# Characterization of leptospirosis among dogs in Oregon, 2007–2011

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**OBJECTIVE**
To characterize the demographics, exposure risks, and outcomes for dogs with leptospirosis in Oregon between 2007 and 2011 and to identify geographic and temporal distributions of known cases of canine leptospirosis within the state during this period.

**DESIGN**
Retrospective descriptive epidemiological study.

**ANIMALS**
72 dogs.

**PROCEDURES**
Reports of laboratory tests for leptospirosis and zoonosis reporting forms voluntarily submitted by veterinarians to the Oregon Health Authority were evaluated to identify dogs with leptospirosis during the study period; data were also collected by examination of medical records or by telephone surveys with veterinarians from reporting facilities.

**RESULTS**
72 confirmed cases of leptospirosis were identified; surveys were completed for 65 cases. Seasonal and spatial distributions coincided with rainfall patterns for the state, with most cases diagnosed in the spring and in the western part of the state. Common exposure risks included contact with water in the environment (14/65) and contact with wildlife (14); 33 dogs had no history of known exposure risks. Among dogs with other conditions at the time of diagnosis (26/64), dermatitis, otitis, or both were the most commonly reported findings (9/26). Of 65 dogs, 44 recovered, 12 died or were euthanized because of leptospirosis, and 9 were lost to follow-up.

**CONCLUSIONS AND CLINICAL RELEVANCE**
Distribution of canine leptospirosis cases in Oregon fit the rainfall theory pattern. Dermatologic conditions were present in 9 of 64 (14%) dogs that had a diagnosis of leptospirosis; however, further investigation is needed to determine whether such conditions predispose dogs to the disease. (*J Am Vet Med Assoc* 2016;248:908–915)

Leptospirosis is considered to be the most widespread and prevalent zoonosis in the world.[1] The disease affects all mammals and is maintained in reservoir hosts that excrete the organisms in urine. Dogs and cattle, as well as wildlife species such as rats, sea lions, and raccoons, can serve as reservoirs for leptospirosis and may facilitate transmission through direct contact with urine or contamination of water.[2] Many reservoir hosts transmit the organisms without developing clinical signs,[3] but in some species that can act as reservoirs, such as dogs and sea lions, individual animals may become ill.[4,5] Infections in dogs and humans are usually associated with contact with infected animals or contaminated water.[6,7]

**ABBREVIATIONS**
MAT Microscopic agglutination test

More than 250 pathogenic serovars of the genus *Leptospira* have been identified,[8] although the serovars that cause illness vary among different species of animals and geographic locations. Of the 12 pathogenic serovars identified in canine infections, serovars Canicola, Grippotyphosa, Icterohemorrhagiae, Pomona, Bratislava, and Autumnalis have been most commonly associated with clinical illness in North America, although the identification of these serovars in most studies[3,7,9,10] was made through use of the MAT, a test in which different serovars can cross-react. Reservoirs for these serovars include pigs (Bratislava and Pomona), horses (Bratislava), skunks and opossums (Grippotyphosa and Pomona), and voles and raccoons (Grippotyphosa).[11] Dogs can act as reservoirs for the serovar Canicola, whereas rats serve as a reservoir for the Icterohemorrhagiae and Autumnalis serovars.[9]

Because of the similar types of exposure risks for leptospirosis in dogs and people, dogs can serve as



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an important sentinel species for human infection.[7,12] The organisms can be transmitted from dogs to humans, although this appears to be uncommon,[5] even among owners and veterinary staff caring for dogs with active leptospirosis.[13] Increased incidence of leptospirosis in dogs has been associated with outbreaks in other species, including marine mammals.[14]

In several studies, the Pacific Northwest has emerged as a geographic focus for leptospirosis in dogs. A study[15] in which investigators examined laboratory submissions for leptospirosis testing of dogs from various parts of the United States between 2000 and 2007 found a spatial clustering of seropositivity for leptospirosis among dogs in Oregon. A high number of canine leptospirosis cases was identified in the state of Washington from 2004 through 2006, and this outbreak prompted a study[16] to investigate the seroprevalence of anti-*Leptospira* antibodies in healthy dogs and in a convenience sample of injured raccoons in that state. The results revealed high serum antibody titers for 27 of 158 (17.1%) of the healthy dogs and 22 of 115 (19.1%) of the raccoons tested. The outbreak in dogs in Washington state occurred in the western part of the state, as did 3 cases of leptospirosis in people during the same time period,[16] supporting the concept of the usefulness of dogs as sentinels for human leptospirosis. In a retrospective histopathologic study[17] performed to evaluate renal tissues of raccoons from Oregon (as well as 4 other geographic locations in the United States), the kidneys of 15 of 86 (17%) raccoons from Oregon had interstitial nephritis, and leptospires were identified in kidneys from 3 of the 15 affected animals.

The objective of the study reported here was to characterize the demographics, exposure risks, and outcomes for dogs with leptospirosis in Oregon between 2007 and 2011 to build on previous studies; we also sought to describe the geographic and temporal distributions of known cases of canine leptospirosis in Oregon during this period.

# Materials and Methods

## Initial screening

Potential cases of canine leptospirosis were compiled from 2 sources. The first source comprised reports to the Oregon Health Authority of results of laboratory tests for leptospirosis performed by veterinary diagnostic laboratories from January 1, 2007, through December 31, 2011. Laboratory reports contained information on age, sex, and breed of patients as well as location (city and county), date of testing, and test results, including measurement of titers for antibodies against specific serovars if the test was an MAT. The second source came from the voluntary reporting of cases of leptospirosis by veterinarians to the Oregon Health Authority during the same period. Reporting by veterinarians was done through a zoonosis reporting form available through the state health authority. Information solicited on the form included the name of the reporting veterinarian; date of the patient's onset of illness; diagnosis; name of the laboratory where testing was performed; type of test or tests done; test results; signalment, including reproductive status (sexually intact or neutered) of the animal; and the city, county, and zip code of the address where the animal was housed. Laboratory reports were examined to assess correspondence between laboratory tests and veterinarian reports.

## Survey administration

Following identification of cases for potential study inclusion through veterinarian and laboratory reports, veterinarians were contacted by telephone, and a questionnaire[a] was administered to verify information obtained from the state's reporting site for each case and gain additional information about the patient. The Institutional Review Board at the University of Iowa determined that this study did not require review by the Board. Data collected included information on patient signalment; county and type of residence (rural, urban, or suburban); dates of first evaluation (for any reason), leptospirosis testing, and onset of illness related to the report; age at onset of illness; testing laboratory, types of tests performed (including serovar identification if applicable), and test results; history of vaccination against leptospirosis; extent of time for which medical records were available; underlying medical conditions and medications being administered at the time of leptospirosis testing; any history of known exposure risk; clinical signs; and patient outcome. Information regarding any known related cases of leptospirosis in the same household or among patient contacts was also collected, and veterinarians were asked their opinion on whether the patient had leptospirosis.

Surveys were administered to the veterinarian who managed the case or, if that person was no longer employed by the practice, to another veterinarian at the practice who reviewed the patient's medical records. All surveys were administered by 1 interviewer (SEG). Some veterinarians chose to send a copy of the medical record rather than complete a survey, and these were not excluded from the study.

## Case selection and data compilation

Only dogs residing in Oregon that had a diagnosis of leptospirosis made by a veterinarian practicing in Oregon between January 1, 2007, and December 31, 2011, and met the case definition were included in the study. Case dogs were defined as those with clinical signs and clinicopathologic findings consistent with active leptospirosis infection (azotemia or serum hepatic enzyme activities above upper limit of the laboratory reference range); positive PCR assay results for a blood or urine sample, a documented ≥ 4-fold increase in serum antibody titers against ≥ 1 *Leptospira* serovar identified through paired tests, or a single serum antibody titer ≥ 1:800 via MAT[7,18] was also required. Dogs for which labora-



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tory testing involved a single MAT additionally had to have a documented medical history that extended back ≥ 1 year and did not include any vaccination against leptospirosis during the year prior to testing. Dogs were excluded from the study if they resided outside of Oregon, if they had received a leptospirosis vaccine in the year prior to their illness and had been tested with a single MAT, or if the medical records were not sufficient to establish a vaccination history in the year prior to diagnosis and the dog had been tested with a single MAT. Additionally, patients were excluded if they had only a single serum antibody titer on record and they had a concurrent medical condition that could account for their illness.

## Data analysis

Data were maintained and evaluated with commercially available spreadsheet software.[b] Descriptive statistics were reported. Categorical variables were described with frequency and percentages.

Demographic analysis for dogs with leptospirosis included sex (male [sexually intact or castrated] or female [sexually intact or spayed]) and age (categorized as < 2 years, 2 to < 6 years, 6 to < 10 years, or ≥ 10 years). Cutoffs for age categories were arbitrarily chosen to create 4 age groups approximately corresponding to those in other studies,[10,13,18,19] although no consistent agreement on age groupings was found among studies on canine leptospirosis. Other assessments included home environment (rural or nonrural), county of residence, possible exposure risks in the 2 weeks prior to illness (contact with water in the environment, wildlife, or animal carcasses; travel; roaming loose; or no known history of possible exposures), patient outcome (fully recovered, recovered with continuing medical issues, was euthanized, or died), underlying medical conditions, and clinical signs reported on initial examination of the patient. Analysis of the proportions of different serovars identified by MAT was also conducted, with the highest antibody titer measured used to designate the presumed serovar infecting the dog. In cases where a second serum antibody titer revealed a 4-fold increase from the previous value, the serovar for which the greatest increase in titer was found was assumed to be the infecting serovar. If the highest antibody titer or titer increase was found for > 1 serovar, all applicable serovars were included in the analysis.

Cases were grouped by month and year of diagnosis to examine seasonal patterns (with meteorologic divisions used to define the start of spring [March 1], summer [June 1], fall [September 1], and winter [December 1]) and temporal patterns of leptospirosis for dogs in Oregon. Geographic mapping was used to characterize the distribution of the disease in dogs throughout Oregon by county of residence.

# Results

The records review initially identified 147 dogs that were tested for leptospirosis during the study period. Of the 147 potential cases, surveys were completed for only 113 dogs; for the remaining 34 dogs, a medical record was not available, the dog resided outside of Oregon, or the veterinarian declined to participate in the survey. Of the 113 dogs for which surveys were completed, 39 were excluded because they did not meet the case definition and 9 were excluded because there was not sufficient information available to make a determination on case criteria; 65 were included in the study. Another 7 dogs had case criteria met without collection of survey information, so that 72 dogs with confirmed cases of leptospirosis were included in the retrospective study. Twenty-nine of these dogs had positive results for a PCR assay and were ill; 13 had a ≥ 4-fold increase in anti-*Leptospira* sp or spp antibody titers and were ill; and 30 were ill, had a single anti-*Leptospira* sp antibody titer of ≥ 1:800, and had not been vaccinated in the previous year.

By year of diagnosis, 2007, 2008, and 2011 had similar numbers of cases (n = 17, 17, and 16, respectively), with a somewhat smaller number of confirmed cases identified for 2009 (n = 10) and 2010 (12). Most cases were reported during spring (n = 30), with the greatest numbers identified in March (10) and April (14). The smallest number of cases was reported during summer (n = 11), but infections with leptospirosis were diagnosed in every month of the year **(Figure 1)**.

The spatial distribution of cases of leptospirosis in Oregon was determined with data from reports and answers to survey questions to determine the county of residence of the dogs with leptospirosis **(Figure 2)**.

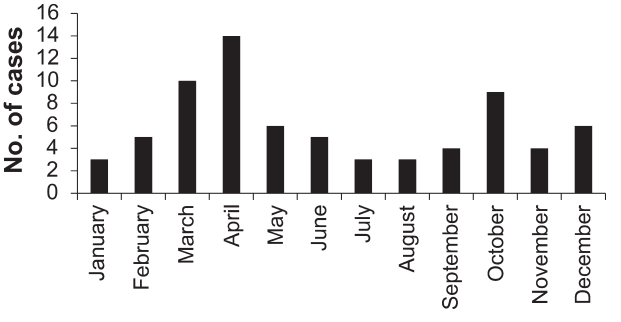


**Figure 1**—Distribution of 72 confirmed cases of canine leptospirosis in Oregon between January 1, 2007, and December 31, 2011, by month of diagnosis. The retrospective study was based on analysis of reports of laboratory tests for leptospirosis or reports of leptospirosis cases voluntarily submitted by veterinarians to the Oregon Health Authority, as well as follow-up telephone surveys with veterinarians from reporting facilities. Only dogs with clinical signs and clinicopathologic findings consistent with active leptospirosis that had positive PCR assay results for a blood or urine sample, a documented 4-fold increase in serum antibody titers against ≥ 1 *Leptospira* serovar identified through paired tests, or a single serum antibody titer ≥ 1:800 via MAT result were eligible for study inclusion; dogs with a single MAT were only included if they had not been vaccinated against leptospirosis in the year prior to diagnosis.



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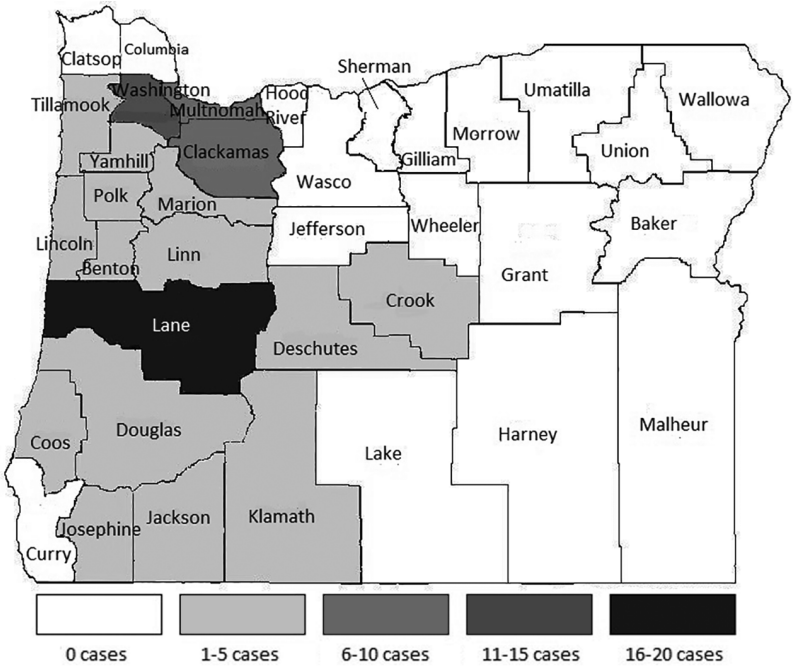


**Figure 2**—Map depicting regional distribution (by county) of 72 confirmed cases of leptospirosis among dogs in Oregon between January 1, 2007, and December 31, 2011.

Cases were concentrated in the western part of the state. Only 3 of 72 (4%) reported cases involved dogs living east of the Cascade Mountains, and no cases were reported from counties east of Crook county.

Puppies and young adult dogs (< 2 years of age) accounted for the smallest proportion of cases (3/72 [4%]), whereas cases were more evenly distributed among the other 3 age categories (2 to < 6 years [24/72 {33%}], 6 to < 10 years [25 {35%}], or ≥ 10 years [20 {28%}]). Thirty-eight of 72 (53%) affected dogs were males (32 neutered and 6 sexually intact). Among the 34 (47%) female dogs, 31 were spayed and 3 were sexually intact.

Surveyed veterinarians were asked to classify each dog's home environment as rural or nonrural (including urban or suburban) according to the location of the owner's home address, but this information was available for only 58 cases; 30 of these 58 (52%) case dogs were reported to live in rural settings.

Among the 65 dogs for which surveys were completed, a history of exposure to wildlife (14 [22%]) was as common as a history of exposure to water sources (14 [22%]). Roaming loose (9 [14%]) and travel (5 [8%]) were also cited for multiple dogs. Of the 5 dogs that had a travel history, 2 had traveled to the Oregon coast, 2 had gone on hunting trips within Oregon, and 1 had traveled to an unspecified location within the state. Two dogs had a history that included contact with an animal carcass (one with a seal and the other with a carcass for which the species was not known), and 2 had a history that included contact with an ill animal (another dog in the household that had a diagnosis of leptospirosis). Twelve dogs had multiple exposure risks reported. Thirty-three of the 65 (51%) dogs for which surveys were available had no recorded information about exposure risks.

Sixty-four dogs had complete medical histories available, and 26 (41%) had ≥ 1 underlying medical condition at the time when leptospirosis infection was diagnosed. The most frequently reported conditions were dermatologic, with 9 of 26 (35%) patients having a history of dermatitis, otitis, or both at the time of diagnosis. Other commonly reported conditions included osteoarthritis (n = 4) and vertebral column conditions (3).

The most commonly reported clinical signs included lethargy (44/65 [68%] dogs), anorexia (39 [60%]), and vomiting (33 [51%]), followed by diarrhea (15 [23%]), fever (13 [20%]), and signs of abdominal pain (8 [12%]). More specific clinical signs suggestive of renal disease (eg, polydipsia [7/65 {11%}] and polyuria [6 {9%}]) or hepatic injury (eg, icterus [7 {11%}]) were seen less frequently, and some dogs had other, nonspecific signs including evidence of myalgia (6 [9%]), weight loss (3 [5%]), respiratory conditions (2 [3%]), or pale mucous membranes (2 [3%]). Outcomes were obtained from the history for case dogs with surveys available. Forty-four of 65 (68%) patients recovered, with 4 of 65 (6%) having ongoing issues related to the illness. Twelve of 65 patients (18%) died or were euthanized (n = 2 and 10, respectively) as a result of the leptospirosis infection. The remaining 9 of 65 (14%) dogs were lost to follow-up, and their outcomes could not be determined.

Fifty-one case dogs were tested by MAT alone or together with a PCR assay. For all 51 dogs, the serovar against which the highest antibody titer was recorded was assumed to be the infecting serovar. The highest percentage of positive MAT test results was attributed to *Leptospira* serovar Autumnalis (26/51 [51%]), followed by Pomona (14 [27%]), Bratislava (7 [14%]), Grippotyphosa (7 [14%]), Icterohemorrhagiae (4 [8%]), and Canicola (1 [2%]). In 9 cases, the MAT tests identified > 1 serovar associated with the highest reported antibody titers. Veterinarian-reported leptospirosis vaccination history revealed that 62 of 65 (95%) case dogs had not been vaccinated in the previous year.

## Discussion

In the present study, we sought to characterize specific features of canine leptospirosis cases in Oregon to better understand the factors leading to clinical illness and outcomes for this disease in dogs. Our data corroborated the findings of a previous study[15] that identified a spatial clustering of leptospirosis in dogs in Oregon as well as a spatiotemporal focus for leptospirosis in the state in 2007,



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but we also found that leptospirosis in dogs in Oregon continued to be reported in all years through 2011, the last year for which data were examined. We found 72 reported cases of leptospirosis in dogs during the 5 years of the study, with the highest numbers of cases in 2007 (n = 17), 2008 (17), and 2011 (16), but we consider this to be a vast underestimation of the actual number of canine leptospirosis cases in the state. There are many factors that contribute to this belief, including the subclinical or mild nature of many cases of infection, nonspecific signs that can be associated with the disease, lack of awareness among owners and veterinarians, and challenges of testing for this infection as well as the voluntary nature of reporting for veterinarians and laboratories during study period. Also, we were unable to confirm some suspected cases because of missing vaccination histories.

To better understand indicators for suspicion of leptospirosis infection, we evaluated the seasonal distribution of known *Leptospira* infections in dogs in Oregon. Previously, leptospirosis in the United States has been characterized as having a seasonal distribution that favors late summer and early fall, with most cases being diagnosed between August and November.[20] The distinct temporal pattern for leptospirosis in Oregon, which differs from seasonal patterns in other parts of the United States, likely relates to the state's weather patterns including relatively mild winters and strong precipitation continuing from fall through spring and greatest amounts of precipitation occurring in November, December, and January. A study[20] conducted by use of data from veterinary teaching hospitals in the United States and Canada found that rainfall can be used to predict the occurrence of leptospirosis, with significant correlation identified between the number of cases diagnosed and rainfall in the preceding 3 months. Our data aligned with these predictions, with the highest numbers of cases identified in March (10/72 [14%]) and April (14/72 [19%]).

The geographic distribution of canine leptospirosis cases in our Oregon study also appeared to be associated with this pattern of rainfall. Sixty-nine of 72 (96%) cases of leptospirosis were identified in dogs residing in the western part of the state, where mean annual precipitation levels are between 75 and 200 inches; this is in contrast to eastern Oregon, where mean annual precipitation is < 20 inches.[21] The spatial distribution of affected dogs in the present study was in agreement with findings of a study[16] in the state of Washington, in which investigators assessed cases of active infections in dogs and found that most of the infected dogs resided in the western part of the state, which has similar geographic rainfall patterns to western Oregon.

In evaluating the demographics of affected dogs in the present study, we found similar numbers of cases of leptospirosis among all adult age groups, including the oldest group (≥ 10 years). Young dogs (< 2 years of age) were least commonly identified as having leptospirosis (3/72 [4%]); this may have been attributable to a more diligent vaccination program for dogs in that age group but was somewhat surprising considering that puppies often have less robust immune systems than do adult dogs. These findings corroborated the results of studies[10,19] that revealed an increased risk of infection with leptospirosis for middle-aged (4 to 6.9 years of age) dogs, compared with results for dogs < 1 year of age, and a more recent study[18] that found an increased risk (approx 3-fold change) of leptospirosis for dogs 5 to 10 and > 10 years of age in northern California, compared with that for dogs < 1 year old; in contrast, compared with the population of the animal identity service dog registration database, puppies (≤ 1 year of age; 61/298 [20.5%]) were overrepresented and older dogs (≥ 10 years of age; 36/298 [12.1%]) were underrepresented in a study[12] on Swiss dogs with leptospirosis.

Whereas 1 previous study[10] found that a diagnosis of leptospirosis was 4.2 times as likely (95% CI, 1.04 to 16.60) for sexually intact male dogs as for sexually intact female dogs, investigators of another study[22] found no difference in distribution of cases on the basis of sex. Roaming behavior of sexually intact male dogs has been cited as a possible reason for the finding of male sex as a risk factor[10]; however, in the present study, most (32/38 [84%]) of the male dogs were neutered and we found similar numbers of male and female dogs that were affected, with males comprising 38 of 72 (53%) case dogs. Traditionally, it has been thought that dogs in rural environments were at substantially greater risk for leptospirosis, but results of some studies[,23,24] have contradicted this notion with findings that residing in newly urbanized (formerly rural) areas or living in urban settings increases the risk of leptospirosis among dogs. In another study,[7] investigators found that proximity to hydrographic features, including open spaces and wetlands, is associated with increased risk of infection. On the basis of the authors' experience, dogs living in rural and nonrural environments in Oregon are likely to have access to these types of landscape features, and our study found approximately equal proportions of case dogs living in rural (30/58 [52%]) and nonrural (28 [48%]) environments.

Certain exposure factors have been found to be significantly associated with leptospirosis, with exposure to outdoor water, swimming, and contact with wildlife increasing the risk for infection.[7] Among patients of our study that had a history of exposure risks, exposure to wildlife (14/65 [22%]) was as common as exposure to water sources (14 [22%]). Five of 5 dogs with a history of travel had traveled within the Pacific Northwest, with histories of travel to the Oregon coast as well as for hunting trips within the state. This type of travel likely increases exposure to water as well as to wildlife. Although some veterinarians who participated in the study survey were able to identify expo-



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sure risks on the basis of history in the medical record, 33 of 65 (51%) dogs had no known history of possible exposure risk at the time of diagnosis, suggesting that leptospirosis should be considered in the differential diagnosis list even for dogs without known exposure risks.

Twenty-six dogs in the present study were known to have underlying medical conditions at the time of leptospirosis diagnosis, and of these, 9 (35%) had dermatitis, otitis, or both. Although these are common conditions among canine patients, this was found in 9 of 64 (14%) cases. Since both of these conditions disrupt the integrity of the skin, it is possible that dermatitis and otitis make it easier for leptospires to penetrate the skin of dogs, thereby predisposing these dogs to leptospirosis. The presence of ≥ 2 wounds on the body has been found to significantly increase the risk of leptospirosis for human patients exposed to water where leptospires are present,[25] and this may also be true for dogs; therefore, further research of this potential association is warranted.

Nonspecific clinical signs in affected dogs, including lethargy (44/65 [68%]), anorexia (39 [60%]), and vomiting (33 [51%]), were commonly reported for dogs at the time of leptospirosis diagnosis. Clinical signs that could be associated with renal disease (polyuria [6/65 {9%}] and polydipsia [7 {11%}]) or hepatic injury (eg, icterus [7 {11%}]) were seen less commonly. These results suggest the need for suspicion for leptospirosis infection in geographic areas where the organisms may be present, despite nonspecific clinical signs; in this situation, results of laboratory testing that indicate azotemia or liver damage can be helpful in pointing to the need for leptospirosis testing.[26]

Both the clinical manifestations and the availability of intensive interventions contribute to the ability of dogs to overcome leptospirosis. In a California study,[19] the case fatality rate was 9 of 67 (13%), whereas in a study[12] in Switzerland, severe manifestations of leptospirosis were common (pulmonary manifestations were identified in 203 of 298 [68.1%] cases, disseminated intravascular coagulation was present in 40 of 298 [13.4%] cases, and 129 of 298 [43.3%] dogs died spontaneously or were euthanized). In the present study, leptospirosis infection resulted in spontaneous death in 2 of 65 (3%) dogs and euthanasia in 10 (15%) for an overall case fatality rate of 18%. Although this case fatality rate was higher than that reported in the California study,[18] the extent of the resources (both medical and financial) available to treat patients was likely different.

The *Leptospira* serovar most commonly identified as the infecting agent by assessment of highest antibody titers in the present study was Autumnalis (found in 26/51 [51%] cases). This result is difficult to interpret, considering that the Autumnalis serovar is known to cross-react with other serovars in MATs, but other studies[15,27] have also identified this as the predominant serovar infecting tested animals. A study[27] that examined laboratory results for leptospirosis MATs in dogs from across the United States identified the Autumnalis serovar as the predominant serovar in half of the states, and another national study[15] identified it as the serovar responsible for a focus of canine leptospirosis in Oregon in 2007. We identified the Pomona serovar as the infecting agent in 14 of 51 (27%) cases in which samples were assessed with MAT. Studies on leptospirosis in dogs from northern California[18] and in stranded California sea lions on the Oregon coast[c] also found Pomona to be the most prevalent serovar in the tested populations, supporting the idea that this is an important contributor to leptospirosis in Oregon. Although it is difficult to tease out the contributions of various serovars in leptospirosis infections because of the propensity for cross-reactions in MAT testing, it is important to note that 26 of 51 (51%) infections identified by MAT in our study were attributed to serovars for which there are vaccines available for dogs (Canicola, Icterohemorrhagiae, Pomona, and Grippotyphosa); because of these cross-reactions and the fact that some of the tests had > 1 serovar reported as the serovar with the highest titer, it is not possible to know how many of these infections would have been prevented through the use of vaccines.

Of the 65 dogs with leptospirosis for which vaccination status was known, 62 (95%) had not been vaccinated against leptospirosis in the previous year. Although the numbers of dogs vaccinated against leptospirosis in Oregon and the proportion of dogs receiving quadrivalent versus bivalent vaccines were unknown, our data suggested that among dogs with leptospirosis diagnosed by means of PCR assay or by paired titer tests, very few (3/65 [5%]) had been vaccinated against *Leptospira* in the previous year. Other studies[12,18] have also reported clinical leptospirosis in dogs that had been vaccinated against it.

Limitations of the present study included the difficulty in ascertaining leptospirosis infection because of incomplete data reported by veterinarians and laboratories. This was addressed through the use of the survey of veterinarians as a means to verify infection status and gain additional demographic and clinical data. Because of the passage of time, it was not possible to reach all veterinarians associated with each test submission; without further information on vaccination history and clinical signs, we could not determine whether active infection was present in some patients and they were thus excluded from the study. This likely led to an underestimation of the number of diagnosed cases of leptospirosis among dogs in Oregon. Additionally, because surveys could not be completed for 7 dogs that still met the case criteria, information on exposure risks, outcomes, home environment, and other factors investigated during the study was not available for many of these cases.



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Data for this study were collected from a variety of sources, including veterinarian reports and laboratory reports as well as a telephone survey that relied on medical records at various veterinary hospitals. The differing formats of the sources of data may have contributed to inconsistencies in data. Furthermore, the nature of the survey, in which veterinarians were asked to review medical records and answer questions about the history, diagnosis, and treatment of patients, was subjective and results could have been affected by recall bias. Additionally, because these data came from various sources and cases were seen at a large number of veterinary practices, the study could not be designed to allow for a control group. As a result, it was not possible to test for associations between factors such as the presence of dermatologic conditions and predisposition to *Leptospira* infection.

Recommendations for further characterizing leptospirosis in Oregon include use of a more complete survey of all testing done for the time period of the study as well as enhanced reporting systems to help optimize the number of cases identified. Routinely recording additional information about each case, such as the presence of dermatologic conditions or other underlying diseases, would also be an asset in creating a database for the analysis of the temporal, spatial, and demographic factors associated with this disease. Improved assessments of the prevalence of leptospirosis dogs in specific regions of the United States can provide important information for assessing the risk of leptospirosis not only in this species, but also in other species including humans. Understanding the factors associated with the disease in canine patients can help direct efforts for prevention of *Leptospira* infections in dogs and may aid in further defining the usefulness of dogs as a potential sentinel species for leptospirosis in people.

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## Footnotes

a. A copy of the questionnaire is available from the corresponding author upon request.
b. Excel, version 2010, Microsoft Corp, Redmond, Wash.
c. Rice J, Duffield D, D'Alessandro D. Dramatic increase in California sea lion strandings along the Oregon coast in 2009 and 2010 (poster presentation). 19th Biennial Conference on the Biology of Marine Mammals, Tampa, Fla, Nov 28-30, 2011.

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**From this month's *AJVR***

## Pharmacokinetics of detomidine following intravenous or oral-transmucosal administration and sedative effects of the oral-transmucosal treatment in dogs

Kristen M. Messenger et al

**OBJECTIVE**
To determine the pharmacokinetics of detomidine hydrochloride administered IV (as an injectable formulation) or by the oral-transmucosal (OTM) route (as a gel) and assess sedative effects of the OTM treatment in healthy dogs.

**ANIMALS**
12 healthy adult dogs.

**PROCEDURES**
In phase 1, detomidine was administered by IV (0.5 mg/m$^2$) or OTM (1 mg/m$^2$) routes to 6 dogs. After a 24-hour washout period, each dog received the alternate treatment. Blood samples were collected for quantification via liquid chromatography with mass spectrometry and pharmacokinetic analysis. In phase 2, 6 dogs received dexmedetomidine IV (0.125 mg/m$^2$) or detomidine gel by OTM administration (0.5 mg/m$^2$), and sedation was measured by a blinded observer using 2 standardized sedation scales while dogs underwent jugular catheter placement. After a 1-week washout period, each dog received the alternate treatment.

**RESULTS**
Median maximum concentration, time to maximum concentration, and bioavailability for detomidine gel following OTM administration were 7.03 ng/mL, 1.00 hour, and 34.52%, respectively; harmonic mean elimination half-life was 0.63 hours. All dogs were sedated and became laterally recumbent with phase 1 treatments. In phase 2, median global sedation score following OTM administration of detomidine gel was significantly lower (indicating a lesser degree of sedation) than that following IV dexmedetomidine treatment; however, total sedation score during jugular vein catheterization did not differ between treatments. The gel was subjectively easy to administer, and systemic absorption was sufficient for sedation.

**CONCLUSIONS AND CLINICAL RELEVANCE**
Detomidine gel administered by the OTM route provided sedation suitable for a short, minimally invasive procedure in healthy dogs. (*Am J Vet Res* 2016;77:413–420)


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