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# The role of movement restrictions and pre-emptive destruction in the emergency control strategy against CSF outbreaks in domestic pigs

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ABSTRACT

Classical swine fever (CSF) outbreaks in domestic pig herds lead to the implementation of standard control measures according to legislative regulations. Ideal outbreak control entails the swift and efficient culling of all pigs on premises detected positive for CSF virus. Often all pig holdings around the detected cases are pre-emptively destroyed to exclude transmission into the neighbourhood. In addition to these measures, zones are defined in which surveillance and protection measures are intensified to prevent further distant disease spread. In particular, all movements are prohibited within standstill areas. Standstill also excludes the transport of fattened pigs to slaughter.

Historical outbreaks provide evidence of the success of this control strategy. However, the extent to which the individual strategy elements contribute to this success is unknown. Therefore, we applied a spatially and temporally explicit epidemic model to the problem. Its rule-based formulation is tailored to a one-by-one model implementation of existing control concepts. Using a comparative model analysis the individual contributions of single measures to overall control success were revealed.

From the results of the model we concluded that movement restrictions had the dominant impact on strategy performance suggesting a reversal of the current conceptual thinking. Additional measures such as pre-emptive culling only became relevant under imperfect compliance with movement restrictions.

The importance of movement restrictions for the overall control success illustrates the need for explicit consideration of this measure when contingency strategies are being amended (e.g. emergency vaccination) and associated risks assessed.



## 1. Introduction

Classical swine fever (CSF) in domestic pig holdings is one of the most damaging livestock diseases in the northern hemisphere (Moennig, 2000). Additionally, trade restrictions in regions suspected of being affected by the disease exacerbate the effects of an outbreak. Logically, international veterinary authorities have established contingency plans in case of CSF detection in an area (e.g. Directive 2001/89/EC; European Commission, 2001). These guidelines provide explicit management strategies for coping with the infection in holdings identified as infected to prevent, as much as possible, further spread. Stamping out of detected outbreaks and related sanitary treatment is supplemented by epidemiological investigations tracing back the network of transmission. In order to prevent ongoing spread, two basic activities are designated in the guidance. First, potential neighbourhood contacts should be excluded by removing all neighbouring herds. Therefore, in the area surrounding an outbreak often all pigs are destroyed

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by pre-emptive culling (Directive 2001/89/EC stipulates a 500 m radius but this is sometimes extended to 1000 m; Vanthemsche, 1996; Staubach et al., 1997; Elbers et al., 1999). Second, restrictions on the movement of animals, people, materials and vehicles should be rigidly enforced. The guideline (i.e. §10 + 11) stipulates such a standstill within both the protection zone (3 km) and the surveillance zone (10 km around an outbreak).

Lessons have been learned from past epizootics (Elbers et al., 1999; Fritzemeier et al., 2000) when stamping-out of infected premises was applied simultaneously with pre-emptive culling and movement restrictions: These combined control efforts resulted in the timely eradication of the epidemic. However, the importance of the two preventive activities remained unknown. The purpose of this study was to gain a better understanding of the importance of pre-emptive culling and movement restrictions for the overall control success.

Our model experiments are motivated by recent discussions of alternative control strategies in case of a CSF outbreak in domestic pigs. Alternative strategy concepts argue in favour of emergency vaccination as a substitute for pre-emptive culling (Mangen et al., 2001; Karsten et al., 2007; Backer et al., 2007, 2009). Understanding how the altered part of the strategy impacts control success would allow for a reasonable assessment of the pros and cons of alternative strategies.

Management-oriented modelling is a particularly useful epidemiological technique for evaluating alternative strategies of disease control (Bates et al., 2003; Keeling et al., 2003; Schoenbaum and Disney, 2003; Eisinger et al., 2005; Garner and Beckett, 2005; Szmaragd et al., 2010). Here the epidemic is modelled in such detail necessary to represent management options explicitly and to provide model output similar to recordings in the field. During the last decade, encouraged by the economic and ethical relevance of large CSF epizootics, several management-oriented models have mimicked classical swine fever outbreaks in different regions or countries (e.g. Jalvingh et al., 1999; Nielen et al., 1999; Karsten et al., 2007; Backer et al., 2009; for a review see Karsten and Krieter, 2005). By necessity, these models coincide broadly with regard to the considered processes or mechanisms. For practical reasons these models are often not accessible for re-use. However, sufficient documentation of the modelling concepts (Schmolke et al., 2010) enables reimplementation in a simulation environment. Therefore we propose a model that repeats approved model features (Harvey et al., 2007; Backer et al., 2009) when mimicking CSF spread. We carried forward available modelling efforts to examine which part of the classic emergency control strategy is responsible for successful eradication in case of a CSF outbreak.

In the following we sketch the logic of our CSF spread model and specify the details of the simulation experiments. We considered overall success, duration of the epizootic, and losses caused by control-related destruction of herds. Furthermore, we adjusted strategy parameters to compensate limited compliance with movement restrictions. Finally, the logic of CSF emergency control is discussed with regard to the outcome of the simulation experiments.

## 2. Methods

### 2.1. Conceptual frame of existing emergency control policy

CSF outbreaks in domestic pig herds require the implementation of standard control measures according to international regulations (e.g. Directive 2001/89/EC). The strategy follows the ideal of controlling the epizootic by rapid destruction ("stamping out") of all pigs on premises where CSF virus was detected (e.g. by clinical inspection or after successful tracing of contact herds). Around detected outbreaks pre-emptive culling is applied within an established circular culling zone of 300–1000 m. Additional intervention measures increase awareness and prevent movement of the infection (e.g. via human mediated contact infections or animal transports). Circular restriction zones are implemented up to 10 km around every detected outbreak. In particular, animal movements are prohibited in these areas, including the transport of fattened animals to the slaughterhouse. Restrictions are foreseen for up to 30 days beyond the last detection of an outbreak herd within the affected area.

### 2.2. Logic of the model

The *modelling purpose* was to understand the role of individual measures during an epizootic in a pig industry area; and to determine whether these roles are congruent with those intended by the usual CSF control strategy.

The *model design* combines local and regional spread of CSF virus between geographically distributed pig herds with the explicit consideration of control measures. The Supplement provides the flow chart, parameter list, and documentation of the model (EcoEpi, 2010). The represented details include detection of animals with clinical symptoms by farmers or veterinarians, establishment of restriction zones, tracing, diagnostic testing of herds, or destruction measures (i.e. stamping-out, pre-emptive culling, and welfare slaughter). Efficiency of movement restriction was explicitly considered by randomly discarding the respective percentage of the regional transmission events that would have occurred without restriction. Movement restrictions did not influence simulated transmission within the local neighbourhood of outbreak herds assuming the worst performance of the measure in the situation of incomplete conceptual knowledge (Staubach et al., 1997; Jalvingh et al., 1999; Stegeman et al., 1999b). Spatial dimension of the model was designed to cover uncontrolled epizootics for one year with at least 99% success.

The *model schedule* performs daily updates of the simulation area (i.e. 500 km × 500 km) after evaluation of the following processes: local spread, regional spread, farmer and veterinary inspection, aging of fattening herds, diagnostic testing of herds, and handling of designated herds in accordance with the available capacity.

The *model input* comprises the direct epidemiological quantities for local transmission (Stegeman et al., 2002), incubation time (Jalvingh et al., 1999; Moennig, 2000), delay in onset of standstill or pre-emptive cull (Stegeman et al., 1999b), likely time interval of detection by different