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Agent-based modeling as an innovative tool to simulate dynamics of disease transmission at the wildlife-livestock interface

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Background:Most epidemiological models have limitations for studying disease transmission in multi-host systems, such as the wildlife-livestock interface. Agent-based modeling (ABM) offers a spatially-explicit framework to simulate the behaviour of individuals (represented as agents) and pathogens, and their interactions with the environment. The objective of our study was to use ABM to investigate dynamics of infectious disease transmission between cattle and elk. Methods: The ABM included four main interrelated modules: pasture, cattle, elk, and pathogens. Pasture represented the geographic environment in which cattle move; it incorporated a model to simulate seasonal grass growth and depletion through grazing. Cattle and elk were described by attributes such as age, body weight, sex, infection status, and physiological status (i.e. pregnancy), which govern their nutritional needs. The use of the same environment by cattle and elk, guided by habitat selection functions, creates pathways for disease transmission. Infection of cattle and elk by the pathogen, or contamination of the environment were modeled as changes of the 'infection status' attribute. Pathogens were simulated by specifying different incubation periods, intra- and inter-species probabilities of infection, recovery times, persistence in the environment etc. The ABM was calibrated with extensive field data and modules were validated using the pattern-oriented modeling approach. Scenarios of intra- and inter-species pathogens transmission were simulated over one year. Results: The model will allow us to quantify the risk of pathogen transmission under current management practices based on pathogen characteristics, and evaluate alternative management scenarios to mitigate this risk. Conclusions: Through modeling the complexity of hosts' interactions with their environment, we can better understand the risks and drivers of disease transmission for different pathogens and cattle management strategies. Relevance: ABM provides an excellent tool for veterinary epidemiologists to simulate scenarios in a complex multi host system supporting decisions on livestock and pasture management.