Optimal control for animal health surveillance and intervention strategies applied to ASF and HPAI

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Introduction

Designing effective control strategies for transboundary animal diseases requires balancing epidemiological impact with practical, economic, and operational constraints not only at official veterinary services considering producers perspective and impacts. Optimal control approaches offer a structured way to compare alternative interventions, especially when decision makers must weigh multiple, sometimes competing objectives in a systematic way. In the context of animal health, these methods can support the design of surveillance systems, and evaluate the feasibility of intervention portfolios under diverse outbreak conditions and the always difficult resource allocation. Here, we present a set of modelling case studies illustrating how optimisation frameworks can be used to explore control options for high-priority livestock diseases in Europe.

Methods

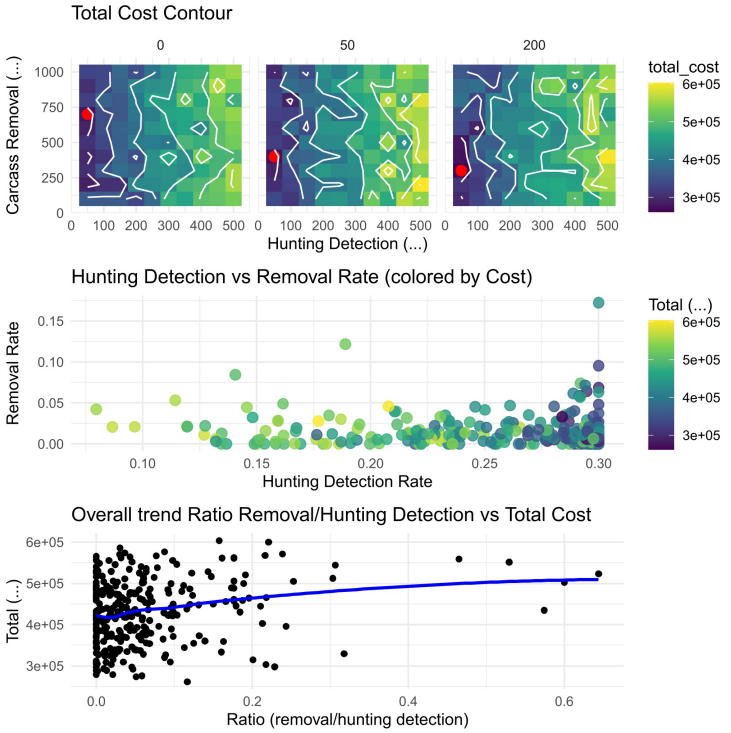
We re-used and developed mechanistic models for two contrasting systems: African swine fever (ASF) in wild boar populations in Germany and Highly Pathogenic Avian Influenza (HPAI) in poultry systems in France. Each model was coupled with an economic evaluation component that quantified both intervention expenditures and outbreak consequences. For HPAI, we assessed combinations of vaccination coverage, and the rates of culling, and preventive depopulation. For ASF, we examined strategies targeting minimizing the outbreak duration and detection efficiency, incorporating hunters' detection rate and carcass removal capacity. Wild boar density estimates were refined using national surveillance data as priors to calibrate the Enetwild wildlife density model. A global–local hybrid optimization algorithm was used to explore feasible strategy combinations across a wide range of cost assumptions and operational constrains evaluating the sensitivity to parameter changes.

Results

Preliminary results show that across both pathogens, optimisation revealed that the most effective strategies depended strongly on the assumed economic environment and epidemiological context. For HPAI, increasing vaccination costs shifted the optimal balance toward greater reliance on culling, whereas lower culling costs favoured broader vaccination coverage. For ASF, intermediate ratios between carcass removal effort and detection pressure produced the shortest outbreaks, highlighting the importance of coordinated surveillance and removal activities. Sensitivity analyses showed that small changes in unit costs or operational limits could substantially alter the recommended strategy.

Discussion

Our findings demonstrate that optimization can clarify how economic and epidemiological factors jointly shape the performance of disease-control strategies. Also, the central importance of a well-defined objective-function to evaluate disease-control/intervention strategies, as different formulations can lead to markedly different recommendations. Explicitly incorporating economic costs into animal-health models ensures that proposed interventions remain realistic and feasible, aligning epidemiological impact with practical resource constraints. Our results show that no single intervention is universally optimal; instead, systematic exploration across objectives and scenarios is essential to identify strategies that perform robustly under varying epidemiological and economic conditions when designing control policies for animal infectious diseases. Our next step will be to incorporate social impacts commonly faced by producers usually not included in the overall cost of outbreak management.



Optimization results ASF: Hunting detection vs removal and outbreak duration time penalty

Keywords: ASF, HPAI, optimisation, modeling, decision-making.

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