Economic impact analysis of Foot and Mouth Disease in the Texas High Plains

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Introduction:

Foot and Mouth Disease (FMD) constitutes a significant threat to the US food supply and the welfare of producers and consumers. FMD is a highly contagious, disease affecting all cloven hoofed species (2). This project is oriented toward a consideration of how vulnerable we are, particularly in the cattle industry and toward estimating the value of alternative potential control strategies. We examine the effects of a FMD outbreak in the Texas High Plains animal feeding region along with the effectiveness of a number of disease management strategies. The evaluation uses a combination of economic and epidemic modeling.

Texas is the largest cattle production state in the U.S., with more than 14 million cattle and calves produced annually. This is about 20% of the nation's beef cattle. The largest source of Texas agricultural revenue comes from beef cattle sales and the Texas cattle industry is first in the country in value of cattle raised. Texas has an estimated 6 million cattle are on feed worth more than $8 billion dollars annually (3). The predominant feedlot area is in the Texas High Plains.

Figure 1: High Plains Study Region.

Methodology:

Primary data collection for livestock densities, movements and economic characteristics occurred through a survey. The epidemic model used here is a version of AusSpread adjusted for the High Plains. AusSpread is a stochastic, state transition model that operates within a geographic information system. The economic model transforms the epidemic results into effects by animal type and calculated trial epidemic cost under different disease management strategies.

Epidemic simulations were done for 4 introduction sites (large feedlot, backgrounder feedlot, large grazing operation, backyard herd) and 16 mitigation strategies made up of combinations of early or late detection, ring or targeted vaccination, adequate or inadequate vaccination supplies, and regular or enhanced surveillance. Each of these 64 scenarios was simulated one hundred times and the results were used to calculate economic costs. Scenario descriptions appear in Table 1.

Results:

Average epidemic results over all scenarios indicate FMD outbreaks lasting 1-2 months, and approximately 100 herds would be slaughtered to control the disease.

The economic model calculated the disease mitigation cost (DMC) encompassing (a) losses incurred within the livestock industry as a result of the outbreak and (b) cost of implementing the disease management strategies employed. Table 2 gives the range of DMCs under the different scenarios for each of the introduction sites.

Early detection reduced the DMCs by approximately 68%, 69%, 74% and 97% for each of the four introduction sites respectively. Vaccination strategies significantly increase the DMC due to direct cost of the vaccine, resources to distribute/administer it and reduced value of vaccinated animals; however, having adequate vaccine availability only appears to reduce epidemic length in feedlot scenarios. Enhanced surveillance increases DMCs for large feedlots by 45%, but reduces costs for backgrounder feedlots, large beef and backyard operations by 31%, 23% and 77% respectively.

Table 1:

Mitigation	Index Herd Type: Lrg Feedlot	Sm Feedlot	Lrg.Beef	Backyard
Ring slaughter, regular surveillance, slaughter of infecteds, slaughter of dc's, early detection	1	2	3	4
Ring slaughter, regular surveillance, slaughter of infecteds, slaughter of dc's, late detection	5	6	7	8
Ring slaughter, regular surveillance, slaughter of infecteds, slaughter of dc's, late detection, targeted vaccination, adequate vaccine	9	10	11	12
Ring slaughter, regular surveillance, slaughter of infecteds, slaughter of dc's, late detection, targeted vaccination, inadequate vaccine	13	14	15	16
Enhanced surveillance, slaughter of infecteds, slaughter of dc's, early detection	17	18	19	20
Enhanced surveillance, slaughter of infecteds, slaughter of dc's, late detection	21	22	23	24
Enhanced surveillance, slaughter of infecteds, slaughter of dc's, late detection, targeted vaccination, adequate vaccine	25	26	27	28
Enhanced surveillance, slaughter of infecteds, slaughter of dc's, late detection, targeted vaccination, inadequate vaccine	29	30	31	32
Slaughter of infecteds, slaughter of dc's, regular surveillance, ring vaccination, early detection, inadequate vaccine	33	34	35	36
Slaughter of infecteds, slaughter of dc's, regular surveillance, early detection	37	38	39	40
Slaughter of infecteds, slaughter of dc's, regular surveillance, late detection, ring vaccination, adequate vaccine	41	42	43	44
Slaughter of infecteds, slaughter of dc's, regular surveillance, ring vaccination, late detection, inadequate vaccine	45	46	47	48
Slaughter of infecteds, slaughter of dc's, regular surveillance, early detection, targeted vaccination, adequate vaccine	49	50	51	52
Slaughter of infecteds, slaughter of dc's, regular surveillance, late detection	53	54	55	56
Slaughter of infecteds, slaughter of dc's, regular surveillance, late detection, targeted vaccination, adequate vaccine	57	58	59	60
Slaughter of infecteds, slaughter of dc's, regular surveillance, early detection, ring vaccination, adequate vaccine	61	62	63	64

Table 2: Range of Economic Costs Using Different Mitigation Strategies in Millions of Dollars

Type of Herds	Minimums	Maximums	Averages	Medians
Within Large Feedlot	55.5-246.8	128.7-981.7	66.7-538.6	62.9-546
Within Backgrounder Feedlot	12.4-15.3	82.3-800	21.2-251.7	12.8-191.7
Within Large Beef	0.77-3.8	42-597.8	3.5-159.1	1.1-79.3
Within Backyard	0.01-23.2	3.2-764.5	0.28-198	0.04-135.5

Table 3:

Comparison	Significantly Different?	Result	P-Value
Within Large Feedlot			
Early vs. late detections	Yes	Lower economic costs	<0.0001
Adequate vs. inadequate vaccines	Yes	Higher Economic costs	=0.0001
Enhanced vs. regular surveillance	Yes	Higher Economic costs	<0.0001
Within Backgrounder Feedlot			
Early vs. late detections	Yes	Lower Economic Costs	<0.0001
Adequate vs. inadequate vaccines	Yes	Higher Economic Costs	<0.0001
Enhanced vs. regular surveillance	No	NA	=0.19
Within Large beef			
Early vs. late detections	Yes	Lower Economic Costs	<0.0001
Adequate vs. inadequate vaccines	Yes	Higher Economic Costs	<0.0001
Enhanced vs. regular surveillance	Yes (95% confidence)	Higher Economic Costs	=0.0137
Within Backyard			
Early vs. late detections	Yes	Lower Economic Costs	<0.0001
Adequate vs. inadequate vaccines	Yes	Higher Economic Costs	<0.0001
Enhanced vs. regular surveillance	Yes (95% confidence)	Higher Economic Costs	=0.028

Analysis of variance (ANOVA) Analysis:

ANOVA was used to determine whether significant variation in model results arose due to the disease control strategies (early versus late detection, adequate versus inadequate vaccine availability, regular versus enhanced surveillance). Results are presented in Table 3.

Large feedlot results display a significant decline in DMC from early detection, adequate vaccination and enhanced surveillance. There was a statistically significant reduction in epidemic length and slaughter under early detection, and a reduced epidemic length under vaccination. However enhanced surveillance did not significantly reduce either epidemic length or slaughter compared to regular surveillance.

Small feedlot results show significant reductions in DMC from early detection and adequate vaccines, but no significant results from enhanced surveillance. All three mitigation strategies result in reduced epidemic length and slaughter.

Large grazing operations show significant reductions in DMC from early detection but an increase in DMC from adequate vaccine. Enhanced surveillance caused a significant difference in DMC at the 0.05 level but not at the 0.01 level. Significant reductions were found in early detection implications for epidemic length and number of slaughtered animals, but neither adequate vaccine nor enhanced surveillance had a significant impact on reducing slaughter. Adequate vaccine caused a longer epidemic length.

The backyard operation showed a significant reduction in epidemic length and slaughter levels from early detection but not adequate vaccination or enhanced surveillance. Early detection and adequate vaccine had significant impacts on DMC while enhanced surveillance had a statistically significant impact at the 0.05 level.

Conclusions:

To control FMD outbreaks the critical dimension is time. The sooner an outbreak is detected, the more control options are available and the more effective they are when applied early. Early detection of FMD, regardless of the introduction herd site, had the largest impact in reducing epidemic length, slaughter levels and event cost. This implies a significant return to educational efforts aimed toward improving livestock herd managers' ability to recognize the early signs of FMD.

Improved vaccine availability was effective only in feedlot cases. Enhanced surveillance as a means of reducing the DMC appears to be effective only for small feedlots, backgrounder beef, and backyard operations; but only contributes to a significant reduction in epidemic length and slaughter levels for small feedlots. Within the constraints of this study vaccination and enhanced surveillance do not appear to be the most effective method of controlling the disease outbreak. The only universally, effective strategy to reduce the total impact of an FMD outbreak is to identify the disease early.

Citations:

(1)Elbakidze, L., L. Highfield, M. Ward, B. McCarl, B. Norby. "Mitigation strategies for FMD introduction in highly concentrated animal feeding regions. Working Paper.

(2)Ward, M.A., B. Norby, B.A. McCarl, L. Elbakidze, R. Srinivasen, L. Highfield, S. Loneragan, and J.H. Jacobs, 2007. The High Plains Project Report, FAZD Report.

(3)US Department of Agriculture: National Agricultural Statistics Service, "Texas State Agriculture Overview, 2004". Jan 3, 2006. http://www.nass.usda.gov/Statistic_by_State/Ag_Overview/AgOverview_Tx.pdf.

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