Evaluation of vaccination strategies for an outbreak of Pseudorabies Virus in U.S. commercial swine using the North American Animal Disease Spread Model

Portacci K. (1*), Reeves A. (2), Corso B. (1), Salman M. (2)
(1) United States Department of Agriculture, Veterinary Services, Fort Collins, CO, USA, *Katie.A.Portacci@aphis.usda.gov
(2) Animal Population Health Institute, College of Veterinary Medicine & Biomedical Sciences, Colorado State University, Fort Collins, CO USA

ABSTRACT

Pseudorabies (PRV), or Aujeszky's disease, was considered eradicated from the United States commercial swine population in 2004, with eradication success attributed to the implementation of a PRV vaccination strategy. However, PRV is still maintained in feral swine populations and PRV may occasionally be found in non-commercial domestic swine exposed to infected feral pigs. To plan for effective response to future outbreaks in commercial swine, it is necessary to evaluate potential vaccination strategies. The North American Animal Disease Spread Model (NAADSM) was applied to determine the most effective vaccination response strategy to PRV in two States. The results indicate that one vaccination strategy may not be effective for the entire United States, rather regional differences such as production practices, population density and local response capacity should be considered in vaccination response planning.

KEYWORDS

Pseudorabies Virus, Aujeszky's, Vaccination, Disease Spread Model, Swine

INTRODUCTION

Pseudorabies (PRV), or Aujeszky's disease, is a disease of economic importance in swine due to abortion, still births and some death loss in breeding and finishing pigs. Swine serve as the only natural host for this herpes virus (Swine Herpes Virus-1). Pigs that survive infection with PRV develop a latent infection. In young pigs, the mortality rate can approach 100%. PRV is fatal in other species such as cattle, sheep, goats, raccoons, cats, dogs and rats, which may become incidentally infected (Pejsak & Truszczynski, 2006).

With the retail value of pork in the United States greater than $30 billion annually, in the 1900s PRV cost the industry an estimated $30 million annually (National Pork Board, 2000). In 1989, the U.S. Department of Agriculture (USDA) began a voluntary eradication program for PRV and invested $10 million over 10 years to eradicate this disease from the commercial swine industry. Because of the availability of a gene deleted vaccine which could be easily differentiated on a screening test, vaccination was essential during the initial eradication efforts. In 2003, all 50 States were considered free of PRV in commercial herds (USDA, 2006).

The virus is still maintained in a portion of the U.S. feral swine population and has been detected in some non-commercial domestic herds, or those swine that are captive but have reasonable opportunities to be exposed to feral swine. Reintroduction of PRV into commercial swine could occur from contact with feral swine or potential introduction of a more virulent strain through fomites or live animals brought into the United States through travel, imports or illegal trade. Vaccination for PRV in the United States no longer occurs and as a result the current commercial swine population is unprotected in the event of an introduction. Vaccination production has also decreased significantly and it is uncertain whether a large enough supply of vaccine would be available in the event of an outbreak.

The objective of this project was to determine the most effective vaccination strategy in the event of an outbreak of PRV in U.S. commercial swine. This information would be used by emergency response planners and the National Veterinary Stockpile to determine if stockpiling vaccination is necessary.

METHODS

The North American Animal Disease Spread Model (NAADSM) was used to simulate PRV outbreaks among commercial swine in two different regions of the United States. NAADSM is a stochastic, spatial, state-transition simulation model for the spread of highly contagious diseases of animals (Harvey, et al. 2007). The NAADSM application provides a framework for the development of customized disease scenarios. Model behavior, such as disease progression, disease spread, and the implementation of control measures including destruction and vaccination, are established by user-defined parameters. The model operates at the level of the herd: entire herds, rather than individual animals, progress from one transition state to the next. Similarly, all disease control measures are implemented at the level of the entire herd.

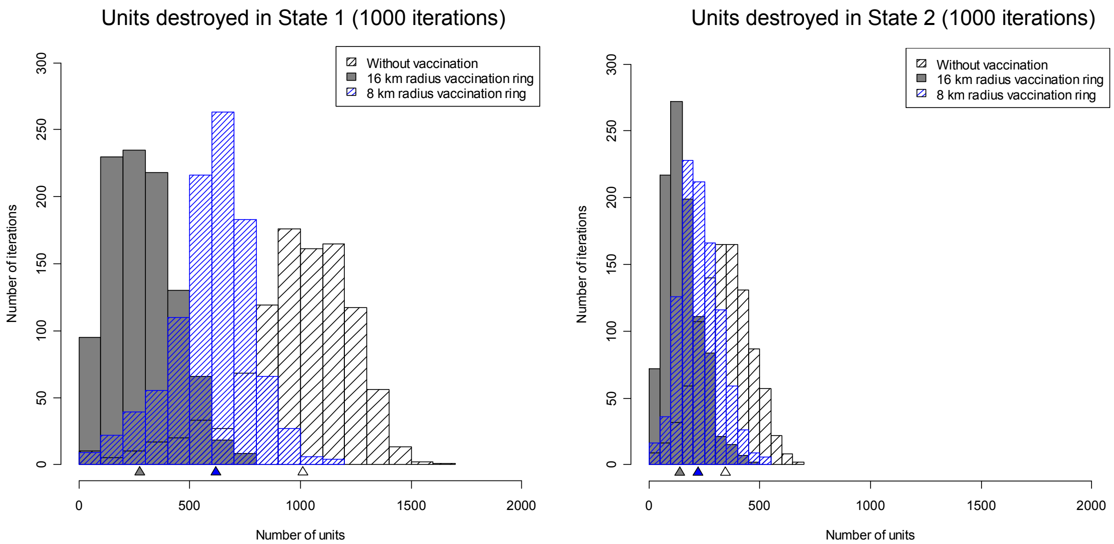
A scenario was chosen to model a highly virulent strain of PRV in two of the largest swine producing States. These Sates were chosen based on the large number of swine, variation in production types (State 1 has many breeding animals and State 2 had many feeder pigs), and the interest and support of these States for this project. Model parameters were developed based on current scientific literature, previous PRV outbreaks, expert opinion and current response recommendations from the USDA.

In the United States, the location of premises are not publically available, therefore premise location, animal numbers and production types were simulated using aggregate data available from the USDA National Agricultural Statistics Service (NASS) 2002 Census. A random point distributor (Hawth's tools) was used in ESRI ArcInfo to distribute premises based on the number of premises in the county. For each of the 5 production types available in NASS (farrow to wean, farrow to finish, farrow to grower, nursery only, finish only) an empirical distribution was constructed for the number of animals and premises with that production type. Through these distributions a size and production type was assigned to each premises.

Three vaccination strategies were compared: a 16 km radius around affected premises, an 8 km radius around affected premises and no vaccination. The model assumed that vaccine was 100% effective and could be delivered by producers as to not limit the number of vaccines used. All movement of animals within 8 km of a detected herd was stopped within 24 hours. All herds within the 8 km radius were tested to detect 5% prevalence with 95% confidence. One thousand iterations of each of the 6 scenarios (3 vaccination strategies in 2 states) were run.

RESULTS

The use of a 16 km vaccination ring, compared to no vaccination, decreased the median duration of the outbreak from 304 days to 145 days in State 1 and from 192 days to 102 days in State 2 ($p < 0.05$, KS test comparing deciles). The median number of premises affected decreased from 1,530 to 428 in State 1 and from 520 to 211 in State 2 when using a 16 km vaccination ring compared to no vaccination ($p < 0.05$). When the 8 km vaccination ring was applied in State 1, significantly fewer herds were affected and destroyed. However, in State 2, there was no statistically significant difference between the 16 km and 8 km vaccination ring.



CONCLUSION

Vaccination would be an effective tool for reducing the outcome and duration of an outbreak of PRV in the United States commercial swine industry. However, a national strategy for vaccination may not be the most effective approach to emergency response and regional differences should be considered when determining the most effective strategy. Differences in population density, herd size and production types were likely responsible for the differences between the two states discussed here, although analysis of these variables has not been conducted.

NAADSM is a valuable tool for disease program managers to evaluate the potential extent of disease spread and estimate resources needed in the event of an outbreak. The results of this analysis provide useful information for emergency response planning and for discussion regarding the capacity to produce a sufficient amount of PRV vaccine.

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