Silent spread of classical swine fever in the UK: where and when to worry?

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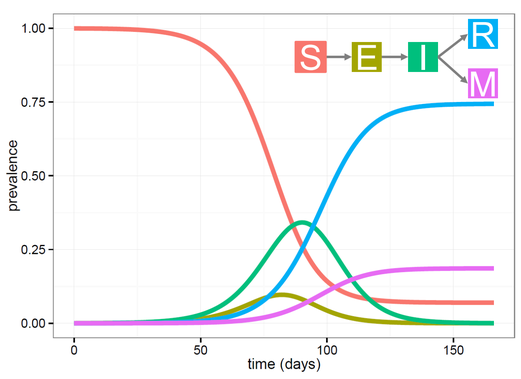


Fig. 1 Spread of CSF within a pig farm. Parameters were extracted from [3]. The model considers a strain spreading with a R_0=2.8, a latent period of 4 days and an infectious period of 15 days. Although all pigs are assumed susceptible (S) at the start, once infected, they pass through various state of infection: the latent but not infectious state (E), infectious state (I) and immune (R) or dead state (M). For illustration, prevalence of CSF in a farm of 2500 pigs is shown.

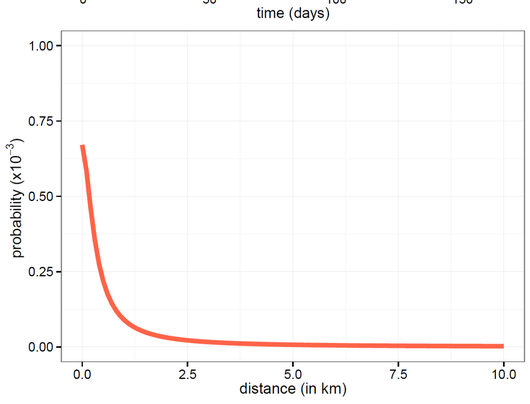


Fig. 2 Fitted kernel transmission function for the 2000 CSF epidemics in East Anglia, UK. Because only 16 cases were reported [2], a Bayesian framework approach [4] was used to fit the transmission function.

Introduction

- Classical swine fever (CSF) is a notifiable, highly contagious disease, which causes devastating haemorrhagic fever of pigs with high mortality rates in its acute form. Incursions may have drastic economic consequences for national swine industries.
- CSF can have a relatively long latent period and non-specific clinical signs which make its detection and control challenging and increases its potential for within and between-country spread during the pre-detection period.
- The length of time that CSF may spread before detection, known as the high risk period (HRP), has ranged from 2 to 9 weeks in previous CSF outbreaks [1,2].

Objective: To estimate the probability that CSF incursions in the United Kingdom (UK) may take off during the HRP.

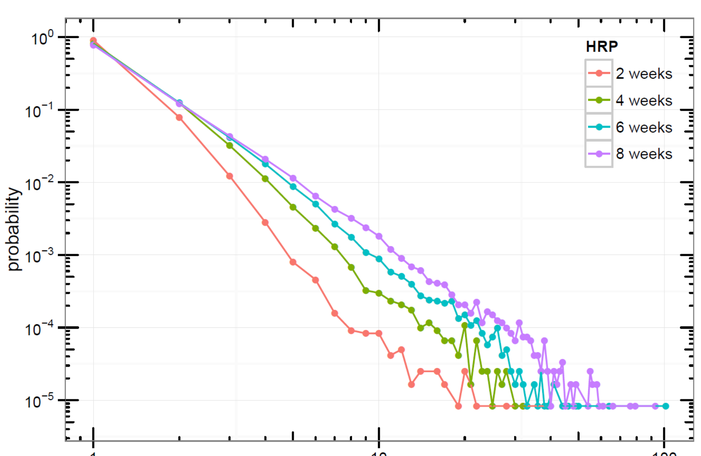
Model framework

- Farms follow a SIR infection process, whereas gathering places (e.g. markets) follow a SIS process.
- Infected gathering places are infectious for 1 day only, whereas farms are infectious until all animals on farm are immune or dead. CSF was considered spreading within farms following a SEIRM infection process (**Fig. 1**).
- Transmission pathways between premises are through animal movement and local spread.
- Infection probability through animal movements depends on (1) the number of pigs moving between premises and (2) the prevalence of infected pigs in premises.
- Infection probability through local spread depends on the shortest distance between farms and is modelled using a kernel transmission function.
- The kernel transmission function has been fitted using data from the 2000 CSF epidemic in East Anglia (**Fig. 2**).
- 10,000 randomly-allocated incursions were generated in the first Monday of each month of the year 2012.
- Probability of epidemic take-off is defined as the probability that an index-case infects ≥ 2 farms during the HRP.

Probability of epidemic take-off

- Over all incursions, 90%, 82%, 79% and 78% of epidemics involved the index-case alone when HRP = 2, 4, 6 and 8 weeks, respectively. (**Fig. 3**).
- The yearly probability of epidemic take-off ranged between 0.017 and 0.101.
- A maximum of 39, 33, 101 and 93 infected premises was estimated when HRP = 2, 4, 6 and 8 weeks, respectively.

Fig. 3 Probability distribution of the number of infected premises (IP) generated during the HRP.



Spatial variations

- The probability of epidemic take-off is strongly related to the distribution of pig farms in the UK (**Fig 4**).
- South West of England, East Anglia and North East of Scotland showed the highest risk of silent spread in the UK (**Fig 4**).
- Epidemics generated from incursions in Scotland are 3.87 times (95% C.I. 3.80 - 3.94) more likely to depend on animal movements than the rest of the UK. Infections were due to animal movements in 76% to 78% of the cases in Scotland, whereas they were due to 18% to 21% of the cases in the rest of the UK.

Temporal variations

- No significant temporal variation of the probability of epidemic take-off was found across the year 2012 (**Fig. 5a**).
- Over the UK, 20% to 23% of infection events were due to animal movements, regardless of the duration of the HRP and the time of the year (**Fig. 5b**).

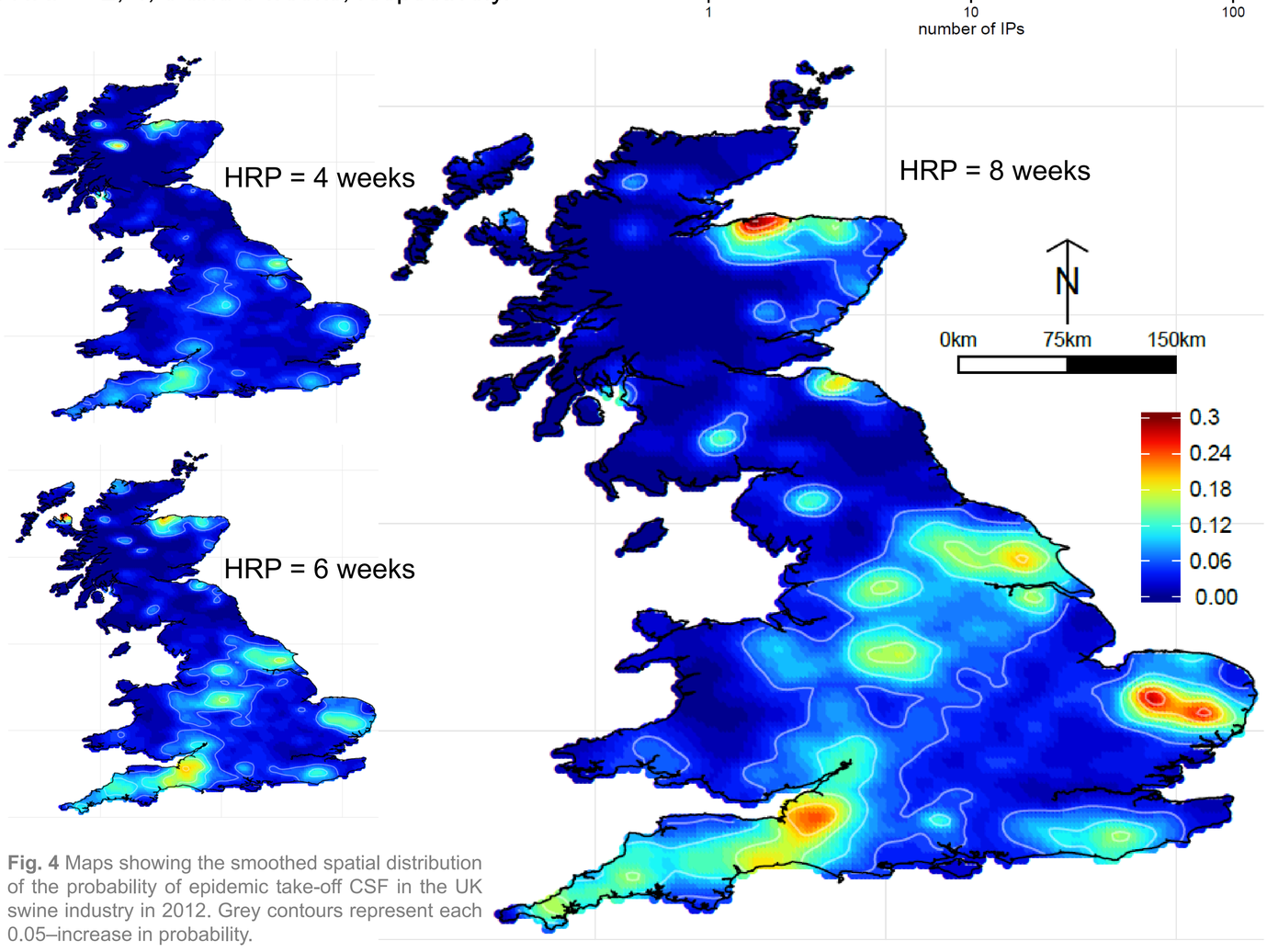


Fig. 4 Maps showing the smoothed spatial distribution of the probability of epidemic take-off CSF in the UK swine industry in 2012. Grey contours represent each 0.05–increase in probability.

Fig. 5 Radar chart showing the evolution of (a) the probability of epidemic take-off and (b) the proportion of infection due to animal movements for an incursion of CSF in the UK swine industry in 2012. Probability of epidemic take-off is defined as the probability that an index-case may infect at least 2 premises during the HRP.

Conclusions

- Although rare, widespread silent epidemics of CSF are possible in the UK swine industry at any time of year.
- Although the probability of epidemic take-off during HRP is strongly related to the distribution of commercial farms, in several areas the risk was increased by the presence of high numbers of non-commercial farms.
- Knowledge of spatial variation in (*i*) the probability of epidemic take-off and (*ii*) the importance of animal movement as a route of infection are key components of biosecurity and surveillance planning.

Acknowledgements

References

[1] Elbers et al. (1999) *Prev. Vet. Med.* 42, 157-184.
[2] Paton (2002) in *Trends in Emerging Viral Infections of Swine* (Eds Morilla, Yoon & Zimmerman), Iowa State Press, Ames, IA.
[3] Backer et al. (2009) *J. R. Soc. Interface* 6: 849–861.
[4] Jewell et al. (2009) *J. R. Soc. Interface* 6: 1145-1151.