

# Simulation of foot-and-mouth disease spread and effects of mitigation strategies to support veterinary contingency planning in Denmark

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## Background

- The spread and control of foot-and-mouth disease (FMD) is complex with multiple transmission pathways and several host species
- Outbreaks of FMD have serious economic and social consequences on the national livestock industry (Export value Denmark: 21 Mio. EUR/day of FMD-susceptible animals/products)
- The introduction of FMD into Denmark still represents a risk (several outbreaks in Europe in the past decades)
- The last FMD outbreak in Denmark was in 1983
- Preparation for a possible entry of FMD is essential for authorities



## Aim

To support veterinary authorities in terms of an effective outbreak response to FMD in Denmark by

- Simulating epidemics in various regions, species, and livestock production systems
- Comparing the epidemiological and economic effectiveness of varying mitigation strategies depending on the introduction scenarios
- Testing the sensitivity of the model in terms of different detection periods and various national resources for an outbreak response

## Epidemiological model: EuFMDiS

- Spatial-temporal spread **within and between herds**
- Epidemic initiated in 1,000 index herds per species (1 iteration per herd):
  - Scenario a):** 4 regions and 3 species covering all productions including herds without outgoing movements to other farms
  - Scenario b):** whole DK and one specific production system per species (e.g. dairy, weaner herds) with large number of movements
- 14 mitigation strategies\*** (e.g. pre-emptive culling, larger zones, protective and suppressive vaccination)

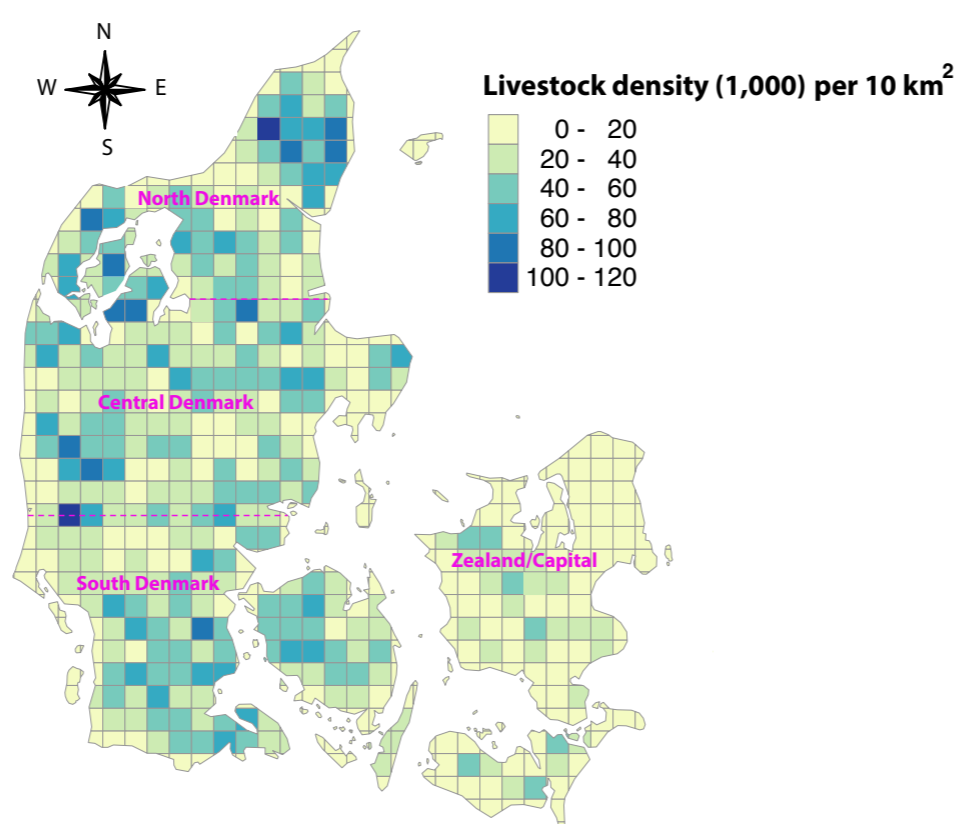


Fig.1: Livestock density map (n=1,000 livestock) per 10 km<sup>2</sup> stratified by North Denmark, Central Denmark, South Denmark and Zealand/Capital (represent the 4 regions of Scenario a).

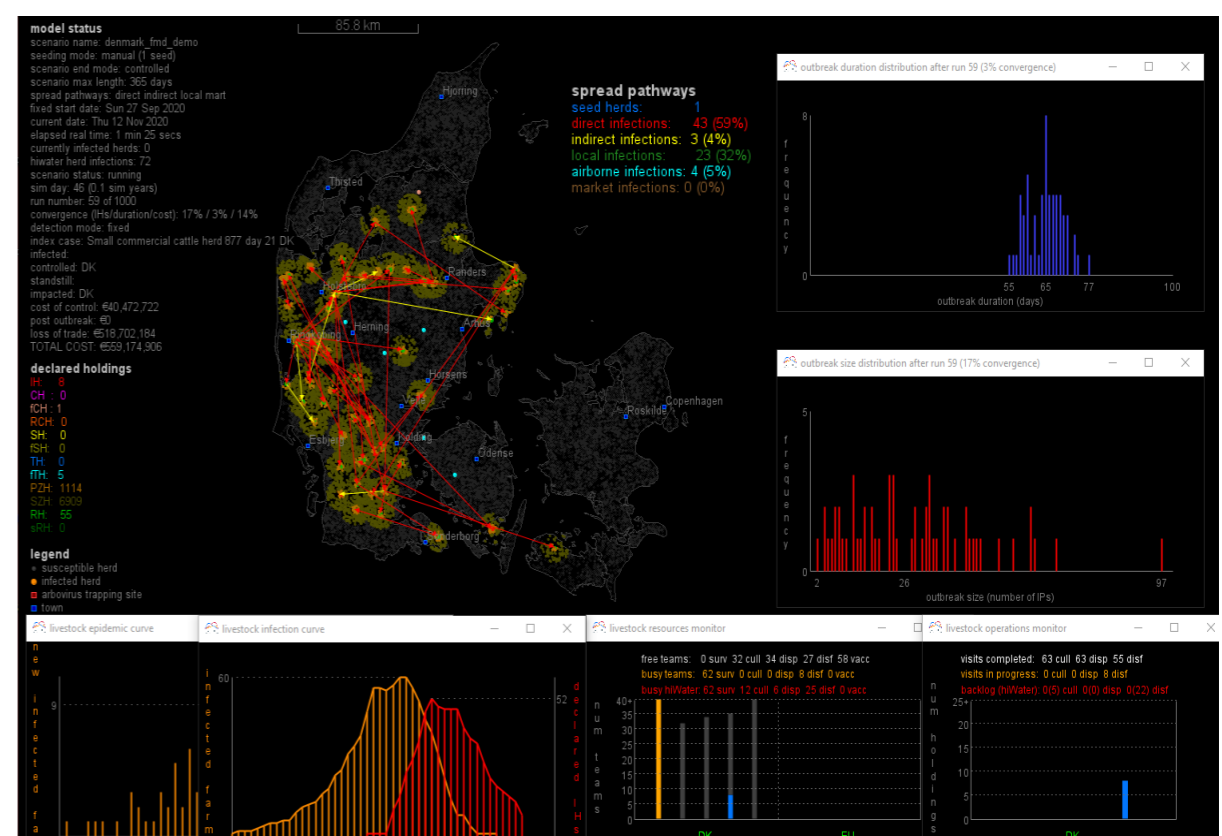


Fig.2: Visualization of the simulation of an FMD-Outbreak in Denmark. Spread between herds in daily time steps through direct contacts, market/saleyard spread, indirect contacts, airborne spread, and local spread.

## Economic model

### Costs of mitigation strategies incl. post-outbreak



Fig.3: Costs for mitigation measures in the model, on average. The size of the boxes is in relation to cost relevance, on average.

### Business interruptions

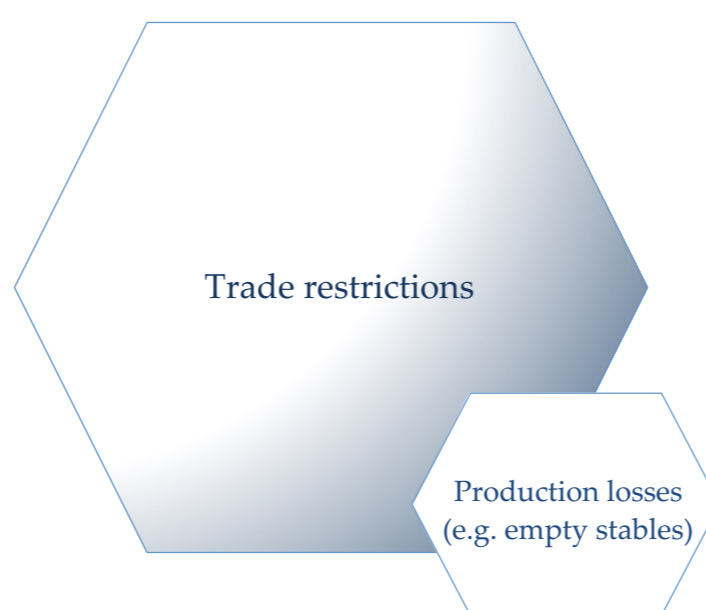


Fig.4: Trade effects and other cost positions in the model, on average. The size of the boxes is explained in Fig. 3.

### Total costs

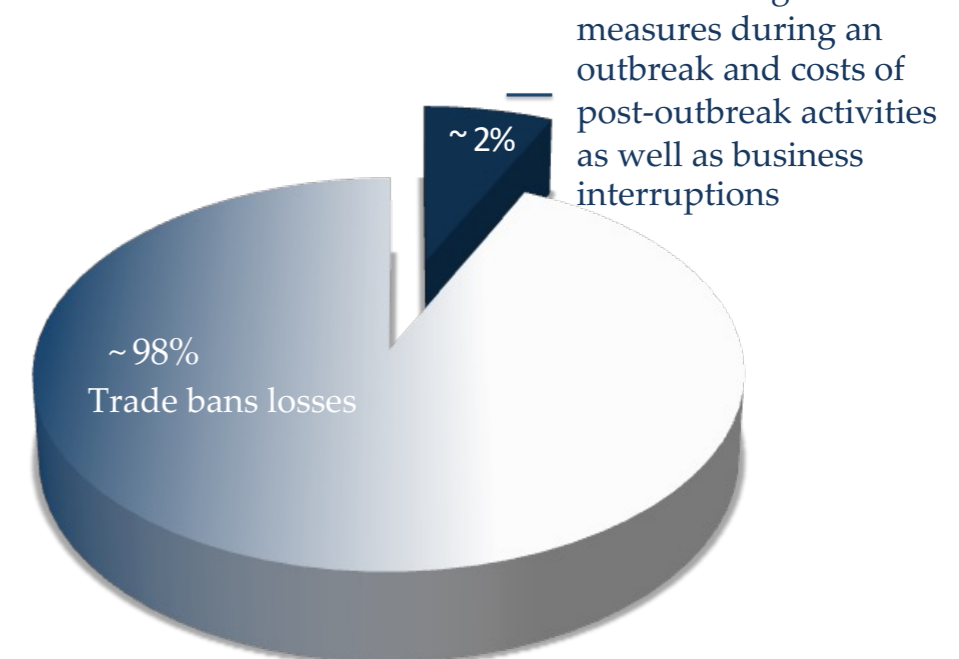


Fig.5: The proportion of the total costs across all scenarios and mitigation strategies, on average. The size of the boxes is explained in Fig. 3.

## Results

- No significant benefits** in terms of number of infected farms, epidemic control duration, and total economic costs, when **additional mitigation strategies\*** were implemented on top of basic control strategies (i.e. 3-day standstill period for all livestock movements, 3-km PZ, 10-km SZ, 14-day trace window)
- The choice of **index herd** (comparing Scenario a and b), **resources for outbreak control** and **detection time** significantly influenced the course of an epidemic
- An inadequacy of resources to undertake the control was detected during the simulations but **doubling of resources will reduce the number of infected farms and total economic losses** (up to 15.6% fewer farms were infected and 15.4% lower total economic losses, on average)
- Pre-emptive culling of dangerous contact herds** to infected herds based on tracing without any confirmation of infections would be the **most beneficial strategy in case of a late discovery of FMD** (i.e. detection day 28 instead of day 21 but with currently available resources for outbreak response)

\* Further details: Conrady, B., Mortensen, S., Nielsen, S. S., Houe, H., Calvo Artavia, F. F., Ellis-Iversen, J., & Boklund, A. (2023): Simulation of foot-and-mouth disease spread and effects of mitigation strategies to support veterinary contingency planning in Denmark (Paper submitted)