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# Spatial analysis and temporal trends of antimicrobial use in Danish pig herds following the introduction of the Yellow Card scheme

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Monitoring systems are essential for detecting changes in disease status in a timely and effective manner [1]. The ability to detect changes in disease occurrence depends to a large extent upon the choice of data source [2].

The VetStat database was implemented in Denmark to monitor the use of drugs in livestock and to ensure transparency and compliance with legislation [3]. It is mandatory to register all purchases of prescription-only drugs for production animals either passively (by pharmacies and feed mills at the point of sale) or actively (by veterinarians).

The Yellow Card scheme was designed to target pig farmers using high amounts of antimicrobials and it was implemented in 2010 [4]. A Yellow Card initially releases an order to reduce antimicrobial use below the threshold within nine months. The Yellow Card scheme is the first of its kind, where interventions are directed at the farmer, based on actual herd-level prescription patterns registered in VetStat. These data provide a unique opportunity to monitor temporal and spatial changes in antimicrobial usage. These data can be used as a proxy for disease occurrence for all Danish Swine herds.

The present study investigated the changes in antimicrobial usage spatial patterns from 2008 to 2017 and the temporal trends with the establishment of the Yellow Card for each age group. The findings might help decision makers to use these data for disease surveillance and define a historical baseline for future monitoring and surveillance programs.

All purchases of antimicrobials made between January 2008 and December 2017 in Denmark were included in the analysis. For each purchase, the date, farm ID, age group, and disease group at the time of prescription were recorded. To make comparisons among the herds, we used Animal Daily Doses (ADD) as the unit of measurement for antibiotic use [5]; ADDkg defines the dose of treatment for 1 kg animal body weight. The number of days between consecutive purchases was used to estimate the average daily use of antimicrobials within the herd, assuming that all purchased antimicrobials were used at a constant rate. The data were then aggregated per month and the number of swine registered in the manure account was used to calculate the amount of antibiotic usage per pig-day for each herd.

An univariate dynamic linear model with a linear growth component, as previously described [6], was used to model each data stream at the herd level. This model is based on a Bayesian framework in which the observed data are combined with available prior information, which is expressed as a prior distribution at each time step. Different combinations of parameters were tested to optimize the models based on data from 2008 to 2009. The growth component of each time series was extracted for each time step  $t$ . Alarms were generated based on a trend for significant differences below zero being found using the 95% CI.

The maps with the monthly antimicrobial usage for each age group were created based on 10 x 10 km cells. The kernel smoothing surfaces were calculated based on a Gaussian model [7]. The median of specific monthly bandwidths was calculated for the age group and used to perform kernel smoothing, in order to identify any temporal differences.

The highest percentage of herds with a significant declining trend of antimicrobial consumption happened in 2010 both for weaner (maximum of 14.8%) and sow (9.7%) herds. For finisher herds, an increasing percentage of farms had a significant decline in the antimicrobial trend from 2011. Curiously, the second increase in herds having significant declining trends was observed between 2012 and 2014 for weaner and sow herds followed by the same type of increase for finisher herds between 2014 and 2015.

In general, the extent of areas with higher antimicrobial consumption decreased between 2008 for the three herd types. In the following years, these areas changed according to the month and the type of herd. The Kernel smoothing maps evidenced increases on the number of areas with a higher antimicrobial consumption for weaner herds in north of Jutland (June 2011 and between October 2011 to February 2012), eastern and south of Jutland (July 2012 and February 2013), both in Jutland and Funen (July 2014) and north and central west of Jutland (between 2016 and 2017). For sow herds, these areas were found in the south of Jutland (all 2010) and central Jutland (March 2015 and June 2016). Regarding the areas with higher antimicrobial consumption in finisher herds, the same areas covered a larger geographic area and were located in Jutland, Funen, and Zealand.

The declines in the antimicrobial consumption observed from the implementation of the Yellow card scheme continued into the first year after the enforcement. The general lower antimicrobial consumption helped to identify small geographical locations with increases on antimicrobial consumption in specific months after the implementation of the Yellow card scheme. Herd-level studies should be carried out to investigate further the causal factors for these increases in antimicrobial use such as the occurrence of disease outbreaks. Quantification of such causal factors is crucial as decision support to future strategies for disease surveillance and outbreak detection.

Figure 1

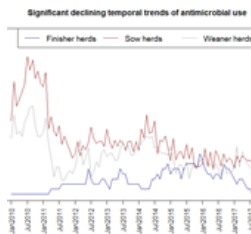
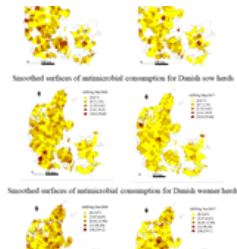


Figure 2



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