

# Development, application, and validation of a survey for infectious disease control practices at equine boarding facilities

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**Objective**—To develop a questionnaire for self-assessment of biosecurity practices at equine boarding facilities and to evaluate infectious disease control practices in these facilities in Colorado.

**Design**—Cross-sectional study.

**Sample Population**—64 equine boarding facilities in Colorado.

**Procedures**—Survey questions were rated according to importance for prevention and containment of equine infectious diseases. Point values (range, 0 to 20) were assigned for possible responses, with greater values given for optimal infection control methods. Questionnaires were mailed to equine boarding facilities in Colorado advertised on the World Wide Web. Survey responses were compared with assessments made by a member of the research team during visits to 30 randomly selected facilities. Agreement among results was analyzed via a kappa test and rated as poor, fair, moderate, substantial, or nearly perfect.

**Results**—Survey responses were received for 64 of 163 (39%) equine boarding facilities. Scores ranged from 106 to 402 points (maximum possible score, 418). Most facilities received better scores for movement and housing of equids than for other sections of the survey. Respondents at 24 of 48 (50%) facilities that routinely received new equids reported isolation of new arrivals. Agreement between self-assessment by survey respondents and evaluation by a member of the research team was determined to be fair to substantial.

**Conclusions and Clinical Relevance**—Most equine boarding facilities have opportunities to improve measures for prevention or containment of contagious diseases (eg, isolation of newly arrived equids and use of written health management protocols). Most self-assessments of infection control practices were accurate. (*J Am Vet Med Assoc* 2010;237:1166–1172)

Equine infectious disease outbreaks are a threat throughout the United States and in other countries with large equine populations. The inclusion of topics on this subject in national and local meetings of the US equine industry and veterinary organizations has emphasized the importance of biosecurity and infection control strategies in prevention and containment of such outbreaks.<sup>1</sup> Reports of infectious disease outbreaks in the United States, such as equine herpesvirus myeloencephalopathy,<sup>2</sup> equine viral arteritis,<sup>3</sup> and infections with *Streptococcus equi* subsp *equi*,<sup>4</sup> West Nile virus,<sup>5,6</sup> vesicular stomatitis virus,<sup>7</sup> equine influenza virus,<sup>8</sup> and *Taylorella equigenitalis*,<sup>9</sup> indicate that

infectious diseases pose a substantial risk to the equine industry. The number of animals and facilities affected by infectious diseases could potentially be reduced through the implementation of infectious disease prevention and control plans at equine facilities.

Biosecurity measures can limit the spread of disease-causing organisms from one location to another or from one animal to another and reduce the risk of introduction and spread of infectious diseases in a facility via people, animals, feed, water, equipment, or vehicles.<sup>10</sup> In a 2005 USDA survey<sup>11</sup> that described the general health and management of the US equine population, 32% of respondents at US equine boarding facilities reported routine isolation of newly arriving equids, 25% indicated that visitors were required to take infection control precautions, and 89% replied that some form of insect control was used at the facility. To our knowledge, the frequency of use of other control measures (eg, appropriate feed storage, written protocols for cleaning, control of visitors, and maintenance of health records) has not been reported for equine boarding facilities. Providing a tool for owners or representatives of equine facilities to objectively evaluate their own biosecurity programs could encourage adoption of more stringent biosecurity measures; various existing programs<sup>12,13</sup> and sources of information<sup>14</sup> incorporate

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components of biosecurity protocols, but none have been specifically designed for use as self-assessment tools. The objectives of the study reported here were to develop and implement a questionnaire for use as a self-assessment tool for evaluation of equine facility biosecurity programs, to describe infectious disease control practices currently in use at selected equine boarding facilities in Colorado, and to evaluate the ability of facility owners or their representatives to assess their infectious disease control practices by use of the questionnaire.

## Materials and Methods

**Questionnaire development and pretest**—A questionnaire was developed for use as an assessment tool<sup>a</sup> for infectious disease control at equine boarding facilities on the basis of results of a review of the literature and existing certification programs for equine facilities (accessed via a World Wide Web search and contact with existing program coordinators). Respondents answered questions about demographics, infectious disease incidence, and methods of disease prevention and control used for all horses, mules, donkeys, and ponies at each boarding facility. The 36 questions were organized into 5 sections on the questionnaire: general facility (eg, grain storage, water source, insect and rodent control, and manure disposal), written health protocols (including procedures for general cleaning, handling of equids with suspected contagious disease, and maintenance of equid health charts), movement and housing of equids (eg, number and frequency of new equids entering the facility, whether equids were housed individually or in groups, and frequency of transportation of resident equids outside of the facility), infection control and isolation practices (eg, isolation of newly arrived equids and those that have traveled, type of isolation area, and vaccines used), and biosecurity strategies for visitors and employees (eg, check-in of visitors and washing of hands before and after interactions with each equid). Disease occurrences included on the questionnaire were eastern and western equine encephalomyelitis, tetanus, and infections with equine herpesvirus, West Nile virus, vesicular stomatitis virus, equine influenza virus, rabies virus, *Streptococcus equi* subsp *equi* (ie, strangles), and equine arteritis virus. Before the questionnaire was finalized, a test was conducted with representatives from 5 equine boarding facilities located in northern Colorado, and the questionnaire was revised into its final version after their input was evaluated.

**Biosecurity scoring**—After the draft questionnaire was developed, 3 veterinarians who had extensive experience in equine infection control with an emphasis on biosecurity (from Kentucky, New York, and Canada) were contacted. These individuals categorized the survey questions as very important, important, somewhat important, or not very important in relation to prevention and containment of equine infectious diseases. After questions were placed into 1 of the 4 evaluation categories, point values for each question on the survey were determined on the basis of the expert rankings, with the highest-ranked question in a category given the highest point value and the lowest-ranked question

in a category given the lowest point value. In some cases, more than 1 question was given the same ranking, and those questions received the same point value.

Potential responses within each of the 5 sections of the questionnaire were then categorized on the basis of the mean of expert rankings in that section as less than adequate ( $\leq 25\%$  individual-question points achieved), fair (26% to 50% individual-question points), moderate (51% to 75% individual-question points), and excellent (76% to 100% individual-question points). Three members of the research group (JLT, AEH, and PSM) who had advanced training in biosecurity independently reviewed these categorizations and assigned point values (range, 0 to 20) for each response, while keeping the point value within an assigned evaluation category point range. Thus, a question viewed as very important to biosecurity had the maximum score of 20 for an excellent response, but a question viewed as not very important had only a maximum score of 5 for an excellent response. The mean of the 3 point values for each item was determined to be the final point value for each response. Score ranges were determined manually by calculating the lowest and highest possible scores for a section and evaluation category.

**Facility recruitment**—A list of equine boarding facilities in Colorado was compiled in April 2007 from those advertising equine boarding services through the World Wide Web.<sup>15</sup> Facilities were identified by use of a search engine<sup>b</sup> and the keyword string “Colorado equine boarding facilities.” Each facility was assigned a code, which was included on the questionnaire to enable masking of evaluators to facility identification after the survey was completed. In June 2007, questionnaires and prepaid envelopes were mailed to all facilities on the list, with requests for responses from the facility owners or managers. To maximize participation, a reminder card was sent to nonrespondents 3 weeks after initial mailing; if no reply was received, a second copy of the questionnaire was sent 5 weeks after the initial mailing; remaining nonrespondents were contacted via telephone 7 weeks after the initial mailing.

**On-site validation**—Sixteen questions (some with  $> 1$  part) were selected for validation. Selected questions were those that could be answered by an observer from the research team during a visual assessment as part of a facility visit. Thirty facilities were randomly selected for the validation visit by use of a random numbers generator<sup>c</sup>; each responding facility was assigned a number (1 through 64), and facilities were contacted to schedule a visit beginning with the facility assigned number 1. If a facility could not be contacted or a visit was declined, the facility assigned the next number in sequence was contacted. Validation was performed at the selected facilities by 1 researcher (ATK), who was unaware of the self-assessment survey responses while performing the assessment. The variables assessed during the site visit were summarized. During the on-site assessment, containers made of hard plastic or metal with secure lids in place at the time of the visit were deemed rodent- and bird-proof for grain storage.

**Data analysis**—All calculations were performed by use of a commercially available software package.<sup>d</sup>

Biosecurity scores were tabulated for general facility, written health protocols, movement and housing of equids, infection control and isolation practices, biosecurity strategies for visitors and employees, and overall biosecurity of the facility on the basis of previously described expert rankings. The survey responses on facility questionnaires and assessments made during the on-site validation were paired for each facility and compared via a kappa test.<sup>16</sup> Agreement between the results of self-assessment and those of on-site validation beyond that expected by chance was evaluated according to the kappa statistic as follows: < 0.20, poor; 0.20 to 0.39, fair; 0.40 to 0.59, moderate; 0.60 to 0.79, substantial; and 0.80 to 1.00, nearly perfect.<sup>16,17</sup>

## Results

**Survey participation**—One hundred ninety-seven equine boarding facilities that advertised boarding services through the World Wide Web were identified in Colorado. Of 197 facilities on the original list, 34 did not have valid mailing addresses. Questionnaires were mailed to the remaining 163 facilities, which were located in 17 of 64 Colorado counties; responses were received from 64 of 163 (39%) facilities. Most (61) respondents provided responses to all survey questions. Respondents' facilities were located in 11 Colorado counties, all of which were east of the Rocky Mountains.

**Descriptive results**—The 64 respondents included 26 (40.6%) facility owners, 19 (29.7%) facility managers, 2 (3.1%) trainers, and 17 (26.6%) individuals whose affiliation with the facility was not specified. Some questions had > 1 possible answer. For those situations, respondents were instructed to select all relevant responses, and such questions were marked on the questionnaire (Table 1). Of 64 facility representatives that responded, 61 (95.3%) reported that 1 or more equids on the premises were vaccinated against West Nile virus; 57 (89.1%), 54 (84.4%), 51 (79.7%), and 42 (65.6%) facilities housed equids that were vaccinated against influenza, tetanus, equine herpesvirus, or eastern or western equine encephalomyelitis, respectively. Fewer respondents indicated use of other types of vaccines, which included vaccinations against strangles at 22 (34.4%) facilities, rabies at 17 (26.6%) facilities, and equine arteritis virus at 4 (6.3%) facilities.

A requirement to isolate newly arrived equids away from resident equids for a designated period of time was reported for 24 of 48 (50.0%) facilities that had new equids arriving on a regular basis. Of facilities that had new equids entering the premises, 9 (18.8%) did not have an isolation area available. Nine (18.8%) facilities had a stall separate from the main (ie, resident equid) barn, 16 (33.3%) had a secluded pen with no direct contact possible between isolated equids and other equids at the facility, 2 (4.2%) had a pen next to those used by other equids, and 12 (25.0%) had a stall used for isolation that was located in the main barn where resident equids were housed (Table 1). Routine isolation of resident equids returning to the facility after traveling was required at 4 of 61 (6.6%) facilities for which a response was received.

Regarding the incidence of contagious equine disease that affected at least 1 equid at the facility during the previous 5 years (ie, from January 2002 until the time of the survey in June 2007), the most commonly reported disease among the 61 facilities for which this question was answered was strangles, which was reported at 14 (23.0%) facilities. West Nile virus affected equids at 9 (14.8%) facilities, and influenza virus affected equids at 8 (13.1%) facilities. One report of salmonellosis was received, and no incidents of herpesvirus or equine arteritis virus infection, rabies, or tetanus were reported.

**Biosecurity practices**—Because expert opinion indicated that equid movement and isolation practices were very important for infection control and prevention, whereas biosecurity protocols for visitors and general cleaning were considered less important, more points were assigned to potential responses related to the former than to the latter. Type of housing and use of health charts were evaluated as important, whereas insect control was determined to be somewhat important. Scores (range, 0 to 20) were determined for each response, and totals were calculated for each of 5 sections (general facility, written health protocols, movement and housing of equids, infection control and isolation practices, and biosecurity strategies for visitors and employees) of the survey according to the ranked importance of questions and answers (Table 2).<sup>e</sup>

Overall biosecurity scores for facilities were determined from the sum of subscores for responses to the questions in each section. Facilities for which all questions in a section were not completed were excluded from analysis for that section only. Overall biosecurity scores for the individual facilities ranged from 106 to 402 (maximum possible score, 418). Responses for the majority (48/62 [77.4%]) of facilities in the study were determined to be fair, moderate, or excellent for most sections of the evaluation. Scores deemed less than adequate were more commonly received in the section on written health protocols (36/62 [58.1%]) because most facilities did not have written protocols related to management of disease outbreaks or general facility cleaning procedures. Not all questions were completed for all facilities, and those that did not complete a section were excluded from analysis for that part; therefore, sample sizes varied.

**On-site validation of survey responses**—To compare results of self assessment at 30 boarding facilities with results of assessment by a member of the research team, representatives of 52 randomly selected facilities were contacted to request a facility visit. The facilities selected for on-site validation were located in 9 of the 11 Colorado counties from which survey responses were received. Requests for a visit were declined at 2 facilities, and 20 could not be contacted by telephone. Individual facility kappa statistic values for the various survey items that were assessed ranged from 0.226 to 0.799, and the mean kappa values for all facilities were evaluated as fair, moderate, or substantial agreement (Table 3). The greatest amounts of agreement between the results of self-assessment and assessment by the research team member were achieved in the general facil-

Table 1—Responses to questions regarding infection control management practices and demographics in a survey of owners, managers, and other representatives of 64 equine boarding facilities in Colorado conducted in 2007.

Variable	No. of facilities	Response	No. (%) of responses
No. of resident equids	62	> 35	34 (54.8)
		20–35	15 (24.2)
		6–19	11 (17.7)
		3–5	2 (3.2)
		< 3	1 (1.6)
Primary source of equid health-care information	64	Veterinarian	60 (93.8)
		Farrier	22 (34.4)
		Other horse owners	15 (23.4)
Feed storage	63	Rodent- and bird-proof containers	57 (90.5)
Surface water*	63	Accessible to equids	19 (30.2)
Equid drinking-water supply	63	Separate	10 (15.9)
		Shared	15 (23.8)
Rodent control (all)	63	Separate and shared	38 (60.3)
		Exterminator	8 (12.7)
		Other methods	53 (84.1)
Insect control (all)	63	Equine insect spray	53 (84.1)
		Insect strips in environment	34 (54.0)
		Equine face masks	32 (50.8)
		Insecticides (inanimate objects and surfaces)	18 (28.6)
		Equine blankets or sheets	17 (27.0)
Manure handling (all)	63	Hauled off property	29 (46.0)
		Manure pile on property	33 (52.4)
		Manure spread on land away from equids	8 (12.7)
		Manure spread on land accessed by equids	3 (4.8)
		Manure left in equine pastures	3 (4.8)
		Composted	3 (4.8)
		Facility cleaning protocols	62
Protocol for containment of suspected infectious disease outbreak	61	Written protocol	26 (42.6)
Equid health charts	62	Written or computerized charts maintained	43 (69.4)
Protocol to contact veterinarian	62	Written protocol	31 (50.0)
Estimated No. of new equids entering the facility/mo	62	None	14 (22.6)
		1–3	35 (56.5)
		4–6	11 (17.7)
		7–9	1 (1.6)
		≥ 10	1 (1.6)
Estimated No. of resident equids leaving and returning to facility/mo	61	None	7 (11.5)
		1–5	35 (57.4)
		6–10	11 (18.0)
		≥ 10	8 (13.1)
		Individual stalls	35 (55.6)
Equid housing (all)	63	Turned out in groups (whether or not individual stalls were used)	38 (60.3)
		Isolation of newly arrived equids away from resident equids for a designated period of time†	48 (50.0)
Routine isolation of resident equids returning to the facility†	48	Required	4 (8.3)
Isolation area available†	48	None	9 (18.8)
		Stall separate from main housing area	9 (18.8)
		Secluded pen, no direct contact with resident equids	16 (33.3)
		Pen, direct contact possible between equids	2 (4.2)
		Stall in main housing area	12 (25.0)
Vaccinations used (all) for most equids at the facility	64	West Nile virus	61 (95.3)
		Equine influenza virus	57 (89.1)
		Tetanus toxoid	54 (84.4)
		Equine herpesvirus	51 (79.7)
		Eastern or western encephalomyelitis	42 (65.6)
		<i>Streptococcus equi</i> subsp <i>equi</i>	22 (34.4)
		Rabies virus	17 (26.6)
		Equine arteritis virus	4 (6.3)
		<i>Streptococcus equi</i> subsp <i>equi</i>	14 (23.0)
		West Nile virus	9 (14.8)
History of infectious disease at facility (January 2002–June 2007)	61	Equine influenza virus	8 (13.1)
		<i>Salmonella</i> spp	1 (1.6)
		None	29 (47.5)
		Mandatory	19 (30.6)
		Optional	12 (19.4)
Visitor check-in	62	Not requested	31 (50.0)
		Hand washing	9 (14.5)
		Boot cleaning	5 (8.1)
		Equipment cleaning	6 (9.7)
Personnel employed at multiple equine facilities	63	Yes	12 (19.0)
		Percentage of personnel trained on infection-control strategies	29 (46.8)
Percentage of personnel trained on infection-control strategies	62	0%	16 (25.8)
		1%–74%	17 (27.4)
		≥ 75.0%	17 (27.4)

Participants for the survey were representatives of facilities that advertised boarding services in Colorado on the World Wide Web in April 2007, had a valid mailing address, and responded to the questionnaire sent via US mail. Not all participants answered every survey question; thus, sample sizes varied slightly. For questions with >1 possible answer, respondents were instructed to select all relevant responses; these are indicated by (all).  
 \*Defined as any source of standing water that could promote insect reproduction. †Sample size for all survey isolation questions was 48 because facilities that did not have an isolation requirement were excluded for the remaining survey isolation questions.

Table 2—Range of scores assessed (number of facilities that were scored within range) for each section of biosecurity measures included in a survey of 64 equine boarding facilities.

Section	Evaluation category			
	Less than adequate	Fair	Moderate	Excellent
General facility	≤ 13 (0)	14–51 (44)	52–63 (11)	≥ 64 (8)
Written health protocols	≤ 73 (36)	74–120 (19)	121–136 (6)	≥ 137 (1)
Movement and housing of equids	≤ 19 (15)	20–30 (13)	31–56 (36)	≥ 57 (0)
Infection control and isolation practices	≤ 35 (18)	36–83 (35)	84–103 (8)	≥ 104 (3)
Visitor and employee biosecurity practices	≤ 22 (11)	23–33 (36)	34–40 (14)	≥ 41 (3)
Overall score	≤ 162 (14)	163–317 (39)	318–402 (9)	≥ 403 (0)

Incomplete survey sections were excluded from analysis and from corresponding sample sizes; thus, results for all facilities are not reported for all sections. Survey questions were evaluated for relative importance to biosecurity by a panel of 3 veterinarians considered to have expertise regarding this subject; point values were assigned for each response to the survey questions by members of the research team. Response point values were weighted, based on the maximum point value a question was assigned. Score ranges for each section were determined by calculating the lowest and highest possible scores for a section and evaluation category. Overall biosecurity scores for respondents were determined from the sum of subscores for their answers to the questions in each section.  
See Table 1 for remainder of key.

Table 3—Results of survey response validation performed via on-site assessment of selected biosecurity variables at 30 of 64 equine boarding facilities for which questionnaires were completed.

Validated item	Mean kappa statistic	Agreement rating
General facility		
Equid feed stored in enclosed bird- and rodent-proof containers	0.658	Substantial
Surface water (eg, ponds, irrigation ditches, or streams) accessible to equids	0.776	Substantial
Common water source (tank or automatic waterers) shared among equids	0.731	Substantial
Written health protocols		
Facility has written protocols for daily general cleaning procedures	0.436	Moderate
Facility has written protocol for containment of suspected infectious disease outbreak	0.299	Fair
Handwritten or computerized health charts are maintained for individual equids	0.702	Substantial
Facility has a written protocol for when to call the veterinarian	0.471	Moderate
Facility has written infection control protocols in place for use by visitors*		
Hand washing	0.432	Moderate
Cleaning of boots	0.563	Moderate
Cleaning of equipment	0.528	Moderate
Facility has written protocol for interaction with isolated equids (to ensure personnel remain separate from, or take disinfection steps before, contact with healthy equids)	0.409	Moderate
Facility has written protocol for keeping equipment separate or disinfected before contact with healthy equids	0.282	Fair
Movement and housing of equids		
Equids at the facility are housed individually	0.591	Moderate
Equids at the facility are kept in groups, or group turnout is used for individually housed equids	0.441	Moderate
Infection control and isolation		
Newly arrived equids are kept in a separate area that does not allow direct contact with resident equids	0.378	Fair
Type of isolation area provided	0.459	Moderate
Distance from isolation area to housing areas where resident equids are kept	0.391	Fair
Visitor biosecurity strategies*		
Facility has a policy for checking in visitors arriving at facility	0.601	Substantial

The 16 survey questions (some with > 1 part; selected from a total of 36 questions) were those that could be answered by an observer from the research team during a visual assessment as part of a facility visit. Agreement between the respondents' self-assessed survey answers and observations recorded during the visit was evaluated as follows: a kappa statistic of < 0.20 was poor agreement, 0.20 to 0.39 was fair agreement, 0.40 to 0.59 was moderate agreement, 0.60 to 0.79 was substantial agreement, and 0.80 to 1.00 was nearly perfect agreement.  
\*Visitors included persons other than facility personnel and owners of equids.  
See Table 1 for remainder of key.

ity category, whereas the least agreement was detected for infection control and isolation practices.

## Discussion

Results of the study reported here indicated that many equine boarding facilities in Colorado have the opportunity to implement additional infectious dis-

ease control measures. Among the facilities for which a complete response was received, 14 of 62 (22.6%) had scores deemed less than adequate for overall facility biosecurity; none were scored as excellent in this category. A small number of facilities (range, 0 to 8) had responses scored as excellent in at least 1 of the 5 biosecurity categories of the survey, but did not score as well in at least 1 of the remaining categories. The scores of

most facilities for the movement and housing of equids were moderate because the number of new equids entering the facility per month was small (range, 1 to 3 equids) and the majority of facilities (35/63 [55.6%]) housed equids in individual stalls.

The usefulness of the questionnaire as a tool for self-assessment by owners or representatives of boarding facilities was evaluated by comparison of survey responses with assessments made by a member of the research team during a facility visit. In general, agreement between the survey responses and assessments made during on-site validation visits was moderate. The least amount of agreement was found for distance between the locations of isolated and resident equids, availability of a written disease outbreak protocol, availability of a written infection control protocol for interactions with equids in isolation, and whether new equids were kept separated from resident equids. The variation that was detected between reported responses and observed practices or conditions could have been attributable to misinterpretation of questions by the survey respondents or an inability to accurately self-assess. In all instances of poor to fair agreement between the survey responses and recorded observations, the observed practices scored slightly lower than the reported practices.

The questionnaire could be improved as a self-assessment tool by removal of those questions rated not very important to biosecurity by the expert panel and subsequently found to have a low kappa statistic (ie, the least amount of agreement between survey responses and recorded observations during on-site validation). The finding of moderate to substantial agreement for most questions evaluated suggested that most facility representatives could accurately assess many of their infection control practices.

Half (24/48) of facilities in the present study that were reported to receive new arrivals on a regular basis did not have an area that allowed for complete physical separation of newly arrived or sick equids from other equids at the facility. Isolation of new animals entering a facility and quarantine of sick equids were deemed to be the most important factors in prevention and control of disease outbreaks on equine facilities by the expert panel used in this study. An ideal isolation area would be located as far as possible from healthy resident equids, so that isolated equids would have no physical contact or shared airspace with other equids.<sup>11</sup>

Most boarding facilities in the present study were reported to house > 35 equids. The National Animal Health Monitoring System's 2005 equine study<sup>18</sup> (designed to estimate health management practices on all US equine operations that housed  $\geq 5$  equids in 28 states) revealed that most (66.1%) facilities housed a mean of 5 to 9 equids, a smaller number than that of the study reported here. At many boarding facilities in Colorado, a large number of equids could be affected should an outbreak of contagious disease occur. The highest risk of introduction of contagious disease is via direct contact among equids.<sup>19</sup> The most prevalent disease reported at Colorado boarding facilities during the 5 years that preceded completion of the survey in the present report was strangles, which can be transmitted from newly arrived equids to resident equids in a facility. The bacterium that causes strangles can also survive in the environment and be transmitted through contact with contaminated bedding, shared equipment, and flies.

Vaccination is an important aid in infectious disease prevention.<sup>20</sup> In the study reported here, all respondents reported administration of  $\geq 1$  vaccine to most equids at their facilities. Although strangles was the most commonly reported infectious disease among surveyed facilities during the 5 years that preceded the present study, only 22 (34.4%) respondents reported vaccination of most equids at their facility against it. Another study<sup>11</sup> revealed that equine facility representatives chose not to vaccinate against strangles because of little risk of disease exposure (1,882/3,349 [56.2%]) or because a veterinarian advised against vaccination (566/3,349 [16.9%]).

Rodents, birds, and insects can transmit infectious disease agents,<sup>21</sup> and control of these vectors could potentially reduce the risk of introduction or exposure of equids to certain infectious disease agents. Most facilities in the present study were reported to use some form of rodent control, and 57 of 63 (> 90%) had grain stored in rodent- and bird-proof containers rather than in manufacturer's feed bags. Safe storage of feed in rodent- and bird-proof containers may decrease the need for exterminator services. However, rodents can still contact feed stored in rodent-proof containers at the time of feeding, and rodents and birds may contaminate areas where equids are fed. Insecticides (ie, sprays for treatment of the environment or surfaces rather than of equids) were used at a smaller percentage of facilities in the present study (18/63 [28.6%]), compared with that reported in a national estimate (41.5%).<sup>20</sup> This is possibly because the state of Colorado has a dry climate and fewer insects, compared with other areas of the country, and because many counties use large-scale insect abatement, which includes mosquito control measures.<sup>22</sup>

Proper handling and disposal of manure can reduce contamination of the equids' environment with parasites and other pathogens found in fecal material, as was shown in a study<sup>23</sup> of a veterinary teaching hospital. Almost half of respondents in the present study indicated that manure was hauled away from the facility, compared with < 17% of operations that use this method according to national estimates.<sup>17</sup> This suggests that owners and managers of Colorado equine boarding facilities may invest more money in manure handling, compared with the estimated national average for equine operations.

Maintenance of written health records and protocols allows for better evaluation of trends over time.<sup>24</sup> In the present study, 43 of 62 (69.4%) facilities were reported to keep organized (handwritten or computerized) equid health records. Because client-owned equids were boarded at the participating facilities, their representatives may have been more familiar with the importance of record keeping, compared with those at other types of equine facilities, or this may have been prompted by the fact that management of a larger number of equids belonging to various owners necessitates written health-record maintenance.

Direct contact among equids in barns or during turnout times increases the risk of contagious disease spread, especially if equids change groups during turnout. More than half of the facilities in the current study had a separate stall for each equid, although at 38 of 63 (60.3%) facilities, equids were turned out in groups where they would have interactions that included direct contact. Movement of humans among equine operations can also promote the spread of disease agents, which can be car-

ried on clothing, footwear, hands, and equipment.<sup>21</sup> The use of protocols for visitors to a facility can reduce the risk of disease agent introduction. However, most facilities in this study did not have any type of check-in requirement for visitors. Written infection control strategies can be obtained through consultation with a veterinary clinician or practitioner, and general guidelines are available from numerous online sources including Web sites of the USDA<sup>10</sup> and the American Association of Equine Practitioners.<sup>25</sup>

All respondents' facilities in the present study were located along the Front Range (east of the Rocky Mountains) of Colorado and were included in the study on the basis of advertisement of boarding services on the World Wide Web. Facilities located in counties with smaller equine populations (information based on available data from the National Agricultural Statistics Service<sup>26</sup>) were more likely to have no response to the survey or to have invalid postal addresses. The results of the study reported here may not reflect the biosecurity practices at equine boarding facilities that were not advertised on the Web or at facilities where management was nonresponsive to survey participation requests.

The economic impact of an outbreak of infectious disease must be weighed against the cost of modifications to current practices that would potentially reduce risk of infectious disease outbreaks. To our knowledge, no analysis of the cost of control of endemic equine infectious diseases, compared with the value of avoidance of a disease outbreak in the United States, has been published. Without this information, equid owners and equine facility owners and managers cannot make informed decisions about the economic benefit of disease control measures. The movement of equids among facilities and population size of a facility (eg, the number of resident equids) may impact the risk for disease introduction and influence the scope of a potential outbreak. Education may also play a key role in improvement of biosecurity practices. A more widely available survey tool such as that used in the present study could provide a useful resource for self-assessment of biosecurity practices at equine facilities. Availability of such resources on the World Wide Web could increase awareness of the importance of infection control, as well as highlight ways to increase equine facility biosecurity.

- Copies of the survey questionnaire are available upon request from the corresponding author.
- Google Web Search, Google Inc, Mountain View, Calif.
- Excel, Microsoft Office 2004 for Macintosh, Microsoft Corp, Redmond, Wash.
- SPSS, version 15.0.1, SPSS Inc, Chicago, Ill.
- A table of points assigned to all questions and responses is available upon request from the corresponding author.

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