Characteristics of biosecurity and infection control programs at veterinary teaching hospitals

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Objective—To characterize biosecurity and infection control practices at veterinary teaching hospitals located at institutions accredited by the AVMA.

Design—Cross-sectional survey.

Population—50 biosecurity experts at 38 veterinary teaching hospitals.

Procedures—Telephone interviews were conducted between July 2006 and July 2007, and questions were asked regarding policies for hygiene, surveillance, patient contact, education, and awareness. Respondents were also asked their opinion regarding the rigor of their programs.

Results—31 of 38 (82%) hospitals reported outbreaks of nosocomial infection during the 5 years prior to the interview, 17 (45%) reported > 1 outbreak, 22 (58%) had restricted patient admissions to aid mitigation, and 12 (32%) had completely closed sections of the facility to control disease spread. Nineteen (50%) hospitals reported that zoonotic infections had occurred during the 2 years prior to the interview. Only 16 (42%) hospitals required personnel to complete a biosecurity training program, but 20 of the 50 (40%) respondents indicated that they believed their hospitals ranked among the top 10% in regard to rigor of infection control efforts.

Conclusions and Clinical Relevance—Results suggested that differences existed among infection control programs at these institutions. Perceptions of experts regarding program rigor appeared to be skewed, possibly because of a lack of published data characterizing programs at other institutions. Results may provide a stimulus for hospital administrators to better optimize biosecurity and infection control programs at their hospitals and thereby optimize patient care. (*J Am Vet Med Assoc* 2008;233:767–773)

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Infection control is an essential component in the operation of all veterinary hospitals.[1] Biosecurity risks include outbreaks of nosocomial infections in hospitalized patients and zoonotic infections in hospital personnel. Through the accreditation process, VTHs at AVMA-accredited schools and colleges of veterinary medicine are expected to have some commonality in standards and practices regarding hygiene, biosecurity, and infection control.[2] However, little is known about characteristics of infection control programs that are actually employed and which practices would best address current biosecurity risks.

Veterinary clinicians and hospital administrators have become increasingly aware of the importance of biosecurity in providing optimal care. Optimally, to allow for the best use of available resources, management decisions related to infection control practices should be based on objective data rather than on personal perception. However, there are no published data characterizing infection control practices across a variety of veterinary hospitals, and only limited information is available regarding rates of important nosocomial infections at veterinary hospitals. Whereas the US CDC have sponsored a series of efforts to characterize and evaluate the efficacy of infection control efforts in human health-care settings,[3–9] similar work has not been performed in the veterinary field. The purpose of the study reported here, therefore, was to characterize biosecurity and infection control practices at VTHs located at schools and colleges of veterinary medicine accredited by the AVMA.

Abbreviations

CI	Confidence interval
CSF	Classical swine fever
EHV-1	Equine herpes virus type 1
FMD	Foot-and-mouth disease
MRSA	Methicillin-resistant *Staphylococcus aureus*
OR	Odds ratio
VTH	Veterinary teaching hospital

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Materials and Methods

Overview—The study was conducted as a cross-sectional survey. The eligible study population consisted of schools and colleges of veterinary medicine accredited by the AVMA that operated a VTH. Eligible institutions were located in North America (n = 31), the European Union (4), Australia (3), and New Zealand (1).[a] The hospital director of each eligible institution was contacted by e-mail to determine whether the institution was willing to participate. If so, the hospital director was asked to identify the individual most knowledgeable about biosecurity and infection control practices at the VTH. At most institutions, a single person was identified as the biosecurity expert, but at some institutions, multiple individuals were identified as being responsible for activities in different hospital sections (eg, small and large animal sections).

Identified experts were contacted by e-mail and invited to participate in a telephone interview. Telephone interviews were 15 to 20 minutes long and were conducted between July 2006 and July 2007. All telephone interviews were performed by 2 investigators who had been trained on uniform collection of data for the study. Study participation was voluntary, and information about individual institutions remained confidential. Prior to initiation of the study, the research protocol was reviewed and approved by the Colorado State University Human Research Committee and the American Association of Veterinary Medical Colleges.

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Telephone interviews—During telephone interviews, experts from participating institutions were asked a series of 63 questions on topics related to hygiene, infectious disease surveillance, management of patient contact, education and awareness regarding infection control, and structure of the infection control program.[b] Participants were also asked to provide their personal opinions on infection control practices and on the rigor of the infection control program at their institutions. No questions were asked about the efficacy of specific infection control practices. Most of the questions were in a yes or no format, although some questions required participants to select from a series of responses or Likert scale categories. For all questions, participants were instructed to indicate when they did not know the answer, if this was appropriate. All responses were accepted as valid without qualifying participants' understanding or interpretation of questions. Interviewers obtained additional information by follow-up e-mail when participants were uncertain of answers at the time of the interview. The questionnaire was validated through internal review and consultations with content experts at Colorado State University.

The structure of each institution's infection control program was characterized through questions regarding responsibilities for program oversight, the format of written policies, and the availability of policies to the general public. Participants were asked questions intended to characterize passive and active surveillance efforts (including microbiologic surveillance of patients and the environment), extent of antimicrobial drug use and antimicrobial resistance in bacterial isolates, policies for detecting and reporting contagious clinical diseases and disease syndromes, and actions to be initiated in the event that particular diseases or agents were identified. Participants were also asked questions regarding the occurrence of outbreaks of nosocomial infection in the 5 years prior to the interview and whether these outbreaks led to the closure of the entire facility or, simply, to restrictions or limits on admission of certain patients.

The portion of the questionnaire focusing on efforts used to improve education and awareness among personnel regarding the infection control program and potential hazards included questions about training requirements, the occurrence of significant health problems in personnel that most likely resulted from zoonotic infection, and the inclusion of statements about risks related to nosocomial infection in informed consent statements. Because a variety of problems related to animal and human health might be perceived as important in different circumstances and it was difficult to develop all-encompassing definitions, the terms "outbreak" and "significant health problem" were not defined or explained to participants, and each respondent was allowed to make his or her own interpretation.

For questions regarding hygiene and management of patient contact, 2 identical series of questions were asked regarding the small animal and large animal sections at each participating institution. If multiple experts with responsibilities for different hospital sections (eg, small animal or large animal section) had been identified, respondents were asked to answer only those questions pertaining to the section they represented. Questions in this portion of the questionnaire were intended to characterize cleaning and disinfection policies, the use of follow-up microbiologic culture to evaluate disinfection efficacy, the use of policies governing attire, and policies regarding segregation and isolation of patients.

In the last portion of the questionnaire, participants were asked how their concerns related to infection control had changed over time and how their programs compared with programs at other institutions in regard to hygiene standards, rigor of infection control efforts, and the risk of nosocomial infections among patients. Additionally, participants were asked to characterize institutional risk related to patient species and caseload.

Data analysis—Survey responses were entered in a computer spreadsheet and summarized. Contingency tables were created to test for associations between responses to different questions and between responses stratified on the basis of the institution's location (North America vs other) and section responsibility of the participant (entire VTH vs small animal section vs large animal section). Odds ratios with associated 95% CIs were calculated, and the χ^2 or Fisher exact test was performed with statistical software.[c] Participant responses characterized as "don't know" were excluded from contingency table analyses. Responses to all questions except the opinion-based questions were tabulated on an institutional basis. Therefore, if > 1 person was interviewed for a particular institution, answers were combined to represent responses for the institution as a single entity. Because responses to opinion-based questions did not necessarily relate to the actions or policies of the institution as a whole, these responses were analyzed without institution-based aggregation.

Results

Survey participants—Hospital directors from 38 of the 39 eligible institutions agreed to participate, including 30 institutions in North America and 8 institutions in other areas of the world. At 26 institutions, a single person was identified as the expert on hospital infection control practices. At the remaining 12 institutions, multiple individuals were identified as being responsible for activities in different hospital sections (eg, small animal, large animal, food animal, and equine sections). Thus, for 10 institutions, 2 experts were invited to participate, and for 2 institutions, 3 experts were invited to participate. Of the 52 biosecurity experts that were contacted, 50 agreed to participate. Overall, 26 individuals provided responses for their VTH as a whole, 10 provided responses for the small animal section at their VTH, 10 provided responses for the large animal section, 2 provided responses for the food animal section, and 2 provided responses for the equine section. In some instances, the person who was identified as most knowledgeable about infection control practices was the hospital director. Other individuals identified as experts in hospital infection control practices held titles such as biosecurity director, chair of the infection control committee, or infection control officer. Two participating institutions only provided responses related to the large animal section of the VTH. Overall, therefore, there were institutional responses available for 38 large animal facilities and 36 small animal facilities. For 1 institution, the small and large animal facilities were located a substantial distance apart, whereas for all other participating institutions, the small and large animal facilities were located at the same site. All participants completed the full survey; an answer of "don't know" was given only 22 times by the 50 participating experts.

Program structure—At 32 of the 38 (84%) institutions, the infection control program was overseen by an infection control committee. Thirty-four (89%) institutions had written policy documents, but only 7 of these 34 (21%) institutions made policy documents available to the general public. Twenty-five of the 34 (74%) institutions with written policy documents had updated them within 1 year prior to the telephone interview.

Institutions with infection control committees were 7.5 times (95% CI, 1.0 to 57.7; $P = 0.05$) as likely to have written policy documents for their program as were institutions that did not have an infection control committee. North American institutions were more likely to have a committee that oversaw infection control program activities than were institutions located in other parts of the world (OR, 5.4; 95% CI, 1.0 to 31.6; $P = 0.06$). Twenty-seven of the 32 (84%) infection control committees included hospital staff members in addition to faculty, 30 (94%) included at least 1 nonveterinarian, and all 32 (100%) included at least 1 member who was responsible for patient care.

At 32 of the 38 (84%) institutions, a single person was designated as being responsible for leading infection control activities. Twenty-eight of the 32 (88%) program leaders were faculty members, 24 (75%) were veterinarians, and 18 (56%) had patient care responsibilities.

Surveillance—Thirty-one of the 38 (82%) institutions reported outbreaks of nosocomial infection during the 5 years prior to the telephone interview, with 17 (45%) reporting > 1 outbreak. Agents most commonly detected in association with outbreaks of nosocomial infection included *Salmonella enterica* (20/31 [65%]), MRSA (13/31 [42%]), and *Escherichia coli* (5/31 [16%]). Other agents reported included *Cryptosporidium parvum* (3/31 [10%]), *Enterococcus* spp (3/31 [10%]), EHV-1 (3/31 [10%]), *Pseudomonas* spp (3/31 [10%]), *Acinetobacter baumannii* (2/31 [6%]), *Clostridium difficile* (2/31 [6%]), *Enterobacter* spp (2/31 [6%]), avian influenza virus (H7N7; 1/31 [3%]), equine influenza virus (H3N8; 2/31 [6%]), *Bordetella bronchiseptica* (1/31 [3%]), *Chlamydophila psittaci* (1/31 [3%]), calicivirus (1/31 [3%]), and dermatophytes (1/31 [3%]).

Twenty-two of the 38 (58%) institutions had restricted patient admissions at some time during the previous 5 years to aid mitigation efforts associated with outbreaks of nosocomial infection, and 12 (32%) had completely closed parts of the facility to control disease spread. *Salmonella enterica* was the agent most commonly cited as the reason for restricting patient admissions (17/22 [77%]), followed by EHV-1 (3/22 [14%]), MRSA (2/22 [9%]), *C difficile* (2/22 [9%]), *C psittaci* (1/22 [5%]), calicivirus (1/22 [5%]), equine influenza virus (1/22 [5%]), and avian influenza virus (1/22 [5%]). One institution restricted patient admissions because of FMD in the region, and another restricted patient admission because of CSF in the region. In both instances, cases were not identified in the teaching hospital, and patient admissions were restricted because of regional control policies imposed by regulatory agencies. In general, the distribution of agents associated with outbreaks of nosocomial infection did not differ between North American institutions and institutions located in other parts of the world, except that many countries, including the United States, were free from FMD and CSF during the 5 years preceding the present study. Fifteen of the 22 (68%) institutions that reported restricting patient admissions at some time during the preceding 5 years had restricted admissions of horses; 8 (36%) had restricted admissions of food animals; and ≤ 2 had restricted admissions of dogs, cats, or nontraditional pet (exotic) species. North American institutions did not differ from institutions located in other parts of the world with regard to proportion reporting at least 1 outbreak ($P = 0.59$), proportion restricting patient admissions in response to an outbreak ($P = 0.61$), or likelihood of complete facility closure ($P = 0.23$).

Nineteen of the 38 (50%) institutions reported that significant health problems attributable to zoonotic infections had occurred among hospital personnel during the 2 years prior to the telephone interview. Agents that were identified included *C parvum* (13/19 [68%]), MRSA (3/19 [16%]), *S enterica* (3/19 [16%]), undefined cutaneous dermatophytes (2/19 [11%]), *Blastomyces dermatitidis* (1/19 [5%]), *Campylobacter* spp (1/19 [5%]), *C psittaci* (1/19 [5%]), *Listeria monocytogenes* (1/19 [5%]), and *Sporothrix schenckii* (1/19 [5%]). North American institutions did not differ from institutions located in other parts of the world with regard to proportion reporting zoonotic infections among personnel ($P = 1.0$).

Many institutions were reportedly engaged in active or passive surveillance for infectious diseases. However,

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surveillance was not necessarily conducted at predetermined temporal intervals (eg, monthly). Common surveillance strategies included summarizing contagious disease diagnoses reported by clinicians (32/38 [84%]) and compiling results of cultures or tests performed for diagnostic purposes (27/38 [71%]). However, these practices were conducted at predetermined intervals at only 23 (61%) institutions. Other active surveillance strategies included routinely submitting environmental samples for bacterial culture (28/38 [74%]) and collecting samples from patients to detect specific contagious pathogens (20/38 [53%]); however, only 21 (55%) and 11 (29%) institutions, respectively, performed these surveillance activities according to a predetermined temporal pattern. Twenty-two of the 38 (58%) institutions compiled information about the occurrence of specific contagious diseases or disease syndromes, but only 14 (37%) did so at predefined temporal intervals. The institutions that conducted surveillance at irregular intervals reported that a perceived risk in part or all of the hospital triggered surveillance activity. Institutions that reported outbreaks of nosocomial infections in the past 5 years were more likely to compile information on contagious disease diagnoses reported by clinicians (OR, 7.0; 95% CI, 1.2 to 43.4; $P = 0.03$) or compile results of cultures or tests performed for diagnostic purposes (OR, 4.6; 95% CI, 0.9 to 23.3; $P = 0.07$) than were institutions that did not report outbreaks of nosocomial infection; however, institutions that did or did not report outbreaks of nosocomial infection did not differ with regard to the likelihood of collecting samples from patients to detect specific contagious pathogens ($P = 0.16$), submitting environmental samples for bacterial culture ($P = 0.27$), or compiling information about the occurrence of specific contagious diseases or disease syndromes ($P = 0.96$). Thirty-four of the 38 (89%) institutions had written instructions regarding which subsequent actions were to be taken if a target agent was confirmed or suspected during surveillance. Eighteen (47%) institutions reported monitoring antimicrobial drug use, such as through pharmacy records, and 31 (82%) reported monitoring antimicrobial susceptibility of isolates recovered from patients.

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Education and awareness—Only 16 of the 38 (42%) institutions required personnel to complete any type of infection control training, and only 7 of these 16 (44%) institutions required personnel to participate in infection control training on > 1 occasion. Educational methods that were used included handouts, online modules, classroom instruction, and shadowing of individuals in the hospital to learn appropriate protocols. Whether training was required was not significantly associated with whether an outbreak of nosocomial disease had been identified in the preceding 5 years ($P = 0.37$) or with whether zoonotic infections had occurred among hospital personnel during the preceding 2 years ($P = 1.00$). Statements about risks related to nosocomial infections were included in informed consent statements that clients signed at 14 (37%) institutions. However, inclusion of such statements was not significantly ($P = 0.62$) associated with the reported occurrence of outbreaks of nosocomial infection. Personnel working as receptionists were reportedly trained to identify and help segregate arriving patients that might have contagious disease at 31 of the 38 (82%) institutions.

Hygiene—Thirty-two of 36 (89%) small animal facilities and 36 of 38 (95%) large animal facilities had written documents outlining procedures to be used when cleaning and disinfecting the hospital environment. In the 5 years preceding the study, 16 of 36 (44%) small animal facilities and 26 of 38 (68%) large animal facilities had undergone physical changes to assist with management of infection control risk. However, whether facilities had undergone physical changes was not significantly ($P = 0.50$ for small animal facilities and $P = 0.85$ for large animal facilities) associated with the occurrence of outbreaks of nosocomial infection. Changes that were reported for small animal facilities included replacing floors or surfaces with easy-to-clean materials, adding handwashing or hand sanitizer dispensing stations, creating new intensive care units, and designing more functional isolation and containment areas. Two institutions had recently added windows to the intensive care unit or isolation area so that patients could be visibly monitored while restricting foot traffic and contact with patients. Changes that were reported for large animal facilities included improving floors by removing stall mats, changing floor surfaces, improving drainage, modifying traffic patterns in hospital areas, creating new or expanding isolation units, and updating cleaning or feeding equipment with materials that were more easily cleaned and disinfected.

Thirty-three of 36 (92%) small animal facilities and 36 of 38 (95%) large animal facilities had policies governing attire for personnel. For 24 of the 33 (73%) small animal facilities and 30 of the 36 (83%) large animal facilities, the stated purpose of the attire policy was to enhance professionalism and aid in infection control efforts, as opposed to either of these reasons alone. Among facilities with attire policies intended to aid infection control, specific attire requirements varied depending on the perceived risk for contagious disease transmission (24/26 [92%] small animal facilities and 33/36 [92%] large animal facilities).

Managing patient contact—All 38 (100%) institutions had isolation facilities for equine patients, and 34 of 36 (94%) institutions had isolation facilities for small animal patients, but only 28 of 38 (74%) institutions had separate isolation facilities for food animal patients. Twenty of 34 (59%) small animal facilities, 29 of 38 (76%) equine facilities, and 14 of 28 (50%) food animal facilities used additional segregation to reduce the risk of contagious disease transmission when patients were not housed in isolation facilities.

Personal opinion—Forty-three of the 50 (86%) participating experts indicated that they believed there were substantial differences in hygiene standards among VTHs located at AVMA-accredited institutions. The likelihood that participants believed there were hygiene differences did not differ between respondents who represented the entire institution and respondents who represented only a section of the hospital ($P = 0.36$). However, respondents from North American institutions were more likely to believe there were substantial differences in hygiene standards among institutions than were respondents from institutions in other areas (OR, 13.1; 95% CI, 1.6 to 102.1; $P = 0.01$). Thirteen of the 43 (30%) respondents who believed there were substantial differences in hygiene standards believed their institutions ranked in the top 10% with regard to hygiene standards. When asked whether their institutions had a rigorous infection control program (yes or no), only 21 of 50 (42%) respondents answered yes. However, when asked to compare their program with programs at other AVMA-accredited institutions, 20 of 50 (40%) respondents said that their VTH ranked in the top 10% with regard to rigor of infection control efforts. There were no detectable differences between respondents from North American institutions and respondents from other areas with regard to how they ranked their institutions for hygiene standards ($P = 0.65$) or rigor of infection control programs ($P = 0.18$).

Few respondents believed their institution ranked higher than other institutions in terms of the risk of nosocomial infection posed by canine and feline patients (2/36 [6%]), equine patients (8/38 [21%]), or food animal patients (3/37 [8%]). When respondents were asked to rank patient species according to concerns they had about introducing contagious agents into the hospital environment, 18 of the 50 (36%) respondents reported that equine patients posed the greatest risk, 14 (28%) reported that bovine patients posed the greatest risk, and 14 (28%) reported that canine patients posed the greatest risk. Only 3 (6%) respondents reported that feline, nontraditional pet (exotic) species, camelids, or pigs posed the greatest risk of introducing contagious agents into the hospitals. Respondents representing only 1 section of the hospital tended to choose species within their sections of the hospital, whereas respondents representing the entire hospital tended to select a large animal species.

Forty-six of 50 (92%) respondents indicated that an increase in caseload was associated with an increase in the risk of nosocomial infection in their patients. However, respondents responsible for only the small animal section of their hospital were 12 times as likely to disagree with this statement as were respondents with other oversight responsibilities (OR, 12.4; 95% CI, 1.1 to 77.0; $P = 0.04$). When asked about their general concern regarding the risk of nosocomial infection in patients, 39 of 50 (78%) respondents reported that they had greater or much greater concern than they did 10 years prior to the study. Similarly, 32 (64%) respondents believed there was a greater true risk (as opposed to increased concern or awareness) of nosocomial infection among their patients, compared with 10 years ago. There were no detectable differences in these perceptions between respondents from North American institutions and respondents from institutions in other areas ($P = 0.53$ and 0.92, respectively).

Discussion

Results of the present study suggested that outbreaks of nosocomial infections were a frequent problem for VTHs located at AVMA-accredited institutions and that zoonotic infections were an important hazard to personnel working in these hospitals. Importantly, the present study was not designed to evaluate the efficacy of individual infection control practices. Thus, although there appeared to be differences among infection control programs, it was not clear which aspects of these programs were the most important or had the greatest impact on the risk of nosocomial infection in these hospitals, and additional study is needed to evaluate the efficacy of specific infection control practices. Equally important, the present study was not designed to determine how extensive or how rigorous infection control practices had to be to substantially decrease the risk of nosocomial infection. Ultimately, such questions are more value based than evidence based, in that it is not possible to determine a single correct level of risk aversion, and there is no way to absolutely determine whether a specific practice is necessary or superfluous. With this in mind, it must also be acknowledged that nosocomial and zoonotic disease threats are undeniable hazards in every veterinary practice. Because veterinarians have an ethical and legal obligation to take reasonable actions to protect their patients and employees from foreseeable harm, it is essential that sufficient attention is paid to infection control practices. The AVMA provides accredited institutions with general expectations regarding maintaining clean facilities and equipment in the VTH,[2] but no specifications are outlined in reference to a certain level of infection control or biosecurity.

As was the case in the present study, previous reports[10–27] about infection control efforts at VTHs have indicated that biosecurity is a priority at most AVMA-accredited institutions. However, despite the apparently widespread occurrence of nosocomial disease outbreaks in these hospitals, we found that formalized training of personnel to help mitigate these risks was limited. By their very nature, extra measures to decrease the risk of nosocomial infection inevitably inconvenience hospital personnel. Furthermore, people naturally gravitate toward the most convenient methods for daily activities. As such, the more personnel are inconvenienced by infection control efforts, the less likely they are to follow prescribed policies unless they understand and believe that those policies are needed and have value. Thus, a critical component of any effective infection control program is educating personnel about potential hazards and the value of established control measures. It is possible for people to acquire information and training over time through personal experience while working in a hospital, but this is an inefficient and unreliable method for disseminating critical information, especially in large, complex facilities such as VTHs.

Although evaluating infection control practices should involve more than simply determining the occurrence of nosocomial disease outbreaks, outbreaks reported in the present study may provide indications of which agents present the greatest challenges and which areas should be targeted for control efforts. It was not surprising that *S enterica* was the agent most commonly reported as causing outbreaks, given that nosocomial salmonellosis has been well documented as a problem at VTHs throughout the world.[11–15,25] Many previous reports of nosocomial salmonellosis outbreaks involved large animal facilities; however, nosocomial salmonel-

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losis was identified in both small and large animal facilities in the present study. Problems with MRSA have also been documented previously,[18,21] and this agent was the second most commonly reported agent associated with outbreaks of nosocomial infection. The zoonotic potential of both of these agents further highlights the importance of infection control efforts in veterinary hospitals. Challenges associated with EHV-1, *C difficile*, *Acinetobacter baumannii*, and *E coli* in VTHs have also been documented previously.[10,17,22,24,26] Given the commonness of anecdotal reports of outbreaks of respiratory tract disease in dogs (ie, kennel cough), cats, and other species, it is also possible that occurrences of these conditions were underreported in the present study.

A few participants from institutions outside of North America in the present study stated that they believed VTHs in North America had a greater risk for outbreaks of nosocomial infection. However, this statement was not supported by results of our study. Importantly, 2 VTHs involved in the present study had been required to restrict admissions to assist with regional control efforts for FMD or CSF, even though no cases had been admitted to these facilities. This highlights the integral place that VTHs hold in terms of the regional infrastructure for veterinary services. It also points to the tremendous impact that endemic and epidemic infectious diseases in animal populations outside a VTH can have on infection control efforts within the VTH.

Another important factor in infection control practices is the risk of zoonotic infection resulting from occupational exposures. Although the present study did not evaluate surveillance efforts specific to zoonotic infection, our impression was that most institutions were not actively working to identify infections or health problems among their personnel. The likelihood that subclinical infections were not detected in combination with the lack of surveillance efforts and the natural reluctance of personnel to report illnesses, such as diarrhea or other potentially embarrassing problems, to hospital administrators leads us to believe that the occurrence of significant health problems related to zoonotic infection was likely underestimated in the present study. Most participants were forthcoming about the zoonotic diseases that had been identified or suspected in their personnel. However, a few were more reserved, possibly because of concerns about public opinion or constraints on their ability to disclose information about human health.

Individuals who oversaw infection control program activities in the present study came from diverse backgrounds and had diverse training. Individuals identified as experts in infection control at participating institutions included faculty and staff, clinicians, microbiologists, and epidemiologists, and the amount of time these individuals devoted to infection control activities varied widely. Effective leadership is essential to the success of an infection control program, and study participants reported that providing effective leadership was especially challenging with regard to obtaining compliance with established protocols. Leaders and committees can choose a variety of approaches to maintain the necessary compliance, but certain administrative positions, more so than others, may aid in achieving the desired level of participation. Many of the leaders of infection control programs at these hospitals were veterinarians who were members of the faculty and responsible for patient care. With the assistance of other infection control committee members, faculty veterinarians might be especially well suited to undertake a leadership role in infection control programs. Faculty veterinarians are well positioned to solicit support from their colleagues in instituting necessary changes and to develop programs to optimize patient care and hygiene among staff and students. However, if the person leading the infection control program also has clinical responsibilities, it may be difficult for that person to remain objective while directing the program.

The surveillance component of an infection control program is an essential system for collecting information necessary to guide ongoing efforts.[1] In the present study, however, we found that surveillance most often was not conducted on a regularly scheduled basis and most commonly relied on passive collection of clinicians' diagnoses rather than on active surveillance efforts. To our knowledge, there are no data to clearly indicate whether regularly conducted, active surveillance is more effective than other strategies for improving infection control in veterinary hospitals. However, increased awareness inherently accompanies more visible surveillance efforts. Clearly, detecting potentially important disease outbreaks before they can have measurable negative impacts on patient health and hospital operations is a valuable outcome of surveillance efforts. However, because the benefits of various surveillance strategies have not been definitively quantified, some critics suggest that the time, energy, and money needed for more intensive surveillance practices outweigh the benefits. In the absence of objective studies to help guide decisions regarding the efficacy of surveillance options, subjective assessments regarding the value of this information would seem to be the only basis for decisions. However, unless more intensive surveillance strategies have been attempted at a facility, there really is no objective basis for rejecting them as being unnecessary. Objective surveillance data are needed for institutions to make informed decisions about the best use of available resources for their facilities and institutional goals.

a. Eligible institutions that were contacted to solicit their participation included the VTHs at Auburn University, the University of California at Davis, Colorado State University, Cornell University, the University of Edinburgh, the University of Florida, the University of Georgia, the University of Glasgow, the University of Guelph, the University of Illinois, Iowa State University, Kansas State University, the University of London, Louisiana State University, the University of Melbourne, Massey University, Michigan State University, the University of Minnesota, Mississippi State University, the University of Missouri, the University of Montreal, Murdoch University, North Carolina State University, The Ohio State University, Oklahoma State University, Oregon State University, the University of Prince Edward Island, Purdue University, the University of Saskatchewan, the University of Sydney, the University of Tennessee, Texas A&M University, Tufts University, Tuskegee University, the University of Pennsylvania, Utrecht University, Virginia Polytechnic Institute and State University, Washington State University, and the University of Wisconsin.

b. Survey available upon request from the corresponding author.
c. Epi Info, version 3.4.1, CDC, Atlanta, Ga.

References

1. Morley PS, Weese JS. Biosecurity and infection control for large animal practices. In: Smith BP, ed. *Large animal internal medicine*. 4th ed. New York: Elsevier, 2008;510–527.
2. AVMA Council on Education. Accreditation policies and procedures of the AVMA Council on Education. May 1, 2007. Available www.avma.org/education/cvea/coe_pp.pdf. Accessed Oct 26, 2007.
3. Eickhoff TC. General comments on the study of the efficacy of nosocomial infection control (SENIC project). *Am J Epidemiol* 1980;111:465–469.
4. Haley RW, Quade D, Freeman HE, et al. Study of the efficacy of nosocomial infection control (SENIC project). *Am J Epidemiol* 1980;111:472–485.
5. Quade D, Culver DH, Haley RW, et al. The SENIC sampling process: design for choosing hospitals and patients and results of sample selection. *Am J Epidemiol* 1980;111:486–502.
6. Whaley FS, Quade D, Haley RW. Effects of method error on the power of a statistical test. Implications of imperfect sensitivity and specificity in retrospective chart review. *Am J Epidemiol* 1980;111:534–542.
7. Hooton TM, Haley RW, Culvert DH. A method for classifying patients according to nosocomial infection risks associated with diagnoses and surgical procedures. *Am J Epidemiol* 1980;111:556–573.
8. Haley RW, Shachtman RH. The emergence of infection surveillance and control programs in US hospitals: an assessment, 1976. *Am J Epidemiol* 1980;111:574–591.
9. Emori TG, Haley RW, Stanley RC. The infection control nurse in US hospitals, 1976–1977. Characteristics of the position and its occupant. *Am J Epidemiol* 1980;111:592–607.
10. Henninger RW, Reed SM, Saville WJ, et al. Outbreak of neurologic disease caused by equine herpesvirus-1 at a university equestrian center. *J Vet Intern Med* 2007;21:157–165.
11. Ward MP, Alinovi CA, Couetil LL, et al. Fecal shedding of *Salmonella* in horses admitted to a veterinary teaching hospital. *J Equine Vet Sci* 2003;23:403–407.
12. Amavisit P, Markham PF, Lightfoot D, et al. Molecular epidemiology of *Salmonella* Heidelberg in an equine hospital. *Vet Microbiol* 2001;80:85–98.
13. House JK, Mainar-Jaime RC, Smith BP, et al. Risk factors for nosocomial *Salmonella* infection among hospitalized horses. *J Am Vet Med Assoc* 1999;214:1511–1516.
14. Tillotson K, Savage CJ, Salman MD, et al. Outbreak of *Salmonella infantis* infection in a large animal veterinary teaching hospital. *J Am Vet Med Assoc* 1997;211:1554–1557.
15. EzEzell H, Tramontin B, Hudson R, et al. Outbreaks of multidrug-resistant *Salmonella* Typhimurium associated with veterinary facilities—Idaho, Minnesota, and Washington, 1999. *MMWR Morb Mortal Wkly Rep* 2001;50:701–704.
16. Sabino CV, Weese JS. Contamination of multiple-dose vials in a veterinary hospital. *Can Vet J* 2007;47:779–782.
17. Sidjabat HE, Townsend KM, Lorentzen M, et al. Emergence and spread of two distinct clonal groups of multidrug-resistant *Escherichia coli* in a veterinary teaching hospital in Australia. *J Med Microbiol* 2006;55:1125–1134.
18. Weese JS, Rousseau J, Willey BM, et al. Methicillin-resistant *Staphylococcus aureus* in horses at a veterinary teaching hospital: frequency, characterization, and association with clinical disease. *J Vet Intern Med* 2006;20:182–186.
19. Dunowska M, Morley PS, Patterson G, et al. Evaluation of the efficacy of a peroxygen disinfectant-filled footmat for reduction of bacterial load on footwear in a large animal hospital setting. *J Am Vet Med Assoc* 2006;228:1935–1939.
20. Morley PS, Morris SN, Hyatt DR, et al. Evaluation of the efficacy of disinfectant footbaths as used in veterinary hospitals. *J Am Vet Med Assoc* 2005;226:2053–2058.
21. Weese JS, DaCosta T, Button L, et al. Isolation of methicillin-resistant *Staphylococcus aureus* from the environment in a veterinary teaching hospital. *J Vet Intern Med* 2004;18:468–470.
22. Weese JS, Armstrong J. Outbreak of *Clostridium difficile*-associated disease in a small animal veterinary teaching hospital. *J Vet Intern Med* 2003;17:813–816.
23. Prescott JF, Brad Hanna WJ, Reid-Smith R, et al. Antimicrobial drug use and resistance in dogs. *Can Vet J* 2002;43:107–116.
24. Boerlin P, Eugster S, Gaschen F, et al. Transmission of opportunistic pathogens in a veterinary teaching hospital. *Vet Microbiol* 2001;82:347–359.
25. Schott HC, Ewart SL, Walker RD, et al. An outbreak of salmonellosis among horses at a veterinary teaching hospital. *J Am Vet Med Assoc* 2001;218:1152–1159.
26. Weese JS, Staempfli HR, Prescott JF. Isolation of environmental *Clostridium difficile* from a veterinary teaching hospital. *J Vet Diagn Invest* 2001;12:449–452.
27. Ravary B, Fecteau G, Higgins R, et al. Control measures for contagious enteric diseases in a veterinary teaching hospital. *Can Vet J* 1999;40:871–877.