0.89-0.97)	/
EWMA	0.56(0.36-0.81)	0.96(0.92-0.97)	/
Negative binomial	0.89(0.50-1.00)	0.90(0.87-0.92)	/
Flat			
Shewart	0.99(0.71-1.00)	0.97(0.91-0.99)	1.28(1.01-2.68)
CUSUM	0.99(0.55-1.00)	0.99(0.94-1.00)	1.35(1.00-3.22)
EWMA	0.81(0.44-0.99)	0.99(0.94-1.00)	2.79(1.43-4.01)
Negative binomial	1.00 (0.75-1.00)	0.95(0.90-0.99)	1.16(1.00-2.15)
Linear			
Shewart	0.96(0.65-1.00)	0.96(0.91-0.99)	2.41(1.09-4.70)
CUSUM	0.99(0.44-1.00)	0.98(0.92-1.00)	2.32(1.06-5.29)
EWMA	0.78(0.34-1.00)	0.98(0.93-0.99)	3.51(1.62-6.00)
Negative binomial	0.99(0.70-1.00)	0.94(0.90-0.99)	1.97(1.02-3.97)
Exponential			
Shewart	0.96(0.66-1.00)	0.96(0.91-0.99)	2.04(1.03-4.90)
CUSUM	0.99(0.48-1.00)	0.98(0.93-1.00)	1.94(1.03-5.43)
EWMA	0.78(0.38-1.00)	0.97(0.93-0.99)	3.35(1.58-6.37)
Negative binomial	0.99(0.71-1.00)	0.94(0.90-0.99)	1.72(1.01-4.24)

For each indicator the median (Minimum-Maximum) values for each age sex category, each outbreak duration (2, 4 and 8 weeks) and magnitude (1 to 4) are presented by outbreak shape and outbreak detection algorithm. Parameters for each algorithm were: for Shewart: K=1.3; for CUSUM: H=2; for EWMA: Lambda=0.4 and L=1.3; for negative binomial regression: 80% confidence interval.

Keywords

Syndromic surveillance; Animal health surveillance; Early outbreak detection; Time series

References

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