Prevalence of and risk factors for serum antibodies against *Leptospira* serovars in US veterinarians

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**Objective**—To determine the seroprevalence of antibodies against *Leptospira* serovars among veterinarians and identify risk factors for seropositivity in veterinary care settings.

**Design**—Seroepidemiologic survey.

**Study Population**—Veterinarians attending the 2006 AVMA Annual Convention.

**Procedures**—Blood samples were collected from 511 veterinarians, and serum was harvested for a microcapsule agglutination test (MAT) to detect antibodies against 6 serovars of *Leptospira*. Aggregate data analysis was performed to determine the ratio of the odds of a given exposure (eg, types of animals treated or biosafety practices) in seropositive individuals to the odds in seronegative individuals.

**Results**—Evidence of previous leptospiral infection was detected in 2.5% of veterinarians. Most veterinarians reported multiple potential exposures to *Leptospira spp* and other pathogens in the previous 12 months, including unintentional needlestick injuries (379/511 [74.2%]), animal bites (345/511 [67.5%]), and animal scratches (451/511 [88.3%]). Treatment of a dog with an influenza-like illness within the past year was associated with seropositivity for antibodies against *Leptospira spp*.

**Conclusions and Clinical Relevance**—Veterinarians are at risk for leptospirosis and should take measures to decrease potential exposure to infectious agents in general. Diagnostic tests for leptospirosis should be considered when veterinarians have febrile illnesses of unknown origin. (J Am Vet Med Assoc 2009;234:938-944)

Because of their frequent contact with multiple animal species, veterinarians are at risk of contracting zoonotic infections.\(^1\) In 2005, the CDC and the AVMA conducted a survey\(^2\) of veterinarians that included their perceived risk of acquiring zoonotic diseases. Leptospirosis was reportedly a concern for 33.7% of small animal veterinarians and 59.0% of large animal veterinarians.

Leptospirosis is a bacterial disease affecting humans and other animals. Fewer than 100 human cases of leptospirosis/y were reported in the United States from 1984 through 1994, the last year in which leptospirosis was a nationally notifiable disease.\(^3\) Symptoms may include headache, fever, myalgia, conjunctivitis, nausea, vomiting, and diarrhea or constipation.\(^4\) Infection with *Leptospira* spp ranges from subclinical to mild, influenza-like illness to serious multisystemic and hepatic disease (Weil's disease). Meningitis, meningoencephalitis, or pulmonary hemorrhage with respiratory failure may also result.\(^5\) Leptospirosis infection during pregnancy may cause abortion.\(^6\) Mild infections may also lead to future chronic disease, including chronic fatigue, neuropsychiatric symptoms, and eye infections.\(^7\)\(^8\) Leptospirosis is often not diagnosed because symptoms may be nonspecific and laboratory diagnosis is difficult.\(^9\) The mortality rate for infected humans ranges from < 5% to 30% in various parts of the world.\(^5\)

Leptospires, excreted in animal urine or tissues of parturition, can survive for weeks to months after becoming established in soil or water. Animals and humans become infected after contact with this soil or water, which may happen by ingestion of contaminated

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**ABBREVIATIONS**

<table>
<thead>
<tr>
<th>CI</th>
<th>Confidence interval</th>
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<tbody>
<tr>
<td>GHLIT</td>
<td>Group Health &amp; Life Insurance Trust</td>
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<tr>
<td>IgM</td>
<td>Immunoglobulin M</td>
</tr>
<tr>
<td>MAT</td>
<td>Microcapsule agglutination test</td>
</tr>
<tr>
<td>NVSL</td>
<td>National Veterinary Services Laboratories</td>
</tr>
<tr>
<td>OR</td>
<td>Odds ratio</td>
</tr>
</tbody>
</table>

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Supported by the O. Wayne Rollins Foundation through a grant to the Center for Public Health Preparedness and Research, Rollins School of Public Health, Emory University.

The authors thank Julie Kearney and Jeff Marshall for assistance with implementation of the study; Doris Miller-Liebl and Pamela Currin for performing laboratory tests; Susan Lance, Corrie Brown, and Christopher Woods for assistance with protocol design; Craig Greene for technical assistance; Christine Moe, Juan Leon, and Melissa Dowd for processing and storage of specimens; Colleen Spellman for data entry; and Lance Waller for assistance with the statistical analysis.

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to obtain information on participant demographics, was removed and stored at 4°C (39°F) or frozen until it
istered survey. The standardized survey was designed
experienced laboratory personnel. The serum separator
tube was centrifuged at 1,800
participant. Afterward, a 10-mL blood sample was collect-
by the Institutional Review Board at Emory University. The study protocol was reviewed and approved
rabies virus was also available to booth attendees when
determination of blood hemoglobin concentration for
 analyzes, determination of serum concentration of pros-
ting for attendees was performed at the AVMA GIILIT
143rd AVMA Annual Convention from July
practicing veterinarians, 18 years of age or older, at-
ning the 143rd AVMA Annual Convention from July

Veterinarians were asked to complete a self-admin-
reported recent exposure to zoonotic diseases, animal
specialty, clinic experience, accidental vaccination, re-
cent illness and injury, and frequency of use of personal
protective equipment and other infection control prac-
tices (eg, handwashing, not recapping needles prior to
disposal, or not eating, drinking, or smoking in animal-
handling areas). The survey and serum sample of each
participant were coded with the same unique identifier
to maintain confidentiality.

Serum antibody testing—An aliquot of each serum
sample was sent from Emory University to the Athens
Veterinary Diagnostic Laboratory at the University of
Georgia, where antibody testing was performed. An MAT
was used to detect antibodies against *Leptospira* serovars
Bratislava, Canicola, Gripotyphosa, Hardjo, Icterohaem-
orrhagiae, and Pomona, as described elsewhere.14,15 All
testing and reading of results were performed by the same
technician who had been trained and had successfully
completed the 2006 USDA NVSL proficiency testing for
the leptospirosis MAT. A cutoff titer of 1:100 was adapted
to the testing conditions of the Athens Veterinary Diag-
nostic Laboratory by standardizing the endpoint readings
with serum samples of known endpoints supplied by the
NVSL in the 2006 leptospirosis proficiency serum panel.
The MAT included 1 positive control sample of known
titer and 1 negative control sample (titer < 1:100). A par-
ticipant was considered seropositive for antibody against
*Leptospira* spp when the antibody titer against any of the
forementioned serovars was ≥ 1:100; all others were
considered seronegative.17,18,19

Subanalyses were performed on the basis of informa-
tion from other reports and results from initial analysis.
Because other researchers have used a seropositive cutoff
titer of 1:200, we also considered individuals with a se-
rum titer of 1:200 as seropositive and considered all other
veterinarians (including those with an antibody titer of
1:100) as seronegative.17 Initial laboratory findings indi-
cated that the predominant reactive serovar was Bratislava;
therefore, individuals with a 1:100 titer against any serovar
other than Bratislava were excluded from the subanalysis.
Individuals with a titer against Bratislava of ≥ 1:100 were
considered seropositive and compared with the remaining
seronegative individuals.

Participants were not informed of their results for
anti-*Leptospira* antibodies because the laboratory used for
testing is not certified through the Clinical Laboratory
Improvement Amendments program. Furthermore,
there was no anticipated clinical benefit to providing
serologic results because antibodies are indicative of
previous rather than acute or recent infection.

Statistical analyses—Data were entered into a da-
base1 and analyzed in aggregate form with commer-
cially available statistical software.2 Medians of ordinal
variables were calculated, and these variables were di-
chotomized at their medians for use in additional analy-
ses. Comparisons between seropositive and seronegative
veterinarians were evaluated with a Fisher exact test for
ordinal and dichotomous variables, and a value of \( P < 0.05 \) was considered significant.

Exact logistic regression was used to determine ORs
and 95% CIs, comparing the odds of a given exposure
among veterinarians seropositive for anti-*Leptospira*

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Materials and Methods

Study subjects—The study population was healthy, practicing veterinarians, 18 years of age or older, at-
tending the 143rd AVMA Annual Convention from July
15 through July 19, 2006, in Honolulu.

During the convention, health and wellness screen-
ing for attendees was performed at the AVMA GHLIT
wellness booth. The booth was open to all veterinar-
ians, their spouses, and veterinary students attending
the convention. Health screenings available to attend-
es included full hematologic and serum biochemical
analyses, determination of serum concentration of pros-
tate-specific antigen for males ≥ 40 years of age, and
determination of blood hemoglobin concentration for
females. Measurement of serum antibody titer against
rabies virus was also available to booth attendees when
they had not been evaluated for that titer within the last
3 years. The study protocol was reviewed and approved
by the Institutional Review Board at Emory University.

Specimen and data collection—Informed consent
and authorization under the Health Insurance Portabil-
ity and Accountability Act was acquired from each par-
ticipant. Afterward, a 10-mL blood sample was collect-
ed from each participant into a serum separator tube by
experienced laboratory personnel. The serum separator
tube was centrifuged at 1,800 \( \times g \) for 8 minutes. Serum
was removed and stored at 4°C (39°F) or frozen until it
was shipped by expedited delivery to Emory University,
where samples were stored at -70°C (-94°F).

Veterinarians were asked to complete a self-admin-
istered survey. The standardized survey was designed
to obtain information on participant demographics,
antibodies with the odds among veterinarians seronegative for anti-
Leptospira antibodies. An OR met significance when the associated P value was < 0.05, indicating that the 95% CI for the OR did not include the null value of 1.0. Variables that achieved a significance of P < 0.10 in the univariate analyses, variables that have been associated with leptospirosis in other studies, and biologically plausible variables were considered for inclusion in a multivariate logistic regression model of risk factors for seropositivity. A backward selection method was used to create the final multivariate logistic regression model, because of the small sample size, exact estimates were used for the ORs and 95% CIs.

Results

General characteristics of study veterinarians—During the AVMA Annual convention in 2006, 1,112 individuals (49.4% female) attended the AVMA GHILT wellness booth. The status of these individuals (eg, veterinarian, spouse of veterinarian, or veterinary student) was unknown. Of these, 535 (48.1%) were enrolled in the study. Twenty-four (4.5%) were excluded because their serum sample was missing, they did not have a DVM degree, or they spent ≤ 50% of their working time in clinical veterinary practice. Therefore, 511 veterinarians were ultimately included. The median age of veterinarians was 46 years (range, 25 to 81 years; interquartile range, 35 to 54 years). Two hundred fifty-seven (50.4%) veterinarians were female, and 253 (49.6%) were male. Veterinarians practiced in various geographic regions of the United States as follows: southeastern, 36.6%; western, 24.5%; midwestern, 22.9%; and northeastern, 13.9%. The remaining 2.1% of veterinarians indicated they worked outside the United States. One hundred seventy-five of 494 (35.4%) veterinarians indicated they had traveled internationally. Most veterinarians (353 [69.2%]) reported that they worked in small (companion) animal practice, followed by mixed small and large animal (105 [20.6%]), exotic animal (26 [5.1%]), equine (9 [1.8%]), food animal (including livestock and poultry; 5 [1.0%]), or another practice type (12 [2.4%]). Nearly all veterinarians reported treating dogs (479 [93.7%]) and cats (479 [93.7%]). Less than a third had treated small ruminants (164 [32.1%]), horses (163 [31.9%]), cattle (148 [29.0%]), exotic mammals (138 [27.0%]), and mammalian wildlife (121 [23.7%]). Next came swine (107 [20.9%]), exotic livestock (100 [19.6%]), and poultry (98 [19.2%]).

Thirty-three of 487 (6.8%) veterinarians believed they had contracted a zoonotic disease through their work, with most of these individuals (20 [60.6%]) reporting they were exposed through skin or mucosal surfaces. Other suspected routes of transmission were fecal-oral (7 [21.2%]), inhalation (7 [21.2%]), parenteral inoculation (1 [3.0%]), and other (5 [15.2%]). Thirty-five of 486 (7.5%) veterinarians reported having inadvertently inoculated themselves with the vaccine against Leptospira. Of the 268 of 464 (57.8%) veterinarians who reported treating an animal with leptospirosis, 86.2% reported treating a dog, 19.8% treated a cow, 3.2% treated a pig, 0.4% treated a rodent, and 3.7% treated another type of animal. The median number of animals with leptospirosis treated per year was 3 (interquartile range, 2 to 6).

In response to questions regarding general measures taken to prevent infection, most veterinarians reported sometimes or always wearing disposable gloves (86.7%), a laboratory coat or equivalent (71.0%), and a surgical mask (66.3%). Most veterinarians (94.7%) reported sometimes or always washing hands before eating, drinking, or smoking, and 96.9% reported washing hands after evaluating an animal. Fewer than half of the veterinarians (42.5%) reported sometimes or always wearing eye protection. Approximately half of the veterinarians (55.0%) reported sometimes or always eating, drinking, or smoking in animal handling areas.

Over the previous year (July 2005 to July 2006), 345 (67.5%) veterinarians were bitten by an animal such that the skin was broken at least once and 220 (43.1%) were bitten at least twice. During the same period, 411 (60.4%) veterinarians were scratched by an animal such that the skin was broken at least once and 248 (46.5%) reported at least 2 animal scratches. Most veterinarians reported at least 1 unintentional needlestick injury (379 [74.2%]) and almost half (248 [48.5%]) reported ≥ 2 in the previous year. Most veterinarians (431 [84.3%]) reported that they sometimes or always recapped needles before disposal. One hundred eighty-eight (36.8%) veterinarians reported being cut by a surgical or necropsy instrument at least once and 97 (19.0%) reported being cut ≥ 2 times within the previous year.

Serum antibody testing—Thirteen of the 511 (2.5%) participating veterinarians had a titer of ≥ 1:100 for antibody against Leptospira, and 7 veterinarians had a titer that exceeded 1:100. The most common leptospiral serovar against which serum antibodies were detected was Bratislava, which was detected in 10 veterinarians. Five of these had a titer of 1:100, 1 had a titer of 1:200, 1 had a titer of 1:400, and 3 others had a titer of 1:800. Two of the veterinarians that were seropositive for serovar Bratislava with a titer of 1:800 were also seropositive for serovar Icterohemorrhagiae (titer, 1:400). Of the remaining 3 veterinarians, one had antibody against serovar Icterohemorrhagiae (titer, 1:800), the second had antibody against serovar Hardjo (titer, 1:800), and the third had antibodies against serovars Pomona (titer, 1:200), Icterohemorrhagiae (titer, 1:800), and Grippotyphosa (titer, 1:100). None of the seropositive individuals had antibody against serovar Canicola.

Of the 13 seropositive veterinarians, 6 were female. All 13 reported treating dogs or cats in the past year, and 6 reported treating an animal with a diagnosis of leptospirosis. None of the 13 reported having a previous diagnosis of leptospirosis, and none reported having inadvertently inoculated themselves with vaccine against Leptospira (Table 1). Although 1 of 494 (0.2%) veterinarians reported having a previous diagnosis of leptospirosis, this individual was not seropositive at the time of testing.

Factors associated with a serum anti-Leptospira antibody titer of ≥ 1:100—Results of univariate analyses indicated that, among the 511 participating veterinarians, neither gender nor primary type of practice was associated with an anti-Leptospira antibody titer ≥ 1:100 (Table 1). With the exception of a report of
Table 1—Results of univariate exact logistic regression analyses of factors potentially associated with seropositivity for anti-Leptospira antibodies in US veterinarians.

<table>
<thead>
<tr>
<th>Variable*</th>
<th>No. (%) seropositive</th>
<th>No. (%) seronegative</th>
<th>OR</th>
<th>95% CI</th>
<th>Pvalue†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 46 y vs ≤ 45 y (511)</td>
<td>7 (53.8)</td>
<td>242 (46.6)</td>
<td>1.23</td>
<td>0.35-4.51</td>
<td>0.93</td>
</tr>
<tr>
<td>Female vs male (510)</td>
<td>6 (46.2)</td>
<td>251 (50.5)</td>
<td>0.84</td>
<td>0.23-2.97</td>
<td>0.98</td>
</tr>
<tr>
<td>Type of practice (510)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small animal</td>
<td>7 (53.8)</td>
<td>346 (69.5)</td>
<td>1.00</td>
<td>—</td>
<td>Ref</td>
</tr>
<tr>
<td>Mixed</td>
<td>5 (38.5)</td>
<td>100 (20.1)</td>
<td>2.47</td>
<td>0.60-9.25</td>
<td>0.23</td>
</tr>
<tr>
<td>Equine</td>
<td>1 (7.7)</td>
<td>8 (1.6)</td>
<td>6.11</td>
<td>0.12-58.27</td>
<td>0.37</td>
</tr>
<tr>
<td>Exotic animal</td>
<td>0 (0)</td>
<td>5 (1.0)</td>
<td>7.66</td>
<td>0-63.96</td>
<td>1.00</td>
</tr>
<tr>
<td>Food animal</td>
<td>0 (0)</td>
<td>26 (5.2)</td>
<td>1.41</td>
<td>0-9.75</td>
<td>1.00</td>
</tr>
<tr>
<td>Other</td>
<td>0 (0)</td>
<td>12 (2.4)</td>
<td>3.08</td>
<td>0-22.43</td>
<td>1.00</td>
</tr>
<tr>
<td>Type of animal treated (511)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dogs</td>
<td>13 (100)</td>
<td>466 (93.6)</td>
<td>1.24</td>
<td>0.20-∞</td>
<td>0.85</td>
</tr>
<tr>
<td>Cats</td>
<td>13 (100)</td>
<td>466 (93.6)</td>
<td>1.24</td>
<td>0.20-∞</td>
<td>0.85</td>
</tr>
<tr>
<td>Ferrets</td>
<td>7 (53.6)</td>
<td>276 (55.8)</td>
<td>0.92</td>
<td>0.26-3.36</td>
<td>1.00</td>
</tr>
<tr>
<td>Rabbits</td>
<td>6 (46.2)</td>
<td>323 (64.9)</td>
<td>0.47</td>
<td>0.13-1.64</td>
<td>0.27</td>
</tr>
<tr>
<td>Horses</td>
<td>6 (46.2)</td>
<td>157 (31.5)</td>
<td>0.86</td>
<td>0.51-6.58</td>
<td>0.41</td>
</tr>
<tr>
<td>Cattle</td>
<td>5 (38.5)</td>
<td>143 (28.7)</td>
<td>1.55</td>
<td>0.39-5.48</td>
<td>0.63</td>
</tr>
<tr>
<td>Wildlife</td>
<td>4 (30.8)</td>
<td>117 (23.5)</td>
<td>1.45</td>
<td>0.32-5.30</td>
<td>0.74</td>
</tr>
<tr>
<td>Small ruminants</td>
<td>4 (30.8)</td>
<td>160 (32.1)</td>
<td>0.94</td>
<td>0.21-3.43</td>
<td>1.00</td>
</tr>
<tr>
<td>Reptiles</td>
<td>4 (30.8)</td>
<td>149 (29.9)</td>
<td>1.04</td>
<td>0.23-3.80</td>
<td>1.00</td>
</tr>
<tr>
<td>Pocket pets</td>
<td>4 (30.8)</td>
<td>315 (63.3)</td>
<td>0.26</td>
<td>0.06-0.94</td>
<td>0.04</td>
</tr>
<tr>
<td>Exotic mammals</td>
<td>4 (30.8)</td>
<td>134 (26.9)</td>
<td>1.21</td>
<td>0.27-4.41</td>
<td>0.97</td>
</tr>
<tr>
<td>Exotic livestock</td>
<td>3 (23.1)</td>
<td>97 (19.5)</td>
<td>1.24</td>
<td>0.22-4.94</td>
<td>0.97</td>
</tr>
<tr>
<td>Avian (nonpoultry) species</td>
<td>3 (23.1)</td>
<td>166 (33.3)</td>
<td>0.60</td>
<td>0.11-2.37</td>
<td>0.65</td>
</tr>
<tr>
<td>Swine</td>
<td>2 (15.4)</td>
<td>105 (21.1)</td>
<td>0.68</td>
<td>0.07-3.19</td>
<td>0.93</td>
</tr>
<tr>
<td>Poultry</td>
<td>2 (15.4)</td>
<td>96 (19.3)</td>
<td>0.76</td>
<td>0.08-3.58</td>
<td>1.00</td>
</tr>
<tr>
<td>Symptoms in previous month (511)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flu-like symptoms</td>
<td>3 (23.1)</td>
<td>36 (7.2)</td>
<td>3.83</td>
<td>0.65-15.80</td>
<td>0.14</td>
</tr>
<tr>
<td>Headache</td>
<td>11 (84.6)</td>
<td>261 (52.4)</td>
<td>4.98</td>
<td>1.07-46.71</td>
<td>0.04</td>
</tr>
<tr>
<td>Muscle aches</td>
<td>6 (46.2)</td>
<td>132 (26.5)</td>
<td>2.37</td>
<td>0.65-8.41</td>
<td>0.21</td>
</tr>
<tr>
<td>Fever</td>
<td>2 (15.4)</td>
<td>23 (4.5)</td>
<td>3.74</td>
<td>0.38-18.70</td>
<td>0.26</td>
</tr>
<tr>
<td>Lethargy</td>
<td>5 (38.5)</td>
<td>67 (17.5)</td>
<td>2.94</td>
<td>0.74-10.49</td>
<td>0.13</td>
</tr>
<tr>
<td>Vague</td>
<td>3 (23.1)</td>
<td>74 (14.9)</td>
<td>1.72</td>
<td>0.50-6.88</td>
<td>0.62</td>
</tr>
<tr>
<td>Vomiting</td>
<td>2 (15.4)</td>
<td>17 (3.4)</td>
<td>5.11</td>
<td>0.51-26.36</td>
<td>0.16</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>2 (15.4)</td>
<td>123 (24.7)</td>
<td>0.55</td>
<td>0.06-2.59</td>
<td>0.69</td>
</tr>
<tr>
<td>Conjunctivitis</td>
<td>1 (7.7)</td>
<td>22 (4.4)</td>
<td>1.80</td>
<td>0.04-13.24</td>
<td>0.91</td>
</tr>
<tr>
<td>Liver</td>
<td>0 (0)</td>
<td>2 (0.4)</td>
<td>5.00</td>
<td>0-274.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Other symptoms</td>
<td>0 (0)</td>
<td>11 (2.2)</td>
<td>2.50</td>
<td>0-16.82</td>
<td>1.00</td>
</tr>
<tr>
<td>Fever &gt; 37.8°C (100°F) in past year (511)</td>
<td>5 (38.5)</td>
<td>171 (34.3)</td>
<td>1.19</td>
<td>0.30-4.22</td>
<td>0.97</td>
</tr>
<tr>
<td>Treated dog with influenza-like illness in past year (511)</td>
<td>12 (92.3)</td>
<td>328 (65.9)</td>
<td>6.20</td>
<td>0.90-267.41</td>
<td>0.07</td>
</tr>
<tr>
<td>Believed contracted zoonotic disease within the past year (487)</td>
<td>0 (0)</td>
<td>33 (6.9)</td>
<td>0.81</td>
<td>0-5.07</td>
<td>0.85</td>
</tr>
<tr>
<td>Routine contact with water (river, stream, ocean, lake, pond, ditch, sewage, or other; 492)</td>
<td>7 (63.8)</td>
<td>330 (68.9)</td>
<td>0.53</td>
<td>0.15-1.93</td>
<td>0.39</td>
</tr>
<tr>
<td>Ever inadvertently inoculated with vaccine against Leptospira (486)</td>
<td>0 (0)</td>
<td>35 (7.7)</td>
<td>0.79</td>
<td>0-5.03</td>
<td>0.84</td>
</tr>
<tr>
<td>Ever treated animal with leptospirosis (464)</td>
<td>6 (50.0)</td>
<td>262 (58.0)</td>
<td>0.73</td>
<td>0.19-2.76</td>
<td>0.79</td>
</tr>
<tr>
<td>Type of animal treated for leptospirosis (268)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dog</td>
<td>4 (66.7)</td>
<td>227 (88.6)</td>
<td>0.31</td>
<td>0.04-3.55</td>
<td>0.30</td>
</tr>
<tr>
<td>Cow</td>
<td>2 (33.3)</td>
<td>51 (19.5)</td>
<td>2.06</td>
<td>0.18-14.84</td>
<td>0.68</td>
</tr>
<tr>
<td>Swine</td>
<td>0 (0)</td>
<td>14 (5.34)</td>
<td>2.22</td>
<td>0-16.53</td>
<td>1.00</td>
</tr>
<tr>
<td>Rodent</td>
<td>0 (0)</td>
<td>1 (0.4)</td>
<td>43.70</td>
<td>0-1703.0</td>
<td>1.00</td>
</tr>
<tr>
<td>Other type of animal</td>
<td>0 (0)</td>
<td>10 (3.8)</td>
<td>3.19</td>
<td>0-24.40</td>
<td>1.00</td>
</tr>
<tr>
<td>Traveled internationally within past year (494)</td>
<td>5 (38.5)</td>
<td>170 (35.3)</td>
<td>1.14</td>
<td>0.29-4.04</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*Within this column, values in parentheses represent total number of veterinarians. †A value of P < 0.05 was considered significant in univariate analyses.

— = Not applicable. Ref = Referent group.

Seropositivity was defined as an antibody titer of 1:100 against any leptospiral serovar.
a headache, those with anti-Leptospira antibodies were no more likely to have been symptomatic in the previous month than other veterinarians. International travel within the past year was not an independent risk factor for seropositivity. A greater proportion of seropositive veterinarians reported treating a dog with an influenza-like illness in the past year, compared with the proportion of seronegative veterinarians, although the difference was not significant. Treatment of pocket pets was the only factor significantly associated with seropositivity.

Being bitten or scratched by an animal, having received an unintentional needlestick injury, or being cut by a surgical or necropsy instrument did not increase the odds of leptospiral seropositivity (data not shown). There were no associations between reported biosafety practices and use of personal protective equipment and seropositivity (data not shown).

On the basis of results of the univariate analyses, a full multivariate model was created, including the variables treatment of pocket pets and treatment of a dog with influenza-like illness in the past year. Because report of a headache within the month prior to the survey lacked clinical specificity for previous Leptospira infection, it was not included. Results of the multivariate model indicated that treatment of pocket pets (OR, 0.21; 95% CI, 0.05 to 0.76; \( P = 0.01 \)) and treatment of a dog with influenza-like illness in the past year (OR, 8.21; 95% CI, 1.17 to 358.00; \( P = 0.03 \)) were significant predictors of a positive antibody response to Leptospira.

Factors associated with a serum anti-Leptospira antibody titer of \( \geq 1:200 \)—Eight (1.6%) veterinarians had a high antibody titer (\( \geq 1:200 \)). All 8 (100%) reported that they had treated a dog with influenza-like illness in the past year, compared with 332 of 503 (66.0%) seronegative veterinarians (including the 5 veterinarians with antibody titers of 1:100; \( P = 0.08 \)). Seven (87.5%) veterinarians with a high antibody titer were \( \geq 46 \) years of age, compared with 242 (48.1%) seronegative veterinarians (\( P = 0.06 \)). Three (37.5%) veterinarians with a high antibody titer reported influenza-like symptoms in the past month, compared with 36 (7.2%) seronegative veterinarians (exact OR, 7.72; 95% CI, 1.15 to 41.5; \( P = 0.04 \)). One (12.5%) veterinarian with a high antibody titer reported treating pocket pets, whereas 318 (63.2%) seronegative veterinarians (exact OR, 0.083; 95% CI, 0.002 to 0.658; \( P = 0.01 \)) reported the same thing.

Factors associated with a serum antibody titer of 1:100 against Bratislava—Ten (2.0%) veterinarians had a serum antibody titer of 1:100 against Leptospira serovar Bratislava. Of various influenza-like symptoms, only headache was significantly associated with seropositivity for Bratislava (exact OR, 8.15; 95% CI, 1.11 to 359.68; \( P = 0.03 \)).

**Discussion**

In the present study of veterinarians attending the 143rd AVMA Annual Convention in 2006, 13 of 511 (2.5%) veterinarians had evidence of previous leptospiral infection. Other estimates of the seroprevalence of leptospirosis include 1.8% among all practicing veterinarians in Illinois between 1956 and 1972, \(^2^2\) 1% among veterinarians in New Zealand in 1974, \(^2^3\) and 2.9% among Austrian veterinarians in 1994. \(^2^4\) We might have expected fewer leptospirosis infections given advances in and greater use of vaccines against Leptospira in veterinary medicine. At the same time, there are reports \(^1^1,^1^2\) of increases in leptospiral infections in wild animals in the United States and a concomitant increase in infections in domestic animals, particularly dogs.

The first veterinary vaccine, developed for dogs in the 1950s, protected against Leptospira serovars Icterohaemorrhagiae and Canicola. The first trivalent vaccine containing distemper virus, infectious canine hepatitis virus, and Leptospira serovar Canicola for dogs was licensed in 1961. \(^2^5\) In 2000, a new leptospirosis vaccine was introduced, which included not only Leptospira serovars Icterohaemorrhagiae and Canicola but also Pomona and Griptotyphosa, to address emerging changes in the distributions of infections by the various serovars. \(^2^6\) In the study reported here, 10 of 13 seropositive veterinarians had antibody against Leptospira serovar Bratislava, which is not included in the canine vaccine. This serovar predominantly infects pigs and horses but has been associated with illness in dogs as well. \(^4^,^1^6\)

Four of the 13 seropositive veterinarians in the present study had antibody against Leptospira serovar Icterohaemorrhagiae, which has been included in the canine vaccine since original production. \(^2^7\) Rodents are the primary reservoir of this serovar, and they may serve as a source of infection for humans as well as other animals. \(^1^6\)

Only 1 veterinarian had antibodies against Leptospira serovars Pomona and Griptotyphosa, and none were seropositive for antibodies against Canicola. Because dogs are the primary reservoir for Leptospira serovar Canicola, \(^1^8\) and this serovar has been included in the old and new vaccines used in dogs, our results were not surprising. Vaccinated animals may still become subclinically infected and shed leptospires in their urine. \(^4^,^2^6,^2^9\) The American Animal Hospital Association Canine Vaccine Task Force has recommended that vaccination of dogs against Leptospira be limited to use in areas where there is a reasonable risk of exposure, primarily because of lack of information on prevalence of various serovars in different geographic areas as well as the risk of postvaccination reactions. \(^3^0\) In cows, sheep, and pigs, annual vaccinations against Leptospira are recommended for confined animals, whereas semiannu-al vaccination should be considered for open herds. \(^3^1\)

There are several rapid serologic assays for the diagnosis of leptospirosis. These include the slide agglutination assay, \(^3^2\) indirect hemagglutination assay, \(^3^3\) MAT, \(^3^4\) immunofluorescence assay, \(^3^5\) ELISA for IgM, \(^3^6,^3^7\) IgM dot-ELISA, \(^3^8\) and IgM dot-ELISA dipstick test. \(^3^9\) Limitations of these assays include low sensitivity in subjects tested during the first week of illness (whole-cell based serologic assays), the requirement for specialized laboratory equipment such as a fluorescence microscope (immunofluorescence assay), the need for skilled personnel to perform the assay (ELISA), and the inability to detect the infecting serogroup. The gold standard is the MAT, with a sensitivity of 98.2% (95% CI, 95.8% to 100.6%) and specificity of 96.4% (95% CI, 94.2).
to zoonotic pathogens such as Leptospira spp may be putting themselves at risk for exposure. 

There is a possibility that the proportion of veterinarians who were exposed to Leptospira during their lifetime was greater than the proportion that we detected. Additionally, we only tested for antibodies against 6 leptospiral serovars. If we had tested for antibodies against a broader spectrum of serovars, we may have detected a higher seroprevalence than we did. Cross-reaction between serovars may also have occurred.

As of December 31, 2006, there were 81,468 veterinarians practicing in the United States, 47.1% of whom were female. This percentage is similar to our study sample, in which 50% of veterinarians were female. The proportion of veterinarians in our study who worked with small animals (69%) was similar to that of the general veterinarian population in the United States (66%); however, the proportion of veterinarians who worked at mixed animal practices was not (21% in our study vs 7.8% in the whole United States). Given these findings, caution should be used when attempting to generalize our results to the US population of veterinarians.

Treatment of pocket pets and dogs with influenza in the previous year were the only factors significantly associated with leptospiral seropositivity when multivariate analysis was performed in the present study. The protective association with pocket pets was either spurious or related to other characteristics of small animal veterinarians that were not measured. For example, veterinarians who treated pocket pets may have been more likely to work in urban areas and may consequently have been less likely to have come in contact with animals infected with Leptospira.

Veterinarians who treated dogs with influenza-like illness in the previous year were more likely to have an antibody response to the Leptospira spp serovars evaluated. Some signs of leptospirosis and influenza-like illness in dogs are similar. Dogs with leptospirosis may have nonspecific signs including fever, depression, lethargy, anorexia, arthralgia or myalgia, and ocular nasosal discharge. As the disease progresses, clinical signs may include vomiting, dehydration, lumbar pain from renomegaly and nephritis, tongue-tip ulceration and necrosis, intussusception, pulmonary hemorrhage, uveitis, pneumonitis, chronic hepatitis, and reproductive failure. Influenza-like illness in dogs may also be evident as fever, nasal discharge, and persistent cough. The similarity between the signs of leptospirosis and those of influenza-like illness suggests that veterinarians treating ill dogs may be putting themselves at risk for exposure to zoonotic pathogens such as Leptospira.

The potential for the veterinarians in our study to have been exposed to zoonotic pathogens is remarkable. Indeed, 74.2% of 311 participating veterinarians reported an unintentional needlestick injury at least once in the past year. In 1998 and 1999, the frequency of needlestick injuries was reportedly 0.43/person/y among companion animal veterinarians and 2.03/person/y among large animal veterinarians. Most veterinarians (84.3%) in our study reported that they sometimes or always recapped needles before disposal, a known risk factor for pathogen transmission in veterinary settings. Another study revealed similar findings in that 63% of veterinarians mostly or always recapped needles prior to disposal. This practice has been regulated in human medicine through the implementation of the Bloodborne Pathogens Regulation (1910.1030) since 1992, the practice has been discouraged in veterinary animal medicine since 2006. Thus, veterinarians should be encouraged to always dispose of uncapped needles in an approved sharps container. In another study, <5% of veterinarians reported wearing appropriate respiratory or eye protection when handling products of conception and only 6.3% of small animal veterinarians reported wearing appropriate personal protective equipment when examining an animal with respiratory signs. In the present study, frequency of use of personal protective equipment was poor, yet most veterinarians reported treating an animal with a diagnosis of leptospirosis. Although no association was evident between lack of protective equipment use and evidence of leptospiral infection, this may have been attributable to the fact that most veterinarians did not use such protection; thus, the power to detect an association was limited. It is essential that personal protective equipment such as gloves, barrier gowns, and eye protection be worn when handling animals with leptospirosis or products (eg, urine or tissue) from animals suspected of having leptospirosis. In the event of a high-risk exposure (eg, direct contact with urine or blood from an infected animal via mucosal membranes or broken skin), the World Health Organization recommends postexposure prophylaxis with doxycycline.

Although it is impossible to eliminate the occupational risk of exposure to zoonotic pathogens in veterinary practice, the risk of infection can be mitigated through early recognition and appropriate management of infected or potentially infected animals, use of good personal hygiene and personal protective equipment, avoidance of recapping needles, as well as proper animal handling and housing. The Compendium of veterinary standard precautions: zoonotic disease prevention in veterinary personnel provides valuable information and guidelines for the prevention of the transmission of zoonotic pathogens from animals to veterinary personnel.

References

