Infection control practices and zoonotic disease risks among veterinarians in the United States

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Objective—To assess the knowledge and use of infection control practices (ICPs) among US veterinarians.

Design—Anonymous mail-out population survey.

Procedures—In 2005 a questionnaire was mailed to US small animal, large animal, and equine veterinarians who were randomly selected from the AVMA membership to assess precaution awareness (PA) and veterinarians' perceptions of zoonotic disease risks. Respondents were assigned a PA score (0 to 4) on the basis of their responses (higher scores representing higher stringency of ICPs); within a practice type, respondents' scores were categorized as being within the upper 25% or lower 75% of scores (high and low PA ranking, respectively). Characteristics associated with low PA rankings were assessed.

Results—Generally, respondents did not engage in protective behaviors or use personal protective equipment considered appropriate to protect against zoonotic disease transmission. Small animal and equine veterinarians employed in practices that had no written infection control policy were significantly more likely to have low PA ranking. Male gender was associated with low PA ranking among small animal and large animal veterinarians; equine practitioners not working in a teaching or referral hospital were more likely to have low PA ranking than equine practitioners working in such institutions.

Conclusions and Clinical Relevance—Results indicated that most US veterinarians are not aware of appropriate personal protective equipment use and do not engage in practices that may help reduce zoonotic disease transmission. Gender differences may influence personal choices for ICPs. Provision of information and training on ICPs and establishment of written infection control policies could be effective means of improving ICPs in veterinary practices. (*J Am Vet Med Assoc* 2008;232:1863–1872)

SPECIAL REPORT

Emerging zoonotic diseases are a growing concern in the public health community. Of 175 species of pathogens classified as emerging, 132 (75%) are zoonotic.[1] Diseases associated with these pathogens include severe acute respiratory syndrome and avian influenza, which have emerged on a global scale, and West Nile virus and monkeypox infections, which appeared in North America over the past 10 years.[2–4] Additionally, classic disease threats such as rabies, plague, leptospirosis, and salmonellosis pose continued enzootic disease threats within the United States.[5–8] Humans have long relied on interactions with other animals for companionship, sport, and food production, but with these interactions comes the risk of zoonotic disease transmission. Veterinarians are uniquely qualified and broadly trained to help prevent the transmission of zoonotic diseases; these professionals play an important role in promoting public health through recognition and treatment of diseases in companion and food animals and through education of clients about diseases that may be transmitted from pets and livestock to humans.[9,10]

Because veterinarians are often the first to encounter potentially infected animals, they and their staff are at risk for development of zoonotic infections and may serve as

Abbreviations	
CI	Confidence interval
ICP	Infection control practice
OR	Odds ratio
PA	Precaution awareness
PPE	Personal protective equipment

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the first line of defense or as a bridge for disease entry into the human population. As reported by McQuiston and Childs,[11] results of previous studies indicate that veterinarians and animal handlers are 10 times as likely to have been exposed to *Coxiella burnetii*, the agent of Q fever, as the general population. In 1999 and 2000, the CDC received reports regarding outbreaks of multidrug-resistant *Salmonella enterica* serotype Typhimurium infections among feline and canine patients, employees, and clients of 4 small animal facilities.[12,13] Nosocomial outbreaks of salmonellosis in equine hospitals have also been reported,[14] and in recent years, methicillin-resistant *Staphylococcus aureus* has emerged as a pathogen of concern among companion animals and horses in veterinary clinical settings in the United States.[15,16] During an outbreak of monkeypox infection in the United States in 2003, veterinarians and their staff represented over 25% of affected humans.[17] In 2003, a Dutch veterinarian died of infection with H7N7 avian influenza virus after visiting an affected poultry farm and failing to take adequate protective precautions.[18] A recent finding that cats are susceptible to highly pathogenic H5N1 avian influenza virus further illustrates the vulnerability of practicing veterinarians to the emerging disease threat associated with avian influenza virus.[19]

In human medicine, prevention of pathogen transmission to health-care personnel during medical procedures is a major concern.[20,21] Unlike human medicine and dentistry, where bloodborne pathogen risks have contributed to the development and implementation of stringent infection control guidelines, standardized ICPs to prevent zoonotic disease transmission have not been widely implemented in veterinary medicine. Failure to appropriately educate staff about zoonotic disease risks can pose a substantial liability to veterinary practice owners, both from a legal and occupational health perspective. In a legal case that was settled out of court, the death of a veterinary clinic worker was attributed to leptospirosis that was likely acquired through contact with a dog that was treated at the clinic. The prosecution argued that the veterinarian had not appropriately isolated the dog and had not provided adequate education and safe work practices for clinic staff.[9] Veterinarians and staff are estimated to file occupational health claims almost 3 times as often as human health-care workers, and 77 of 2,058 (4%) claims filed by veterinarians in Germany during 2002 were in regard to infectious diseases with reported animal-to-human disease transmission.[22]

The purpose of the study of this report was to evaluate a subset of practicing veterinarians in the United States to assess the knowledge, attitudes, and practices of veterinarians with respect to ICPs as well as to facilitate an understanding of self-perceived zoonotic disease risks in veterinary practice. The survey was conducted in 2005 by the CDC in collaboration with the AVMA. Survey results were to be used to guide formulation of national recommendations to improve infection control and protect the health and welfare of the veterinary community.

Materials and Methods

Study design—A survey was conducted to assess the knowledge, attitudes, and practices of US veterinary practitioners regarding ICPs and zoonotic disease risks. The 2004 AVMA membership list, which included 69,029 practitioners grouped into 18 primary employer categories, was used to select the eligible population of veterinary practitioners. Of those AVMA members, 48,548 were listed under a primary employer code that was suggestive of clinical practice (including college or university, self-employed, self-employed practice owner, and private clinical practice employee) and were eligible to participate in the survey. Practitioners eligible for study participation were further selected from 22 possible AVMA species codes. Five codes of interest were selected for this study and collapsed into 3 categories of practice type: small animal (AVMA species code, feline practice or small animal practice; n = 29,553), large animal (AVMA species code, bovine practice exclusive or large animal all species; 2,045), and equine (AVMA species code, equine exclusive; 2,404). Although data were also collected for mixed-practice veterinarians (AVMA species code, equine or small animal, mixed practice 80% large, mixed practice 80% small, or mixed practice; n = 11,183), those data are not reported here because the types of practice varied so widely across the category.

Sample size calculations were performed in standard computer software[a] with power set at 80% and error set at 5%. Because mail surveys typically have a low response rate, surveys were mailed to more veterinarians than were needed to achieve the required power.

The survey instrument, which was created specifically for this study, was a 2-page questionnaire that was mailed to veterinarians who were randomly selected from the pool of eligible practitioners; recipients included 2,414 small animal veterinarians, 1,287 large animal veterinarians, and 1,467 equine veterinarians. An introductory letter and a postage-paid return envelope were included in the mailing. Prior to distribution of the questionnaire, AVMA members were informed about the survey through a notice printed in the *Journal of the American Veterinary Medical Association*, and a reminder postcard was mailed to all recipients approximately 4 to 6 weeks after the questionnaire was mailed. Respondents remained anonymous. Three months were allowed for responses to be returned by mail. Data were entered into a standard database for analysis. Because respondents were not identified on the questionnaires, duplication checks were performed by comparing demographic factors to ensure practitioners did not submit > 1 completed questionnaire. In some instances, respondents chose not to answer every question; unanswered questions became missing values in the analysis. Because veterinarians who provide care to small animals, large animals, and equids may each have their own unique set of risks and behaviors, results for each practice type were analyzed separately.

Assessment of ICPs—Veterinarians' knowledge, attitudes, and practices regarding use of PPE were assessed for different practice scenarios. Personal protective equipment use when handling animals with specific clinical signs or when performing certain activities was designated as appropriate or not appropriate on the basis of whether the choice of PPE would reduce exposure to known zoonotic disease agents or, in the case of blood exposures, whether the level of PPE conformed to standard guidelines practiced in human medicine.[21] Appropriate practices included the use of protective outer clothing and gloves when handling an animal that had dermatologic signs, respiratory tract signs, vomiting or diarrhea, neurologic signs, or hemorrhage. Protective outer clothing and gloves were also the minimum PPE considered appropriate during handling of feces or urine samples, collection of blood samples, and performance of an oral or rectal examination. In addition to protective outer clothing and gloves, the additional use of a surgical mask or eye protection was considered appropriate for handling products of conception or aiding in parturition, performing surgery, or performing a necropsy. The percentage of veterinarians that chose to use additional PPE in specific clinical scenarios, compared with the level of PPE used during examinations of apparently healthy animals, was explored.

Perception versus practice—Participants' responses regarding their personal concerns about the risk of infectious diseases or injuries (as presented in the questionnaire) were categorized as concerned (a perception of moderate, high, or very high risk) and not concerned (a perception of slight or no risk). Participants' perceptions about risks (ie, concerned or not concerned) were evaluated in relation to their PPE use or behavior (ie, appropriate vs not appropriate) for various exposure scenarios.

Comparisons according to PA ranking—To determine whether certain demographic characteristics were associated with poor ICPs, respondents were compared by a unique scoring system. By use of a systematic Likert point system and questionnaire responses, each respondent was assigned a score that reflected the stringency of his or her practices. A score of 0 through 4 was assigned to each response for each individual (higher scores were assigned as respondents reported behaviors more likely to protect against zoonotic disease transmission or use of additional PPE when handling animals or engaging in specific activities; **Appendix**). Scores were summed for each individual (PA score).

Within each practice type, respondents were categorized on the basis of their PA scores as being in the upper 25% or lower 75% of summed scores (designated as high or low PA ranking, respectively). A low PA score corresponded to less than ideal ICPs. Initial comparisons of characteristics between the 2 categories of respondents were made by use of logistic regression analysis; ORs and 95% CIs were calculated for the comparisons. Variables with a P value < 0.10 on initial analysis were included in a multivariate logistic regression analysis by fitting a series of hierarchical logistic models. Characteristics were retained in the final model at values of $P < 0.05$.

Results

Of the 5,168 small animal, large animal, and equine veterinarians who were sent the mailing, 2,133 (41%) returned completed questionnaires. Respondents that reported a practice type matching the category of practice described in the AVMA membership list were retained for final analysis; the final sample population of 1,842 veterinarians included 1,070 small animal veterinarians, 316 large animal veterinarians, and 456 equine veterinarians.

Demographic and clinic characteristics of the respondents by practice type were assessed (**Table 1**). The age of respondents ranged from 24 to 77 years. Among small animal veterinarians, the median age was 45 years. Median ages for large animal and equine veterinarians were 46 years and 43 years, respectively. Gender was equally distributed among small animal and equine veterinarians, but large animal veterinarians were predominantly male. A majority of veterinarians (69.0% to 88.1%) in each practice type reported working in a veterinary practice that did not have a written infection control policy. Few veterinarians (6.7% to 8.5%) reported that they had access to particulate filters (ie, N-95 respirators that filter at least 95% of airborne particles) at work, and fit-testing of available respirators was rarely undertaken. When asked about prior rabies vaccination status, > 90% of veterinarians across practice types (range, 94.4% to 97.1%) indicated they had been previously vaccinated against rabies; however, < 25% (range, 18.0% to 23.3%) reported that an anti-rabies virus antibody titer assessment had been performed within the past 2 years.

Assessment of ICPs—Veterinarians' responses to frequency of behaviors related to hand hygiene, sharps man-

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Table 1—Demographic and practice characteristics of US veterinarians in 2005 by practice type, as determined from responses to a mailed questionnaire. Data are presented as number of veterinarians (%).

	Practice type		
Variable	**Small animal**	**Large animal**	**Equine**
Demographic			
Male	508/1,068 (47.6)	255/314 (81.2)	262/455 (57.6)
Age ≥ 45 y	564/1,070 (52.7)	183/316 (57.9)	211/456 (46.3)
Practicing veterinary medicine ≥ 10 y	785/1,070 (73.4)	241/316 (76.3)	304/456 (66.7)
Owner or partner in practice	575/1,064 (54.0)	228/315 (72.4)	300/454 (66.1)
Working ≥ 40 h/wk	657/1,069 (61.5)	267/316 (84.5)	396/456 (86.8)
Board certification	68/1,065 (6.4)	34/314 (10.8)	72/453 (15.9)
Practice characteristic			
Teaching or referral hospital	61/1,065 (5.7)	32/312 (10.3)	50/449 (11.1)
Mobile services only	20/1,054 (1.9)	207/311 (66.6)	212/450 (47.1)
Clinic services only	989/1,054(93.8)	17/311 (5.5)	42/450 (9.3)
Clinic and mobile services	45/1,054 (4.3)	87/311 (28.0)	196/450 (43.6)
Practice has written infection control policy	247/797 (31.0)	35/293 (12.0)	89/399 (22.3)
Personnel have access to particulate respirator*	79/929 (8.5)	19/282 (6.7)	30/388 (7.7)
Fit of respirators has been tested	10/72 (13.9)	1/18 (5.6)	2/27 (7.4)
Vaccination status			
Vaccinated against rabies	1,016/1,063 (95.6)	303/312 (97.1)	423/448 (94.4)
Serum anti-rabies virus antibody titer assessed within preceding 2 y	228/978 (23.3)	61/289 (21.1)	73/408 (17.9)

*Specifically, N-95 respirators that filter at least 95% of airborne particles.

agement (ie, management of waste items or devices that have corners, edges, or projections capable of cutting or piercing the skin), and barrier or isolation practices were evaluated **(Table 2)**. Among small animal veterinarians, 55.2% (590/1,069) reported always washing their hands before eating, drinking, or smoking at work, and 48.4% (516/1,066) reported always washing their hands between patient contacts. In contrast, fewer large animal (31.1% [98/315]) and equine (28.1% [128/456]) veterinarians reported always washing their hands prior to eating, drinking, or smoking at work; only 18.2% of large animal (57/314) and equine (83/456) veterinarians reported always washing their hands between patient contacts. Small animal veterinarians appeared most likely to eat in animal handling areas, with only 13.8% (147/1,067) reporting that they never engaged in this behavior.

Veterinarians among all practice types reported high rates (92.0% to 98.5%) of recapping needles prior to disposal. Small animal veterinarians who reported always recapping needles prior to disposal were significantly more likely to have sustained a needlestick in the past 12 months (OR, 2.08; $P = 0.001$) than veterinarians who did not recap needles. Only 69.2% (218/315) of large animal veterinarians and 86.6% (395/456) of equine veterinarians indicated that they always used an approved container to dispose of used sharps, compared with 95.6% (1,022/1,069) of small animal veterinarians. Some veterinarians from each practice type reported recycling disposable needles or syringes intended for 1-time use, although this behavior was most common among large animal veterinarians. When dealing with an animal suspected of having a serious zoonotic disease, most small animal and equine veterinarians reported always using barrier or isolation practices, such as isolating the animal, limiting human contact with the animal, removing outerwear before examination of other patients, and sterilizing equipment that had been used on the animal of concern. Fewer than half of the large animal respondents reported always isolating the animal or limiting human contact with it.

The reported use of PPE by veterinarians for common practice scenarios was also assessed **(Table 3)**. Overall, vet-

Table 2—Behaviors that influenced infection control among US veterinarians in 2005 by practice type, as determined from responses to a mailed questionnaire. Frequency data are presented as number of veterinarians (%).

Category of behavior	Specific practice or behavior	Practice type (No. of respondents)	Reported frequency				
			Never	Seldom	Sometimes	Mostly	Always
Hand hygiene							
	Washing hands before eating, drinking, or smoking at work	SA (1,069)	2 (0.2)	17 (1.6)	55 (5.1)	405 (37.9)	590 (55.2)
		LA (315)	1 (0.3)	10 (3.2)	43 (13.7)	163 (51.8)	98 (31.1)
		E (456)	3 (0.7)	14 (3.1)	78 (17.1)	233 (51.1)	128 (28.1)
	Eating or drinking in animal handling areas	SA (1,067)	147 (13.8)	302 (28.3)	472 (44.2)	86 (8.1)	60 (5.6)
		LA (314)	65 (20.7)	117 (37.3)	110 (35.0)	17 (5.4)	5 (1.6)
		E (452)	80 (17.7)	138 (30.5)	185 (40.9)	35 (7.7)	14 (3.1)
	Washing or sanitizing hands between patient contacts	SA (1,066)	0	15 (1.4)	112 (10.5)	423 (39.7)	516 (48.4)
		LA (314)	14 (4.5)	48 (15.3)	81 (25.8)	114 (36.3)	57 (18.2)
		E (456)	2 (0.4)	49 (10.8)	136 (29.8)	186 (40.8)	83 (18.2)
Sharps management							
	Recapping of needles prior to disposal	SA (1,066)	85 (8.0)	120 (11.3)	186(17.5)	334 (31.3)	341 (32.0)
		LA (314)	9 (2.9)	15 (4.8)	32 (10.2)	108 (34.4)	150 (47.8)
		E (456)	7 (1.5)	11 (2.4)	27 (5.9)	105.(23.0)	306 (67.1)
	Disposal of needles in an approved sharps container	SA (1,069)	9 (0.8)	5 (0.5)	7 (0.7)	26 (2.4)	1,022 (95.6)
		LA (315)	11 (3.5)	10 (3.2)	14 (4.4)	62 (19.7)	218 (69.2)
		E (456)	2 (0.4)	9 (2.0)	7 (1.5)	43 (9.4)	395 (86.6)
	Sterilization and reuse of disposable needles or syringes	SA (1,069)	765 (71.6)	114 (10.7)	147 (13.8)	34 (3.2)	9 (0.8)
		LA (315)	187 (59.4)	37 (11.8)	66 (21.0)	19 (6.0)	6 (1.9)
		E (455)	385 (84.6)	26 (5.7)	27 (5.9)	11 (2.4)	6 (1.3)
Barrier or isolation practices*							
	Isolation or quarantine of the affected animal	SA (1,032)	10 (1.0)	22 (2.1)	94 (9.1)	238 (23.1)	668 (64.7)
		LA (303)	3 (1.0)	25 (8.3)	53 (17.5)	116 (38.3)	106 (35.0)
		E (437)	7 (1.6)	9 (2.1)	40 (9.2)	93 (21.3)	288 (65.9)
	Restriction of No. of people that have contact with the affected animal	SA (1,036)	12 (1.2)	20 (1.9)	58 (5.6)	281 (27.1)	665 (64.2)
		LA (303)	2 (0.7)	15 (5.0)	41 (13.5)	98 (32.3)	147 (48.5)
		E (437)	6 (1.4)	6 (1.4)	23 (5.3)	98 (22.4)	304 (69.6)
	Removal of outerwear before contact with other patients	SA (1,036)	29 (2.8)	62 (6.0)	132 (12.7)	233 (22.5)	580 (56.0)
		LA (303)	4 (1.3)	24 (7.9)	26 (8.6)	85 (28.1)	164 (54.1)
		E (437)	14 (3.2)	23 (5.3)	47 (10.8)	72 (16.5)	281 (64.3)
	Sterilization of all equipment after use on the affected animal	SA (1,033)	10 (1.0)	32 (3.1)	67 (6.5)	210 (20.3)	714 (69.1)
		LA (304)	12 (4.0)	20 (6.6)	32 (10.5)	82 (27.0)	158 (52.0)
		E (435)	8 (1.8)	11 (2.5)	23 (5.3)	78 (17.9)	315 (72.4)

*Barrier or isolation practices were those performed during management of animals suspected of having a serious zoonotic disease.
SA = Small animal. LA = Large animal. E = Equine.

Table 3—Use of PPE in common practice scenarios among US veterinarians in 2005 by practice type, as determined from responses to a mailed questionnaire. Data are presented as number of veterinarians (%).

Activity	Practice type (No. of respondents)	No special precautions taken (level 1)	Protective clothing or gloves (level 2)	Protective clothing and gloves (level 3)	Protective clothing and gloves, plus a surgical mask, goggles, or face shield (level 4)	Protective clothing, gloves, surgical mask, and goggles or face shield (level 5)	Level of PPE considered appropriate for activity's zoonotic disease transmission risk
Handling an animal that appears healthy							1 through 5
	SA (1,069)	449 (42.0)	615 (57.5)	5 (0.5)	0 (0.0)	0 (0.0)	
	LA (316)	75 (23.7)	184 (58.2)	54 (17.1)	3 (0.9)	0 (0.0)	
	E (456)	382 (83.8)	70 (15.4)	3 (0.7)	1 (0.2)	0 (0.0)	
Handling an animal with dermatologic signs							3 through 5
	SA (1,063)	219 (20.6)	654 (61.5)	189 (17.8)	1 (0.1)	0 (0.0)	
	LA (316)	27 (8.5)	122 (38.6)	164 (51.9)	3 (0.9)	0 (0.0)	
	E (453)	156 (34.4)	249 (55.0)	47 (10.4)	1 (0.2)	0 (0.0)	
Handling an animal with respiratory signs							3 through 5
	SA (1,064)	296 (27.8)	701 (65.9)	55 (5.2)	11 (1.0)	1 (0.1)	
	LA (316)	46 (14.6)	193 (61.1)	74 (23.4)	3 (0.9)	0 (0.0)	
	E (454)	225 (49.6)	163 (35.9)	64 (14.1)	3 (0.4)	0 (0.0)	
Handling an animal with gastrointestinal signs							3 through 5
	SA (1,061)	215 (20.3)	619 (58.3)	221 (20.8)	6 (0.6)	0 (0.0)	
	LA (313)	25 (8.0)	120 (38.3)	164 (52.4)	4 (1.3)	0 (0.0)	
	E (445)	89 (20.0)	123 (27.6)	223 (50.1)	8 (1.8)	2 (0.5)	
Handling an animal with neurologic signs							3 through 5
	SA (1,057)	267 (25.3)	616 (58.3)	161 (15.2)	10 (0.9)	3 (0.3)	
	LA (313)	19 (6.1)	97 (31.0)	184 (58.8)	12 (3.8)	1 (0.3)	
	E (450)	154 (34.2)	217 (48.2)	73 (16.2)	5 (1.1)	1 (0.2)	
Handling an animal with hemorrhage							3 through 5
	SA (1,062)	175 (16.5)	535 (50.4)	342 (32.2)	10 (0.9)	0 (0.0)	
	LA (313)	26 (8.3)	125 (39.9)	158 (50.5)	4 (1.3)	0 (0.0)	
	E (450)	168 (37.3)	197 (43.8)	80 (17.8)	5 (1.1)	0 (0.0)	
Handling of fecal samples							3 through 5
	SA (1,066)	73 (6.9)	527 (49.4)	462 (43.3)	4 (0.4)	0 (0.0)	
	LA (316)	8 (2.5)	91 (28.8)	213 (67.4)	4 (1.3)	0 (0.0)	
	E (451)	33 (7.3)	346 (76.7)	70 (15.5)	1 (0.2)	1 (0.2)	
Handling of urine samples							3 through 5
	SA (1,064)	183 (17.2)	601 (56.5)	277 (26.0)	3 (0.3)	0 (0.0)	
	LA (315)	22 (7.0)	122 (38.7)	167 (53.0)	4 (1.3)	0 (0.0)	
	E (448)	77 (17.2)	310 (69.2)	60 (13.4)	0 (0.0)	1 (0.2)	
Collection of blood samples							3 through 5
	SA (1,064)	402 (37.8)	645 (60.6)	16 (1.5)	1 (0.1)	0 (0.0)	
	LA (316)	66 (20.9)	157 (49.7)	90 (28.5)	3 (0.9)	0 (0.0)	
	E (454)	389 (85.7)	57 (12.6)	8 (1.8)	0 (0.0)	0 (0.0)	
Performing an oral examination							3 through 5
	SA (1,061)	325 (30.6)	612 (57.7)	121 (11.4)	3 (0.3)	0 (0.0)	
	LA (315)	38 (12.1)	124 (39.4)	149 (47.3)	4 (1.3)	0 (0.0)	
	E (451)	245 (54.3)	170 (37.7)	34 (7.5)	2 (0.4)	0 (0.0)	
Performing a rectal examination							3 through 5
	SA (1,060)	6 (0.6)	455 (42.9)	596 (56.2)	3 (0.3)	0 (0.0)	
	LA (315)	4 (1.3)	59 (18.7)	249 (79.1)	3 (1.0)	0 (0.0)	
	E (453)	2 (0.4)	333 (73.5)	117 (25.8)	1 (0.2)	0 (0.0)	
Handling products of conception or assisting with parturition							4 and 5
	SA (929)	60 (6.5)	342 (36.8)	482 (51.9)	45 (4.84)	0 (0.0)	
	LA (314)	17 (5.4)	88 (28.0)	205 (65.3)	4 (1.3)	0 (0.0)	
	E (433)	52 (12.0)	229 (52.9)	152 (35.1)	0 (0.0)	0 (0.0)	
Performing surgery							4 and 5
	SA (1,048)	1 (0.1)	33 (3.2)	159 (15.2)	786 (75.0)	69 (6.6)	
	LA (314)	4 (1.3)	39 (12.4)	220 (70.1)	50 (15.9)	1 (0.3)	
	E (440)	3 (0.7)	93 (21.1)	96 (21.8)	236 (53.6)	12 (2.7)	
Performing a necropsy or handling tissues							4 and 5
	SA (1,042)	2 (0.2)	223 (21.4)	456 (43.8)	387 (37.1)	74 (7.1)	
	LA (316)	3 (1.0)	33 (10.4)	266 (84.2)	13 (4.1)	1 (0.3)	
	E (433)	2 (0.5)	145 (33.5)	242 (55.9)	36 (8.3)	8 (1.9)	

See Table 2 for key.

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erinarians from each practice type chose to use some combination of PPE more frequently when examining an ill animal or when handling potentially infectious specimens than when handling an animal that appeared healthy. However, appropriate PPE was used by < 25% of small animal veterinarians when examining animals with dermatologic (17.9% [190/1,063]), respiratory (6.3% [67/1,064]), gastrointestinal (21.4% [227/1,061]), or neurologic signs (16.5% [174/1,057]). Among large animal veterinarians, 82.4% (263/319) and 95.6% (302/316) failed to use respiratory or eye protection when performing surgical procedures and when conducting a necropsy or handling tissues, respectively. Nearly 50% (212/445) of equine veterinarians failed to use appropriate PPE when handling an animal with diarrhea, and 84.0% (379/451) failed to use appropriate PPE when handling fecal samples. The reported frequency of use of respiratory or eye protection when aiding with parturition or handling products of conception was markedly low; < 5% of veterinarians in any of the 3 assessed practice types reported this behavior.

Perception versus practice—Veterinarians' concerns about specific zoonotic diseases were evaluated, and practices among concerned veterinarians were assessed.

Small animal veterinarians

Among the small animal veterinarian respondents, most were concerned about risks associated with ringworm organisms (71.2% [756/1,062]), gastrointestinal bacteria (38.8% [411/1,059]), gastrointestinal parasites (36.5% [388/1,063]), leptospires (33.7% [357/1,060]), rabies virus (21.5% [228/1,061]), *Toxoplasma gondii* (20.5% [218/1,061]), and unknown or emerging pathogens (20.1% [206/1,025]). Despite the stated perceptions of risk, most concerned small animal veterinarians still did not engage in use of appropriate PPE when managing animals with clinical signs suggestive of certain zoonotic illnesses. For example, 70.7% (159/225) of small animal veterinarians who were concerned about rabies did not use appropriate PPE during examination of an animal with neurologic signs; 71.2% (275/386) who were concerned about gastrointestinal parasites and 70.9% (290/409) who were concerned about gastrointestinal bacteria did not use appropriate PPE during examination of an animal that had gastrointestinal signs. Among veterinarians who were concerned about dermatophytosis, 80.6% (605/751) did not use appropriate PPE during examination of an animal with dermatologic signs.

Large animal veterinarians

Among the large animal veterinarian respondents, most were concerned about ringworm organisms (73.1% [228/312]), gastrointestinal bacteria (71.3% [223/313]), leptospires (59.0% [184/312), *Brucella* spp (36.2% [113/312]), gastrointestinal parasites (32.1% [100/312]), and rabies virus (29.1% [91/313]). Of the large animal veterinarians reportedly concerned about dermatophytosis, 43.4% (99/228) failed to use appropriate PPE during examination of an animal with dermatologic signs. In addition, 35.7% (35/98) of practitioners who were concerned about gastrointestinal parasites and 39.8% (88/221) of those concerned about gastrointestinal bacteria failed to use appropriate PPE during examination of an animal that had gastrointestinal signs. Of large animal veterinarians who were concerned about rabies, 32.2% (29/90) did not use appropriate PPE during examination of an animal with neurologic signs. Among practitioners who expressed concern about brucellosis, 99.1% (111/112) failed to use respiratory or eye protection when aiding parturition or handling products of conception.

Equine veterinarians

Among the equine veterinarian respondents, most were concerned about gastrointestinal bacteria (40.5% [182/449]) and ringworm organisms (40.3% [181/449]). However, 90.1% (163/181) of veterinarians

Table 4—Results of initial logistic regression analyses of demographic and practice characteristics among US veterinarians that had low or high PA ranking in 2005 by practice type, as determined from responses to a mailed questionnaire. On the basis of questionnaire responses, each respondent was assigned a PA score that reflected the stringency of his or her ICPs by use of a systematic Likert point system. A score of 0 through 4 was assigned to each individual (higher scores were assigned as respondents reported behaviors less likely to result in zoonotic disease transmission or use of additional PPE when handling animals or engaging in specific activities). Within each practice type, respondents were categorized on the basis of their PA scores as being in the upper 25% or lower 75% of summed scores (designated as high or low PA ranking, respectively). Data are presented as number of veterinarians (%).

	Small animal		Large animal		Equine	
Variable demographic	Low PA ranking	High PA ranking	Low PA ranking	High PA ranking	Low PA ranking	High PA ranking
Age ≥ 45 y[a]	446/820 (54.4)	118/250 (47.4)	139/234 (59.4)	44/82 (53.7)	154/343 (44.9)	57/113 (50.4)
Male[a,b]	410/818 (50.1)*	98/250 (39.2)	195/232 (84.1)*	60/82 (73.2)	197/342 (57.6)	65/113 (57.5)
Practicing veterinary medicine ≥ 10 y	605/820 (73.8)	180/250 (72.0)	181/234 (77.4)	60/82 (73.2)	225/342 (65.8)	79/112 (70.5)
No board certification[a,b,c]	774/815 (95.0)	223/250 (89.2)	212/232 (91.4)	68/82 (82.9)	294/341 (86.2)	87/112 (77.7)
Practice characteristic						
≥ 3 veterinarians in the practice	300/820 (36.6)	95/250 (38.0)	95/234 (40.6)	37/82 (45.1)	124/343 (36.2)	39/113 (34.5)
Not an owner or partner in practice	372/816 (45.6)	117/248 (47.2)	61/223 (26.2)	26/82 (31.7)	112/342 (32.8)	42/112 (37.5)
Part-time (working < 40 h/wk)	315/819 (38.5)	97/250 (38.8)	40/234 (17.1)	9/82 (11.0)	46/343 (13.4)	14/113 (12.4)
Not working at a teaching or referral hospital[a,b,c]	778/816 (95.3)	226/249 (90.8)	211/230 (91.7)	69/82 (84.2)	311/337 (92.3)*	88/112 (78.6)
Mobile services only[c]	13/810 (1.6)	7/244 (2.9)	151/229 (65.9)	56/82 (68.3)	171/340 (50.3)	41/110 (37.3)
Practice does not have a written infection control policy[a,c]	458/618 (74.1)*	92/179 (51.4)	195/217 (89.9)	63/76 (82.9)	244/296 (82.4)*	66/103 (64.1)

[a–c]Superscript letters indicate that this variable was considered significant in the initial analysis (value of $P < 0.10$) for small animal veterinarians (a), large animal veterinarians (b), and equine veterinarians (c) and was included in the multivariate model.
*Variable was associated with low PA ranking via multivariate logistic regression analysis (value of $P < 0.05$ was considered significant).

who were concerned about dermatophytosis did not use appropriate PPE during examination of an animal with dermatologic signs. Of those individuals who were concerned about gastrointestinal bacteria, approximately 33.3% (60/180) did not use appropriate PPE when handling an animal with gastrointestinal signs.

Comparisons on the basis of PA ranking—In each practice category, data for veterinarians with low PA rankings were compared with data for veterinarians with high PA rankings to determine whether certain demographic characteristics were associated with less stringent ICP (**Table 4**). On initial analysis (in which a value of $P < 0.10$ was considered significant), 5, 3, and 4 characteristics were associated with low PA ranking for small animal veterinarians, large animal veterinarians, and equine veterinarians, respectively. By use of multivariate logistic regression analysis (in which a value of $P < 0.05$ was considered significant), 2 characteristics were significantly associated with low PA ranking for small animal veterinarians: being male (OR, 1.83; 95% CI, 1.30 to 2.85; $P < 0.001$) and working in a practice that did not have a written infection control policy (OR, 2.80; 95% CI, 1.97 to 3.96; $P < 0.001$). For large animal veterinarians, only the characteristic being male remained significantly associated with low PA ranking (OR, 1.93; 95% CI, 1.06 to 3.53; $P = 0.03$). For equine veterinarians, the only variables that remained independently associated with low PA ranking were not working in a teaching or referral hospital (OR, 2.49; 95% CI, 1.18 to 5.26; $P = 0.02$) and working in a practice that did not have a written infection control policy (OR, 1.87; 95% CI, 1.03 to 3.38; $P = 0.04$).

Discussion

In the present study, the application of ICPs and perceptions of zoonotic disease risks among veterinarians engaged in clinical practice in the United States were evaluated via a survey. Results indicated that reported behaviors regarding hand hygiene, sharps management, and barrier or isolation practices as well as personal choices for PPE in common practice scenarios varied widely among practitioners. On the basis of the data collected in our study, there is evident room for improvement across practice types. For example, the present study revealed that most practitioners, particularly small animal veterinarians, reported occasionally eating or drinking in animal handling areas, a practice that carries a high risk for fecal-oral transmission of zoonotic pathogens. In addition, the percentage of respondents who reported always washing their hands prior to eating, drinking, or smoking at work was low; barely half of small animal practitioners and fewer than a third of large animal or equine practitioners reported engaging in this protective behavior. Veterinarians in all 3 categories reported even lower rates of hand washing between patient contacts. Unwashed hands pose a risk for zoonotic disease transmission to humans and for nosocomial transmission among veterinary patients. The more appropriate behaviors could be promoted by practice policies that require handwashing and that designate break rooms or eating areas separate from animal areas in clinic settings.

Veterinarians from each practice type reported greater use of PPE during examination of ill animals or when handling high-risk products, when compared with use of PPE during examination of healthy animals; however, the type of PPE used was not always appropriate to protect against transmission of likely pathogens. Many zoonotic pathogens, such as ringworm organisms and enteric bacteria and parasites, are transmitted via direct contact with contaminated body surfaces and body fluids or via a fecal-oral route involving contaminated hands or clothing. In the present study, appropriate PPE use (including wearing of protective clothing and gloves) during examination of ill animals or handling of high-risk products was reported by a small proportion of small animal and equine veterinarians. Additionally, > 95% of veterinarians from all practice types reported that appropriate respiratory or eye protection was not used when aiding an animal during parturition or when handling products of conception, despite the fact that small droplets or aerosols of body fluids (with an associated high risk for *C burnetii* and *Brucella* spp transmission) can be released during both procedures.[23,24] Large animal veterinarians also reported markedly low frequency of use of respiratory or eye protection during surgical procedures or necropsies, although these procedures also carry a risk for transmission of zoonotic diseases through contact with splashes or droplets of body fluids.

Results of our study also indicated that fewer than 25% of veterinarians with prior rabies vaccination had their serum anti-rabies virus antibody titer checked within the past 2 years, which is recommended in areas where rabies virus is enzootic in terrestrial wildlife.[25] Although the survey did not specifically capture this information, veterinarians may not be aware of national recommendations for routine assessments of anti-rabies virus antibody titers. Questionnaire responses received in the present study also indicated that veterinarians from each practice type frequently engaged in activities that increased the risk of percutaneous injury, such as recapping needles; among small animal veterinarians, there was an association between recapping needles and recent needlestick injuries. In human medicine, there is a similar association,[26] and standard precautions for human health-care workers discourage recapping of needles. In several studies[27–29] of veterinarians, rates of needlestick injuries were considered unacceptable. Results of 1 study[27] of female veterinarians indicated that 64% (1,620/2,532) of respondents reported receiving at least 1 needlestick since veterinary school graduation. Of 438 needlesticks that resulted in at least 1 adverse effect in that study, 18 (4.1%) were recorded as resulting in a severe or systemic adverse effect. One accidental self-injection directly resulted in a spontaneous abortion. Another study[28] revealed that 19 of 199 (10%) veterinarians in Wisconsin reported needlestick exposures during administration of *Mycobacterium avium* subsp *paratuberculosis* bacterin; 5 needlestick events were associated with adverse reactions. Among 23 veterinarians or veterinary students who reported accidental exposure to the brucellosis vaccine RB51, 19 (83%) reported that exposure occurred via needlestick.[29] Although infection control guidelines in human medicine emphasize protection against bloodborne pathogens, similar concerns are not widely recognized by veterinarians because few zoonotic pathogens of concern in the United States are currently considered to be bloodborne. However, several exotic zoonotic pathogens, including Ebola and Rift Valley fever viruses, are potentially transmitted through contact with blood, and the threat of emerging bloodborne pathogens should be seriously considered by the veterinary community.[30,31] In veterinary medicine, commonly reported practices, such as recapping needles or washing and reuse of needles and syringes, present an unacceptable and preventable risk for parenteral exposures to pathogens in blood samples. Education is useful in improving compliance with occupational safety guidelines that recommend never recapping needles among human health-care providers[32] and may be similarly useful in promoting appropriate ICP among veterinary practitioners.

The emergence of infections with novel influenza viruses in unexpected species, such as the recent outbreak of an equine influenza virus in dogs in the United States and detection of H5N1 avian influenza virus infection in cats in other countries, illustrates the potential for influenza viruses to infect mammalian hosts of multiple species.[19,33,34] In addition, persons who are occupationally exposed to swine are at risk for infection with influenza viruses of porcine origin, which are often more pathogenic to humans than viruses of human origin.[35,36] Because influenza viruses have a high propensity for cross-species transmission and zoonotic potential, veterinarians should be particularly vigilant for the presence of unexplained respiratory tract disease in animals. However, results of the present study indicated that veterinarians in small animal, large animal, and equine veterinary practice were unlikely to use appropriate PPE during examination of an animal with respiratory tract signs; in fact, < 20% of veterinarians from each practice type indicated that they were concerned about influenza. The fact that only 12.1% (54/445) of equine veterinarians in our study reported concern regarding influenza is especially worrisome given the recent crossover of an equine influenza virus from horses to dogs.[33] In human medicine, current recommendations for health-care workers who treat patients infected with avian or pandemic strains of influenza virus include recommendations for use of particulate respirators (N-95 respirators or those that filter > 95% of airborne particles) in situations involving direct contact with patients with pneumonia and during aerosol-generating procedures, such as resuscitation, intubation, or nebulization.[37] When caring for animals infected with zoonotic influenza virus strains, veterinarians should take similar precautions for protection. However, the findings of our study suggested that < 10% of veterinarians had occupational access to N-95 respirators. Moreover, as directed by the Occupational Safety and Health Administration,[38] the appropriate fit of N-95 respirators among personnel should be ensured (whenever the respirators are required in a workplace); yet, only a fraction of veterinarians with access to respirators had undergone the required fit-testing. These findings suggest that veterinary professionals may be inadequately prepared to implement protective measures when inhalational transmission of a zoonotic pathogen is of concern.

Although additional barriers to implementation of high-standard ICPs may not have been assessed in the present study, education for veterinarians and veterinary staff regarding appropriate ICPs is clearly needed. Via multivariate logistic regression analysis of the study data, small animal and large animal veterinarians who were male were significantly more likely to have low PA rankings indicating less than ideal ICPs. Results of some studies[39–41] indicate that in regular community settings and even health-care settings, males may be less likely to comply with handwashing recommendations than females. Findings in our study indicated that gender is associated with differences in veterinarians' approaches to ICPs; thus, educational initiatives that are tailored toward men may be warranted. Equine veterinarians who worked in teaching or referral hospitals were less likely than equine veterinarians in other practice settings to rank in the lower 25% in regard to ICPs; a similar association was not detected among small animal or large animal veterinarians. Because teaching hospitals and referral clinics are often viewed as setting the standard of care, it would be expected that appropriate ICPs would be more rigorously implemented in these facilities; however, results of the present study did not identify similar workplace-based differences among small animal and large animal practitioners.

The finding that small animal and equine veterinarians working in practices that did not have a written infection control policy were significantly more likely to have low PA rankings suggested that practice policies play an important role in influencing personal choices for ICPs among veterinarians. The availability of a written policy may serve as a resource to help educate or remind veterinarians about appropriate protective practices. In addition, practice owners who support implementation of an infection control policy may be more likely to observe and remind veterinary personnel to adhere to recommended protective practices and to provide appropriate infection control supplies (eg, gloves and gowns), thereby influencing personal choices made by their associates. In the authors' opinion, every practice (whether clinic-based or mobile) should have a written infection control policy accessible to the practice employees, and management should provide training and oversight on the implementation of the plan. Based in part on the findings from our study, the National Association of State Public Health Veterinarians developed a Compendium of Veterinary Standard Precautions in 2006 that addresses prevention of zoonotic diseases in veterinary personnel and includes a model infection control plan for veterinary practices.[42]

The results of the study of this report are subject to limitations. The study was not able to determine whether responses may have been received from veterinarians who were working in the same clinic and adhering to the same clinic policies; thus, the possibility exists that the questionnaire was received and responses provided by > 1 practitioner/practice. It is possible that the findings were subject to selection bias because only AVMA members were eligible for inclusion in the survey. However, 86% of US licensed veterinarians are estimated to be members of AVMA,[43] so the sample pool was likely more widely representative than would have been achieved through other membership lists.

Furthermore, gender distribution among respondents appeared similar to gender distributions among large animal, small animal, and equine veterinarians practicing in the United States.[44] Because the survey addressed a potentially sensitive topic (ie, personal choices regarding infection control), the demographics of veterinarians who responded may have been different from those who chose not to participate. However, some researchers suggest that persons with a higher education are more likely to return questionnaires—a factor that could minimize response bias in our study—and others suggest that response bias is minimized when response rates exceed 40%.[45,46] Although the anonymous nature of returned questionnaires makes it difficult to assess demographic differences between respondents and nonrespondents, no obvious differences in terms of geographic location of practices from which responses were received and those to which questionnaires were mailed were evident.

In the present study, we originally included veterinarians who classified themselves as mixed animal practitioners in the mailing list. However, this category was not included in our analysis because it encompassed a broad range of actual practice types. Nevertheless, many US veterinarians engage in mixed animal practice, and these veterinarians should consider their own individual practice style to determine which category (ie, small animal, large animal, and equine veterinarian) included in this report is most applicable.

Results of our study indicated a need for education and policy regarding ICPs in the veterinary profession. Adoption and implementation of specific infection control guidelines may decrease employee absence as a result of illness, increase client trust, and increase the economic performance of the clinic. Additional studies to investigate some of the primary barriers to effective ICPs, such as low perceived risk, cost of equipment, and staff inconvenience and discomfort, would be important to identify areas in which education may be useful. As emerging zoonotic diseases become increasingly prevalent, it will be imperative for the veterinary profession to adopt guidelines such as those stated in the Compendium of Veterinary Standard Precautions.[42] Distribution of information about ICPs through continuing education programs and curricula in US veterinary schools would facilitate acceptance and understanding of recommended guidelines. It would be prudent for veterinarians to take steps to protect themselves as well as their staff, clients, and patients. In doing so, the important role of the veterinary profession as a primary line of defense against the spread of zoonotic diseases will be further highlighted.

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Appendix

Scoring system used to assess behaviors of US veterinarians in 2005 (determined from responses to a mailed questionnaire) that were used to create an individual's PA ranking.

Behavior at work	Never	Seldom	Sometimes	Mostly	Always
Washing hands before eating, drinking, or smoking at work	0	1	2	3	4
Eating or drinking in animal handling areas	4	3	2	1	0
Washing or sanitizing hands between patient contacts	0	1	2	3	4
Recapping of needles prior to disposal	4	3	2	1	0
Disposal of needles in an approved sharps container	0	1	2	3	4
Sterilization and reuse of disposable needles or syringes	4	3	2	1	0
Measures taken when suspect animal has zoonotic disease	**Never**	**Seldom**	**Sometimes**	**Mostly**	**Always**
Isolation or quarantine of the animal	0	1	2	3	4
Restriction of No. of people that have contact with the animal	0	1	2	3	4
Removal of outerwear before contact with other animals	0	1	2	3	4
Sterilization of all equipment after use on the animal	0	1	2	3	4
Behavior in specific situations	**No special precautions taken**	**Protective clothing or gloves only**	**Protective clothing and gloves**	**Gloves, protective clothing, and mask or face shield**	**Gloves, protective clothing, plus mask and face shield**
Handling a healthy animal	0	1	2	3	4
Handling an animal with dermatologic signs	0	1	2	3	4
Handling an animal with respiratory signs	0	1	2	3	4
Handling an animal with gastrointestinal signs	0	1	2	3	4
Handling an animal with neurologic signs	0	1	2	3	4
Handling an animal with hemorrhage	0	1	2	3	4
Handling of fecal samples	0	1	2	3	4
Handling of urine samples	0	1	2	3	4
Handling of products of conception or assisting with parturition	0	1	2	3	4
Collection of blood sample	0	1	2	3	4
Performing an oral examination	0	1	2	3	4
Performing a rectal examination	0	1	2	3	4
Performing surgery	0	1	2	3	4
Performing necropsy or handling tissues	0	1	2	3	4