Syndromic surveillance on phone calls about cattle health problems for early detection of emerging diseases

H BROUWER1*, A DE BONT-SMOLENAARS1, L VAN WUIJCKHUIS1, G VAN SCHAIK1, 2
1Department of Farm Animal Health, Faculty of Veterinary Medicine, Utrecht University, the Netherlands
2Department of Farm Animal Health, Deventer, the Netherlands

*H.brouwer@gdanimalhealth.com

Abstract
The aim of this study was to develop a real-time syndromic surveillance system based on calls to the helpdesk ‘Veekijker’ concerning non-specific health problems (drop in milk production, fever, diarrhoea and fertility disorders) in cattle for early detection of emerging infectious diseases. The outbreak with Schmallenbergvirus (SBV) that emerged in the Netherlands in 2011 was used as case study.

A time series analysis was run for which data were aggregated on week level. Second, a spatiotemporal cluster analysis was run for which data were aggregated on postal district-week level. In both analyses, at least four consecutive weeks with one or more alerts of increased phone calls on one or more symptoms were considered a signal needing follow-up actions.

The results from the time series analysis showed four signals with an increased number of phone calls about at least one of the four symptoms in 2011 and actions would have been taken early August and in September. The spatiotemporal cluster analysis showed ten signals and actions would have been taken mid July until the beginning of September. The syndromic surveillance on phone calls would have resulted in follow-up actions mid July, whereas in reality, without syndromic surveillance, the actions to verify whether a disease had emerged, started on August 25, 2011.

This study showed that combining results of real-time syndromic surveillance on ‘Veekijker’ phone calls about cattle health problems provides quantitative information to ‘Veekijker’ veterinarians and may increase the sense of urgency in the initial phase of an emerging disease outbreak.

Keywords: early-warning, syndromic surveillance, dairy cattle

Introduction
Since 2002, a national surveillance system is operational to monitor trends and developments in animal health and to early detect (re)emerging diseases in livestock in the Netherlands. For the latter a telephone helpdesk ‘Veekijker’ is operational and staffed by veterinary experts. This helpdesk receives approximately 4,000 calls about cattle each year. The aim of this helpdesk is to provide free veterinary and diagnostic advice and in turn, the helpdesk gains information on health problems which are registered in a central database. Most phone calls concern non-specific symptoms, such as fever, diarrhoea, drop in milk production and fertility disorders in dairy cattle. However, many (re)emerging diseases show non-specific symptoms at the onset of the disease and may be misinterpreted as endemic diseases. Therefore, there was a need for a tool to quantify and combine phone calls on non-specific symptoms among dairy cattle. The aim of this study was to develop a real-time surveillance system based on phone calls about non-specific symptoms in dairy cattle that provides quantitative information to veterinary experts concerning cattle health problems. The Schmallenbergvirus (SBV) that emerged in Dutch ruminants in 2011 causing drop in milk production, fever and diarrhoea at the early onset of the epidemic was used as case study.

Materials and methods

Phone calls
Phone calls concerning the symptoms fever, diarrhoea, drop in milk production and fertility disorders were available from January 1, 2009 to December 31, 2011. These data included unique farm identification or unique veterinary practice number, date of the phone call, cattle category (dairy, young stock, bull, veal, suckler cow), and symptom (drop in milk production, fever, diarrhoea and fertility disorders (including abortions)). Geographic location of Dutch dairy herds and veterinary practices were provided by GD Animal Health.

Statistical analysis
First, for each of the symptoms a time series analysis was run for which the data were aggregated on week level. For each week, a two-weekly moving sum of phone calls was determined to have sufficient numbers of phone calls per week. A linear regression model was used in which seasonality was taken into account by including sine/cosine harmonics as predictors. The number of harmonics was chosen according to the AIC criterion to best fit the observed number of phone calls. The analysis was repeated every week with an updated moving baseline period of the previous 104 weeks. For each week, the difference between observed and predicted number of calls was determined (the residual). A linear regression model was used in which seasonality was taken into account by including sine/cosine harmonics as predictors. The number of harmonics was chosen according to the AIC criterion to best fit the observed number of phone calls. The analysis was repeated every week with an updated moving baseline period of the previous 104 weeks. For each week, the difference between observed and predicted number of calls was determined (the residual). Weeks in which the residual exceeded the threshold value (95th percentile of the distribution of residuals from the baseline period) were considered alert weeks. Statistical analyses were performed using STATA/SE version 14 software (1).
Second, for each of the symptoms a spatiotemporal cluster analysis was run to identify space-time clusters of increased number of phone calls on drop in milk production, fever, diarrhoea and fertility disorders. Data were aggregated on postal district-week level and uploaded in SaTScan (2). A prospective analysis was carried out using a space-time permutation model (3). We scanned for ‘high rate’ clusters, i.e. increased number of phone calls than would have been expected. The analysis was repeated every week with an updated moving baseline period of the previous 104 weeks. The maximum spatial cluster size was set at 10% of the population at risk. A p-value was assigned to each cluster using Monte Carlo hypothesis testing (999 simulations). Clusters of increased number of phone calls were defined as windows with a p-value ≤0.05 and considered alerts.

For both analyses, the threshold to trigger an alarm was set when at least four consecutive weeks with one or more alerts of increased number of phone calls on drop in milk production, fever, diarrhoea and/or fertility disorders were found. These alarms were considered as signals needing follow-up actions. It was thought that the SBV epidemic started mid August and the first signal obtained by ‘Veekijker’ was on 25 August 2011 (4). However, because of the delay between infection and appearance/absence of clinical signs and limited awareness of SBV in the initial stage of the epidemic, it was assumed that reporting of clinical suspicions were probably delayed. Therefore, alarms were considered true up to four weeks prior to suspicion (5). Alarms that were found from mid July 2011 onwards were considered alarms that could have been associated with the SBV epidemic.

Results
The results from the time series analysis showed four signals with an increased number of phone calls about at least one of the four symptoms in 2011, namely i) 6 August (alerts in weeks from 9 July until 5 August) and ii) September 10, 17 September and 24 September (alerts in weeks from 13 August until 23 September, Figure 1). The first signal could have been associated with the start of the SBV epidemic and was 19 days earlier than the first signal obtained by ‘Veekijker’ without syndromic surveillance. The signals found in September were in the period during which SBV quickly spread among Dutch dairy cattle.

The spatiotemporal cluster analysis showed ten signals and follow-up actions would have been taken on i) 9 April and 16 April (alerts in weeks from 12 March until 15 April) and ii) 16 July until 3 September (alerts in weeks from 8 June until 2 September, Figure 2). The signals in April were found in a period in which it was unlikely that SBV had emerged. The signals from 16 July until mid August could have been associated with the start of the SBV epidemic, whereas the signal on 16 July was 40 day earlier than the first signal obtained by ‘Veekijker’ without syndromic surveillance. The consecutive signals found from mid August until the beginning of September were found in the period SBV quickly spread among Dutch dairy cattle.
Discussion

As many emerging diseases show non-specific symptoms at the start of the epidemic, these signs may be interpreted as endemic diseases and the start of an epidemic may go unnoticed. This study showed that combining the signals from a real-time syndromic surveillance on phone calls concerning four non-specific symptoms provides quantitative information to veterinary experts and, combined with their expertise, may increase the sense of urgency in the initial phase of an emerging disease outbreak. When the syndromic surveillance on phone calls would have run in real-time in 2011, it would have resulted in follow-up actions mid July, whereas in reality, without syndromic surveillance, the follow-up actions, to verify whether a disease had emerged, started at the end of August 2011.

In this study, only data on phone calls concerning four non-specific symptoms were combined. In addition, phone calls on other non-specific symptoms such as respiratory problems can be included. On the other hand, routinely available data on bulk milk and fertility have shown to be suitable for syndromic surveillance to increase the sense of urgency in the initial phase of an emerging disease outbreak (5). If routinely available census data, such as bulk milk collection recordings and fertility records are timely available, these data can also be included to increase the sensitivity of the syndromic surveillance for early detection of disease outbreaks.

In this study, an appropriate threshold to trigger an alarm was set when at least four consecutive weeks with one or more alerts of increased number of phone calls about drop in milk production, fever, diarrhoea and/or fertility disorders were found. The choice of an optimal threshold to trigger an alarm is an important issue when setting up a syndromic surveillance and might differ between countries. For example, lowering the threshold to trigger an alarm to two consecutive weeks, will increase sensitivity and timeliness of the surveillance system but decrease specificity due to more false alarms. The costs of follow-up actions have to be taken into account and to keep them at an acceptable level, only combined alerts could be investigated. On the other hand, the choice of the temporal and geographical unit might differ per health problem and between countries, depending on the availability and frequency of collection of the data and the occurrence of health problems after the onset of a disease outbreak.

The results from the space-time cluster analysis showed that clusters with increased phone calls concerning more than one symptom from the same area and the same time period were detected. Some space clusters about non-specific health problems increased in time, which could have been associated with the spread of the SBV virus to multiple farms in the vicinity. The detection of multiple clusters of different symptoms from the same area and the increase of space clusters in time are important signals and have to be taken into account when setting an optimal threshold to trigger an alarm.
References
1. **StataCorp.** *Stata Statistical Software: Release 14.*
   College Station, TX: StataCorp LP, 2015
2. **Kulldorff M and Information Management Services, Inc.** SaTScan™ v8.0: Software for the spatial and space-time scan statistics. [www.satscan.org], 2009

Acknowledgement
This study was financed and supported by the Dutch Ministry of Economic Affairs and the producer and interbranch organisations for dairy and veal.