Simulations of foot-and-mouth-disease epidemics: sensitivity analysis of input parameters

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Simulation models are a helpful tool to evaluate emergency plans for highly contagious diseases. In a previous project, "InterspreadPlus" (Epicentre, Massey University, NZL) was used to simulate the effects of control measures on FMD epidemics. However, some results were implausible as more extensive control measures resulted in larger outbreaks. Thus, in the present project we evaluated the influence of 13 selected input factors on the models outputs in InterspreadPlus Version 1.0.48.9 by sensitivity analysis following a given design of experiment.

The input factors were grouped in: time to onset of infectivity TOI (1), population density (1), contacts between farms (9), airborne (1) and local spread (1). For all input factors, a low and a high value was derived from the previous projects input data (1% and 99% percentile from a cumulative distribution, @RISK, or data from the literature). Thus, 2^{13} combinations (scenarios) were possible. As it was virtually impossible to run all scenarios, a fractional factorial Resolution4-Design (design 2^{k-p}; k: total number of factors, p: number of factors without the need of calculating every combination) was the prime choice to account for main effects and two-factor interactions. Thus, with 64 scenarios the whole range of possible combinations was properly covered. Scenarios were set to twenty iterations with up to 200 time periods (days).

Total computing time took 2667 hours. 40 scenarios were run as planned. But 24 stopped while running and were set to 5 iterations and 100 days. The remaining data was extrapolated.

Meta models used logistic regression for IP and TP to determine factors causing epidemics running out of control (>100 IP) and factors causing epidemics lasting at least 200 days (censored data). For controlled epidemics and lasting up to 199 days, Poisson Regression for IP and survival analysis (Cox Regression) for TP were applied.

In all models TOI was the most relevant input factor. In logistic models (IP and TP) this factor alone explained 86% to 93% of the total variance. Where a farm was assumed to be infective relative to its time of infection, the epidemic was likely to run out of control in contrast to scenarios where infectivity started relative to the onset of clinical signs.

Since TOI was the most important factor explaining the models outputs, InterspreadPlus was not recommended in evaluating emergency plans for the Swiss situation. As only virus's and animal's nature determine this factor, there is limited possibility to have an impact on it by control measures.