Effect of movement controls and biosecurity on transmission of disease by indirect contact and the role of vaccination in the control of foot and mouth disease in livestock production systems in the central United States

Sanderson MW (1), Forde-Folle, KN (2), Reeves, A (3)

(1) Department of Clinical Sciences Kansas State University, Manhattan, Kansas, United States
(2) United States Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services, Centers for Epidemiology and Animal Health, Ft Collins, Colorado, United States
(3) Animal Population Health Institute, Department of Clinical Sciences Colorado State University, Ft Collins, Colorado, United States.

ABSTRACT

Via simulation modeling, the potential impact of an introduction of Foot and Mouth Disease (FMD) into the state of Kansas in the Central United States was assessed, and the effects of control measures were compared using the North American Animal Disease Spread Model. One cow-calf herd in central Kansas was latently infected at the initiation of the simulation. Direct and indirect contact transmission was modeled along with reductions in indirect contacts, probability of transmission following indirect contact and vaccination. Most FMD transmission was due to indirect contact between herds and decreasing indirect contact or the probability of disease transmission following indirect contact decreased the median number of herds and animals infected and destroyed, as well as the length of the outbreak. These results highlight the importance of biosecurity and movement restrictions and the need for further research to assess their proper role and the role of vaccination in an FMD outbreak affecting U.S. production systems.

KEYWORDS

Foot and Mouth Disease, Disease Modeling, Disease Control

INTRODUCTION

Introduction of Foot and Mouth Disease (FMD) to the United States would result in large economic and production impacts to livestock producers and the economy as a whole. Effective management of an introduction of FMD is crucial to minimize the impact and disease modeling is an effective way to simulate the effect of different control measures. The North American Animal Disease Spread Model (NAADSM) is a spatially explicit, stochastic model for evaluation of control measures for infectious foreign animal diseases. The state of Kansas in the central USA has a large population of livestock including many cattle and swine as well as sheep and goats.

MAIN TEXT

Via simulation modeling, the potential impact of an introduction of Foot and Mouth Disease (FMD) into the state of Kansas in the Central United States was assessed, and the effects of control measures were compared using NAADSM. A simulated population of livestock operations was generated based on data from the U.S. Department of Agriculture's National Agricultural Statistic Service and Kansas Confined Animal Feeding Permit data. The population included 60,778 herds defined by latitude and longitude, production type (Cow-calf, Large Feedlot, Small Feedlot, Dairy, Swine, Sheep, and Goats), and herd size. One 242 head cow-calf herd in central Kansas was the initial latently infected herd in an otherwise susceptible population.

Rates of direct and indirect contact were estimated between each production type pair based on expert opinion. Direct contacts included shipment of livestock between herds in a latent, subclinical and clinical state. Herds detected as positive for FMD, were quarantined blocking further direct transmission. Indirect contacts modeled included veterinarians, feed truck deliveries, milk truck pick-ups, salesmen, nutritionists, AI technicians, hoof trimmers, employee contact, and neighbors. Three levels of reduction in indirect contact were modeled (10%, 20% and 30% of baseline level) by implementing movement controls following the first detection, and three levels of probability of disease transmission following indirect contact were modeled (10%, 15% and 20%), along with either no vaccination or a 10 kilometer vaccination ring around infected premises.

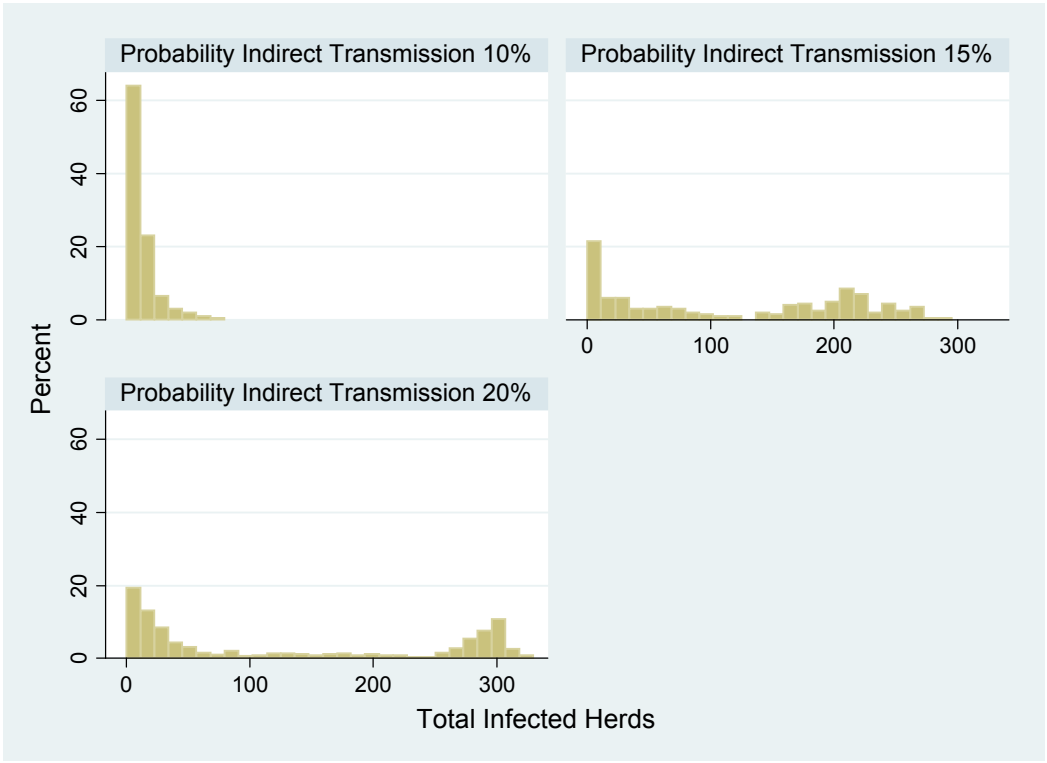

Figure 1 Total Infected Herds by the Probability of Disease transmission following Indirect Contact

The majority of FMD transmission was due to indirect contact between herds. Vaccination had little effect in these scenarios, but increasing the effectiveness of movement controls to decrease indirect contact and decreasing the probability of disease transmission following indirect contact decreased the median number of herds and animals infected and destroyed, as well as the length of the outbreak.

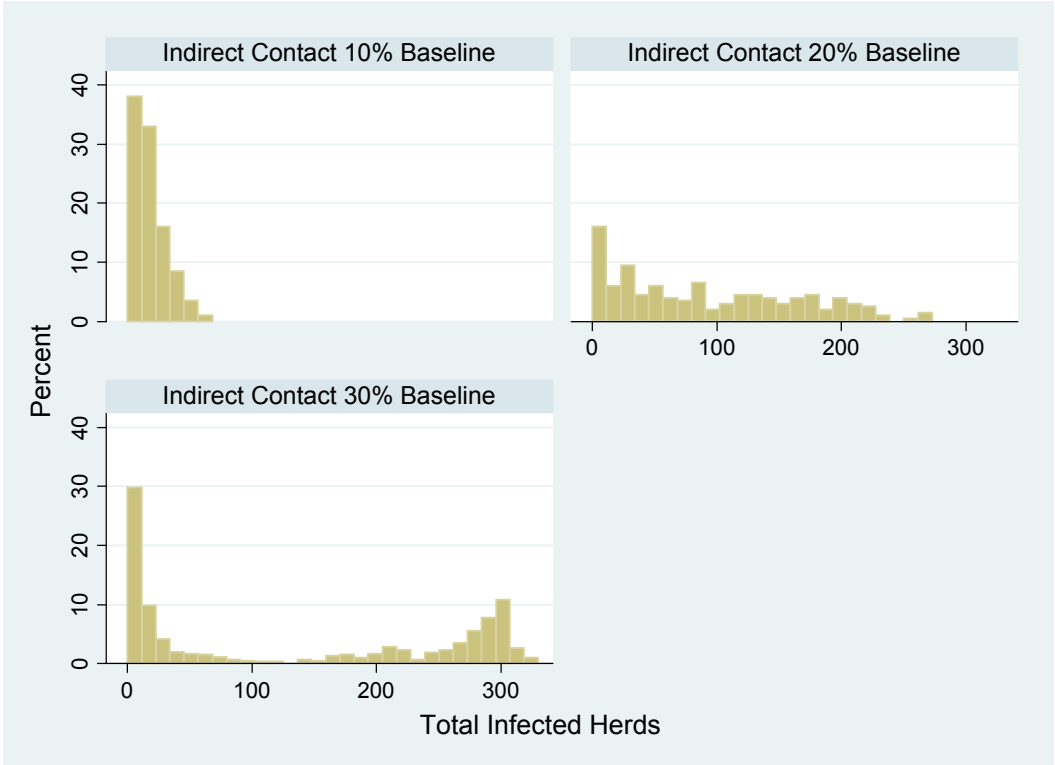

Figure 2 Total Infected Herds by the Percent of Baseline Pre-outbreak Indirect Contacts.

The high proportion of infections due to indirect transmission in these scenarios was likely due to the higher number of indirect contacts compared to direct contacts. Additionally once an infected herd was detected as positive all direct contacts ceased precluding any further direct transmission of infection by positive herds while indirect contacts continued.

These results highlight the importance of biosecurity and movement restrictions and the need for further research to assess their proper role and the role of vaccination in an FMD outbreak affecting U.S. production systems. Movement controls may be disruptive making optimal implementation essential during an outbreak. Increasingly stringent movement restrictions on indirect contacts may be difficult to maintain during an outbreak and may also result in animal welfare concerns, especially if feed and veterinary care cannot be expeditiously delivered. As such, implementing more stringent movements restrictions on people, vehicles, and equipment may not be attainable for the duration of an outbreak. Accurate estimates of the probability of transmission following indirect contact and the effect of specific biosecurity practices in decreasing the probability of transmission in U.S. production systems are also needed.

Effective biosecurity practices may control transmission and mitigate animal welfare concerns associated with increased movement controls, allowing continued production on non-affected farms. The practical implementation of effectively disinfecting vehicles, equipment, and individuals leaving the premises however, can be challenging. Further data on the efficacy of specific practices in the field setting is not available; however, more precise knowledge of their values is needed for optimal decision making.

Because most disease spread was the result of indirect transmission over a distance, local vaccination around an infected premise did not decrease disease spread. Despite this finding, it's important to note that while increasing biosecurity and movement controls related to indirect contacts may be beneficial, the true achievable level is unknown. Decreasing the probability of disease transmission following indirect contacts through the use of sanitation and biosecurity may also be beneficial; if either or both of these levels of control cannot be achieved then vaccination early and over a wide area may be the next most efficacious method for controlling an outbreak of FMD.

CONCLUSION

Movement restrictions to control indirect contacts between herds and biosecurity to control the probability of transmission following indirect contact were very influential in the models reported here. Further data on the effectiveness and practical implementation of movement controls and biosecurity practices in the field setting is needed for optimal decision making.