PEER REVIEWED

Feedyard Manager and Veterinarian Responses to a Delphi-like Feedyard Biosecurity Survey

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Abstract

A Delphi-like survey series was used to gain knowledge about feedyard biosecurity and security from feedyard managers and feedyard veterinarians. A panel of managers and a panel of veterinarians were selected after being recommended as experts in the industry. Three rounds of the same survey were used to gather consensus opinion from each expert panel about perceived disease risks and mitigation strategies. Both groups were given the same survey, with two additional questions about domestic and international terrorists asked of veterinarians. Results showed veterinarians and managers have very similar views on the likelihood of disease caused by terrorism, natural introduction, or accidental introduction, and on the importance of on-site security. Both groups agreed that foot-and-mouth disease virus (FMDV) or toxins would be the most likely agents to be introduced by a terrorist. Respondent groups disagreed on the importance of preventative products, disease transmission control and environmental control. Most differences can be attributed to veterinarians placing less importance on the aforementioned categories when considering likely routes of introduction for diseases considered in the survey. Difference in awareness of these issues is significant because veterinarians are pivotal in educating feedyard staff members about prevention of disease entry and transmission.

Keywords: bovine, feedyard, feedlot, biosecurity

Résumé

Un questionnaire de type Delphi, administré à des producteurs et à des médecins vétérinaires de parcs d'engraissement, a été utilisé pour approfondir nos connaissances sur la biosécurité dans les parcs d'engraissement et sur la sécurité. On a choisi un jury de producteurs et un jury de médecins vétérinaires considérés comme des experts dans l'industrie. Un consensus d'opinion a été atteint après trois rondes du même questionnaire quant aux risques envisageables de maladie et aux stratégies d'intervention. Les deux groupes ont reçu le même questionnaire mais deux questions supplémentaires ont été demandées aux médecins vétérinaires concernant la menace terroriste domestique et internationale. Les résultats ont montré que les médecins vétérinaires et les producteurs ont des points de vue très similaires sur les chances de maladie attribuables au terrorisme ou à une introduction naturelle ou accidentelle et sur l'importance de la sécurité sur les sites. Les deux groupes étaient d'accord que le virus ou des toxines de la fièvre aphteuse seraient les agents les plus vraisemblablement introduits par des terroristes. Les deux groupes n'étaient pas d'accord sur l'importance des produits préventifs, sur le contrôle de la transmission des maladies et sur le contrôle environnemental. Le fait que les médecins vétérinaires mettent moins d'accent sur ces trois derniers points lorsqu'ils considèrent les voies d'introduction les plus probables pour les maladies incluses dans le questionnaire explique la plus grande partie des différences entre les deux groupes. Une différence de perception au niveau de ces enjeux est importante car les médecins vétérinaires sont essentiels dans l'éducation du personnel des parcs d'engraissement en ce qui concerne la prévention de l'entrée et de la transmission des maladies.

Introduction

Biosecurity and security are important for disease prevention in any agricultural production system. Feedyards are particularly vulnerable to disease introduction because of the large number of cattle procured from multiple sources, as well as the large concentration of animals in one location.[3] Further, feedyards are mostly outdoor facilities, with the exception of a few total confinement operations. Unlike the indoor, total con-

finement operations in the swine industry, with this natural environment comes a large perimeter that is more difficult to control. The high cattle turnover rate in the feedyard allows new cattle arrivals to introduce pathogens and to be exposed to existing pathogens at the yard, making it difficult or impractical to control disease introduction to the feedyard in some instances. The high concentration of animals in a feedyard is a potentially attractive target for bioterrorism by domestic or international terror groups. The extensive perimeter of a typical feedyard provides numerous opportunities for unauthorized entry to the feedyard by individuals or groups with malicious intent. If the goal of a terror group is to damage the economy of the beef industry and the United States in general, large numbers of cattle could be infected by selected agents with a relatively small amount of resources or time. The economic losses associated with treatment or elimination of a toxic (i.e. organophosphate) or infectious (i.e. foot-and-mouth disease virus (FMDV)) agent in a feedyard would be substantial. These issues highlight the need for appropriate security and biosecurity practices in feedyards.

This paper discusses findings from a survey of two expert groups associated with the feedyard industry: feedyard veterinarians and feedyard managers. The information is a valuable resource for determining the current understanding of real and perceived threats to feedyard security, as well as strategies to minimize routes of disease introduction. The purpose of this Delphi-like survey was to utilize the knowledge of feedyard veterinarians and feedyard managers to determine the importance of different aspects of biosecurity/security in feedyards.

Materials and Methods

Survey development

A Delphi-like survey series was submitted to feedyard veterinarians and managers of midwestern and southwestern feedyards to assess expert knowledge and opinion regarding security and biosecurity risks and practices. The survey followed the iterative nature of a Delphi survey, but without the exploration phase employed in a traditional Delphi survey. Experts responded directly to pre-established questions regarding disease introduction and mitigation strategies. Questions were asked about the probability of accidental, natural and terrorist introduction of specific disease agents or toxins. Natural introduction was defined as one in which human activity is not directly involved, such as introduction of disease agents by wildlife or introduction of toxins by mechanical failure. Accidental introduction was defined as involving direct but unintentional human activity, such as an introduction of a disease agent by unclean boots or introduction of toxins by feed-mixing errors. Terrorist introduction was defined as involving intentional human activity to introduce a disease agent or toxin. Six choices were provided for respondents to rank the probability of each agent's introduction by accidental, natural and terrorist means. Respondent choices were: very high probability, high probability, moderate probability, low probability, no probability and I don't know, represented by the numbers 1-6, respectively.

Questions were also asked about the importance of preventative products (available vaccines, dewormers, antibiotics and veterinary health care), environmental control (wildlife control, bird control, insect control, cleaning procedures and decontamination procedures), disease transmission control (isolation of incoming animals and isolation of sick animals) and on-site security (guards, fences, movement of vehicles on the property, traffic control, employee screening and employee education) in minimizing the probability of introduction of disease into a feedyard. Again, six choices were provided for respondents to rank the importance of preventative products, environmental control, disease transmission control and on-site security for each agent. Respondent choices were: very high importance, high importance, moderate importance, low importance, not important and I don't know, represented by the numbers 1-6, respectively.

Fourteen disease agents and toxins were considered for each question (Tables 1 and 2). Feedyard managers and veterinarians were given the same survey (total of 98 possible responses) with the addition of two questions in the veterinary survey (total of 107 possible responses). The additional questions asked veterinarians about security measures and risks associated with domestic and international terrorist groups. Veterinarians were provided one free-form response question for other comments.

Initially, six feedyard managers were chosen to pretest the design of the survey and the clarity of the questions. Four managers reviewed and commented on the survey structure and clarity. Revisions were made and the survey was prepared for data collection. The survey was approved by the Kansas State University Institutional Review Board Committee for Research Involving Human Subjects prior to submission to the participants. A copy of the survey is available from the corresponding author.

Cooperator recruitment

Nineteen midwestern and southwestern feedyard managers were recommended for inclusion by academic and consulting feedyard veterinarians. Based on recommendations by academic veterinarians associated with the beef industry, 15 veterinarians in consulting prac-

Table 1. Comparison of managers and veterinarian responses* to probability of disease introduction by terrorist, natural or accidental introduction.

Diseases	Terrorist introduction		Natural introduction		Accidental introduction	
	Managers	Veterinarians	Managers	Veterinarians	Managers	Veterinarians
Anthrax	2	4	4	4	4	4
Beef Measles[a]	4	5	4	3	4	3
TB[b]	4	4	4	3	4	4
BVD	4	4	2	1	3	2
BSE	5	5	4	5	4	5
CBP[c]	4	4	2	4	3	4
FMD	2	2	4	4	4	3
Lice	5	5	2	1	3	4
MCF[d]	4	5	4	4	4	4
Mange[e]	4.5	5	3	2	4	3
Salmonellosis	4	4	2.5	2	3	3
Screwworm[f]	4.5	5	4	4	4	5
Toxins[g]	2.5	3	4	4	4	3
VS[h]	3	4	4	3	4	4

Scale:
1-very high probability
2-high probability
3-moderate probability
4-low probability
5-no probability

*Median responses from round 3
[a] *Cysticercus bovis*
[b] *Mycobacterium bovis*
[c] Contagious Bovine Pleuropneumonia-*Mycoplasma mycoides* subsp. *mycoides*
[d] Malignant catarrhal fever
[e] Sarcoptic or Psoroptic
[f] Old or New World
[g] Heavy metals or pesticides
[h] Vesicular stomatitis

tice, academia and industry were recommended for the survey. Both groups were contacted by phone, given an explanation of why they were selected as well as a description of the survey series and asked to participate.

Survey conduct

In order to maximize response, the survey was offered to managers and veterinarians as either an electronic survey utilizing the Kansas State University on-line survey system or as a hard copy sent by mail. Participants were allowed to respond by whichever means they preferred. Reminders were e-mailed every five days for three weeks, or until the participants completed the survey. If necessary, participants were also contacted by phone to encourage completion of the survey. Three rounds of the same survey were given to each feedyard manager and veterinarian. Following each round, median responses were calculated for each question and each group separately (feedyard managers and veterinarians). Therefore, the second round had the same question set, including the median response to each question from the first round. This process was repeated again, providing median scores from the second round of the survey to cooperators and eliciting their answers for the third round.

Analysis

Third-round median responses were calculated and summarized for each question and each group for comparison utilizing a commercially available spreadsheet program (Excel 2003, Microsoft Corp, Redmond, WA). For questions where the median score of veterinarians and managers differed by more than 2, a Wilcoxon rank-sum test was used to determine if significant differences were present between the responses of the two groups.

Results

Of the 19 managers recommended for the survey, 18 managers contacted by phone agreed to participate.

Table 2. Comparison of managers and veterinarian responses* to the importance of preventative products, environmental control, disease transmission control and on-site security in preventing disease introduction.

Diseases	Preventative products		Environmental control		Disease transmission control		On-site security	
	Managers	Veterinarians	Managers	Veterinarians	Managers	Veterinarians	Managers	Veterinarians
Anthrax	4	4	2	4	2	4	3	3
Beef Measles[a]	4	4	2	3	2	5	3	3
TB[b]	3	4	2	4	2	3	4	4
BVD	1	2	2	4	2	2	3	4
BSE	3	5	2	5	4	5	4	4
CBP[c]	2	4	2	4	2	2	3	4
FMD	2	4	1	3	1	2	1	2
Lice	2	1	2	4	2	3	4	4
MCF[d]	3	4	3	4	2	4	4	4
Mange[e]	2	1	2	4	2	2	4	4
Salmonellosis	3	3	2	2	2	2	3	3
Screwworm[f]	3	4	3	4	3	4	4	4
Toxins[g]	4	4	2	2	4	5	2	3
VS[h]	3	4	2	4	2	3	3	3

Scale:
1-very high importance
2-high importance
3-moderate importance
4-low importance
5-not important

*Median responses from round 3
[a] *Cysticercus bovis*
[b] *Mycobacterium bovis*
[c] Contagious Bovine Pleuropneumonia-*Mycoplasma mycoides* subsp. *mycoides*
[d] Malignant catarrhal fever
[e] Sarcoptic or Psoroptic
[f] Old or New World
[g] Heavy metals or pesticides
[h] Vesicular stomatitis

A current phone number was not found for one manager. One manager that agreed to cooperate was inadvertently dropped from the survey list. The remaining 17 managers surveyed represented Kansas (12), Nebraska (2) and Texas (3). Of the 15 veterinarians contacted, 13 agreed to participate in the survey. One veterinarian did not respond to messages and was not contacted, and another did not consent. The remaining 13 veterinarians surveyed represented Kansas (5), Texas (2), Nebraska (1), Missouri (1), Oklahoma (1), Idaho (1), Colorado (1) and Iowa (1). Fourteen managers (82%) responded to the first round of surveys, 10/17 (59%) responded to the second round and 12/17 (71%) responded to the third round of surveys. The reported manager response rate in the second round was lower than the actual response rate because some managers responded both electronically and by mail. The duplicate surveys could not be identified because of the anonymous nature of both methods, so only the electronic surveys were used. All cooperating veterinarians responded to the first round of surveys, 11/13 (85%) responded to the second round and 9/13 (69%) veterinarians responded to the third round of surveys.

A summary of the median responses from the third round of surveys is shown in Tables 1 and 2. Between the first and third rounds of the survey, 29% of question-specific median responses changed in the manager survey, and 33% changed in the veterinarian survey. Ranges narrowed in 71% (70/98) of the manager's responses and in 68% (73/107) of the veterinarian's question-specific responses from the first to the third round of the survey. Veterinarians and feedyard managers had similar views on the likelihood of disease introduction from terrorism, natural introduction, or accidental introduction, and on the importance of on-site security. Veterinarian responses indicated preventative products, disease transmission control and environmental control to be less important in minimizing probability of dis-

ease introduction compared to feedyard managers. This difference between respondent groups was most consistent in the area of environmental control across all diseases included in the survey except salmonellosis and toxicosis (Table 2).

Manager and veterinarian responses were significantly different when asked about the importance of environmental control for minimizing the probability of introduction of Bovine Spongiform Encephalopathy (BSE) ($P<0.05$). Veterinarians thought environmental control was not important, while managers thought environmental control was of high importance for minimizing the probability of introduction of BSE.

Manager and veterinarian responses were also significantly different when asked about the importance of disease transmission control for minimizing the probability of introduction of *Cysticercus bovis* ($P<0.05$). Veterinarians thought disease transmission control was not important (range 4-5), while managers thought it was of high importance (range 1-2) for minimizing the probability of introduction of *Cysticercus bovis.*

Veterinarians indicated they believed properly maintained perimeter fences and locked perimeter gates were very highly important, while they considered decreased feedyard visibility and decreased media exposure to be moderately important for reducing the probability of domestic or international terrorism (Table 3). Veterinarians also believed feedyards had a very high probability of being attacked by a domestic terrorist group, as well as a high probability of being attacked by an international terrorist group. Veterinarian free-form responses indicated a recognition of the importance of feed source and feed storage security, of evaluating economic feasibility of control measures and of raising the general awareness level of these issues in feedyards.

Table 3. Veterinarian responses* to the importance of deterrent measures in decreasing the probability of domestic or international terrorism in a feedyard.

Deterrent measures	Veterinarians
On-site security guard(s)	2
Maintaining a perimeter fence	1
Locking perimeter gates	1
Video surveillance	2
Employee background screening	2
Decreasing feedyard visibility[a]	3
Decreasing feedyard media exposure[b]	3

Scale:
1-very high importance
2-high importance
3-moderate importance
4-low importance
5-not important

*Median responses from round 3
[a] Visibility from highway or road
[b] Internet presence, name recognition associated with marketing

Discussion

This Delphi-like survey method is useful for eliciting expert opinion in areas where relevant data from the scientific literature is scarce.[7] Utilizing pre-existing questions effectively reduced the time commitment required by respondents to provide valid responses while maximizing response rate. Within each peer group, question-specific median responses from the previous round were provided to respondents for consideration during the last two rounds of the survey. Participants answered the same survey multiple times which allowed them to reconsider their responses in light of their peers' responses to the same questions from the previous round. Unlike a face-to-face round table discussion, individual responses are equally represented without the potential social pressure to agree with an outspoken peer.

Feedyard veterinarians noted the need for increased education and awareness of security and biosecurity issues. The difference in responses between veterinarians and managers indicates an opportunity for consulting veterinarians to provide education to feedyard managers and staff on the relative importance of disease introduction risks and routes of transmission (Table 2). This survey series identified environmental control of disease, disease transmission control and preventative products as particular areas where perception of risk and effectiveness of mitigation strategies differs between feedyard managers and feedyard veterinarians. For example, the difference between feedyard managers and veterinarians in the importance of preventive products and environmental control for BSE risk in the feedyard indicates an area of needed education. There are no available preventive products for BSE, and while the agent may survive in the environment, it seems more likely that BSE would be introduced through contaminated feedstuffs, which would not be prevented through environmental control.

The difference between the two groups when asked about *Cysticercus bovis* showed a similar difference of knowledge regarding the importance of disease transmission control. Feedyard managers believed disease transmission control was of high importance for control of *Cysticercus bovis* risk in the feedyard, while veterinarians believed disease transmission control was not important (range 4-5) in controlling *Cysticercus bovis* risk in the feedyard. Humans are the host needed to complete the life cycle of this disease, so the route of

transmission for *Cysticercus bovis* may fall more into the area of feedyard staff education and awareness. The disease can be prevented if infected humans are not allowed to defecate in and contaminate animal feed. By definition in this survey, disease transmission control included isolation of incoming animals and isolation of sick animals. Feedyard managers are either unaware of the transmission of *Cysticercus bovis* or did not apply this description in categorizing the importance of disease transmission control for *Cysticercus bovis*.

Differences in awareness of these issues are significant because veterinarians are pivotal in educating the feedyard staff about prevention of disease entry and spread. If managers are not cognizant of the relative importance of interventions for biosecurity and security, they will benefit from additional expertise from consulting veterinarians in these areas. Veterinarians should be experts on disease risks and routes of transmission in the feedyard.

Veterinarians can provide training to managers and feedyard employees on security and biosecurity practices and the development of effective, economic plans. Although managerial duties differ between feedyards, managers share the role as a decision maker in all feedyards. Decisions made by an informed manager will contribute to the health of the cattle and the success of the feedyard. This survey provided information on the views of each group which are useful in developing effective security and biosecurity programs. Development of a security program starts with a good understanding of disease threats and routes of introduction. The survey identified diseases that are perceived to be most threatening. It also identified some differences in knowledge between veterinarians and managers regarding disease transmission, and provided guidance to veterinarians on areas where managers need additional training. Understanding the disease increases the effective application of practical prevention protocols.

Because of the high turnover of cattle in feedyard systems, some traditional biosecurity methods of preventing endemic disease introduction are not applicable. There are, however, security and biosecurity measures that may be warranted to prevent intentional introduction of disease agents and toxins. Veterinarians recognized the need for increased awareness and security. They considered some practices to be valuable deterrent measures, particularly perimeter fences and locked gates. Veterinarians should communicate the perceived importance of these deterrents; however, perimeter fences capable of stopping human access may be quite expensive and the cost benefit should be examined. Further research is needed to quantify the value of specific deterrent practices in decreasing the likelihood of a terrorist introduction. Relevant literature is lacking on the most important risks and the effectiveness of security and biosecurity risk mitigation strategies.[12] Discussions and examination of general law enforcement and corporate data on the effectiveness of deterrent practices may be useful.

Veterinarians and feedyard managers had similar views on the likelihood of disease introduction from terrorism, natural introduction, or accidental introduction, and on the importance of on-site security. Both groups believed that FMDV was a high-probability threat within the category of terrorist introduction. Managers also thought anthrax was a high-probability threat. Al Qaeda documents found during execution of the war in Afghanistan indicate recognition of anthrax as an agent of bioterrorism.[1,10,18] Despite the evidence of Al Qaeda intent to use anthrax, veterinarians thought anthrax to be a low-probability event. Clearly introduction of FMDV to the United States could have massive economic consequences. The accidental introduction of FMDV into the United Kingdom in 2001 cost approximately 11 billion US dollars in direct and indirect costs.[5] Losses from an introduction of FMDV in the United States have been estimated from $14 billion to $60 billion.[8,13] Prevention of its introduction into the country is largely a function of the United States Department of Agriculture (USDA). Once introduced, the USDA would implement its plan for response to a highly contagious disease, including zones of eradication.[6] Both veterinarians and managers agreed on-site security may be a valuable tool in deterring terrorists from introducing FMDV to a particular feedyard. However, if a neighboring feedyard is infected, the "secure" feedyard may still be in the resulting quarantine and "stamping out" area. According to the National Animal Health Monitoring System Feedlot 99 survey, only 18% of feedyards restrict movement of people on the facility for biosecurity/security purposes.[15] If FMD is introduced to the US, a ready plan to increase on-site security at the feedlot would be beneficial.

Both groups believed toxins were a moderate- to high-probability threat from terrorist introduction. Historical precedents exist for both intentional and accidental introduction of toxins into livestock feed.[9] Contamination could occur at the feed manufacturing facility, subsequently exposing numerous livestock facilities. This highlights the need for feedyards to preferentially deal with feed manufacturers that maintain security systems analogous to the Hazard Analysis Critical Control Points (HACCP) model. Alternatively, toxins could be introduced directly to a particular feedyard by a terrorist group or by disgruntled neighbors, competitors or employees. Numerous domestic terrorist groups do exist and have made attacks on animal agriculture, which suggests the importance of deterrent security measures.[4] On-site security practices may make this more difficult to achieve and deter all but the most

determined attempts or send the terrorist off to an "easier" facility.

The information gathered in this survey is not sufficient to identify all the data necessary to make economic decisions regarding security and prevention of disease introduction. It does provide an understanding of the perception of potential threats to the feedyard industry. Groups like the Earth Liberation Front, Animal Liberation Front and People for the Ethical Treatment of Animals are active antagonists of animal agriculture of all species. They have publicly stated they would welcome FMDV into the United States primarily because they believe it would be good to relieve production animals from their captivity and suffering.[8] In contrast, international terrorists may use a bioterrorism agent for the potential detrimental effects on the economy of the United States.[4,16]

Assessing the economic value of biosecurity and security plans is challenging because good estimates of the probability of a terrorist event are lacking. While we have some historical precedent of feed poisoning, the probability that a domestic or international terrorist group would employ these techniques is unknown. Clearly domestic terrorist groups have shown themselves willing to resort to extreme measures in an attempt to publicize their views and influence public policy.[2]

Conclusion

Objective data on real versus perceived risk is difficult to obtain for terrorist disease introduction risks. However, bioterrorism agents such as anthrax have been considered by Al Qaeda, suggesting that protective measures may be needed.[1,10,18] Objective data on natural or accidental disease introduction risk and impact is more available but still incomplete.[11,14,17] Further data from experimental studies and disease modeling would be helpful to further characterize these risks and impacts. Additional knowledge of the probability and magnitude of risks and the effectiveness of mitigation strategies is needed for risk assessment and the development of economic and effective biosecurity plans for feedyards. The results reported here are helpful in further understanding risk perception in the feedyard from those who likely know it best. Recognition of educational and training needs will help veterinarians to direct implementation of rational biosecurity and security plans on feedyards.

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