Seroprevalences of feline leukemia virus and feline immunodeficiency virus infection in cats in the United States and Canada and risk factors for seropositivity

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OBJECTIVE
To estimate seroprevalences for FeLV antigen and anti-FIV antibody and risk factors for seropositivity among cats in the United States and Canada.

DESIGN
Cross-sectional study.

ANIMALS
62,301 cats tested at 1,396 veterinary clinics (n = 45,406) and 127 animal shelters (16,895).

PROCEDURES
Blood samples were tested with a point-of-care ELISA for FeLV antigen and anti-FIV antibody. Seroprevalence was estimated, and risk factors for seropositivity were evaluated with bivariate and multivariable mixed-model logistic regression analyses adjusted for within-clinic or within-shelter dependencies.

RESULTS
Overall, seroprevalence was 3.1% for FeLV antigen and 3.6% for anti-FIV antibody. Adult age, outdoor access, clinical disease, and being a sexually intact male were risk factors for seropositivity for each virus. Odds of seropositivity for each virus were greater for cats tested in clinics than for those tested in shelters. Of 1,611 cats with oral disease, 76 (4.7%) and 157 (9.7%) were seropositive for FeLV and FIV, respectively. Of 4,835 cats with respiratory disease, 385 (8.0%) were seropositive for FeLV and 308 (6.4%) were seropositive for FIV. Of 1,983 cats with abscesses or bite wounds, 110 (5.5%) and 247 (12.5%) were seropositive for FeLV and FIV, respectively. Overall, 2,368 of 17,041 (13.9%) unhealthy cats were seropositive for either or both viruses, compared with 1,621 of 45,260 (3.6%) healthy cats.

CONCLUSIONS AND CLINICAL RELEVANCE
Seroprevalences for FeLV antigen and anti-FIV antibody were similar to those reported in previous studies over the past decade. Taken together, these results indicated a need to improve compliance with existing guidelines for management of feline retroviruses. (*J Am Vet Med Assoc* 2017;251:187–194)

Feline leukemia virus and FIV affect cats across the globe. In 2006, a cross-sectional seroprevalence survey of 18,038 cats in the United States and Canada reported that 2.3% of cats were seropositive for FeLV antigen and 2.5% of cats were seropositive for antibodies against FIV.[1] In 2009, another survey of 11,144 cats in Canada reported seroprevalences of 3.4% for FeLV and 4.3% for FIV.[2] Risk factors for seropositivity in both surveys were identified as sexually intact reproductive status for males, adulthood, outdoor access, and unhealthy condition. In both studies, cats tested in veterinary clinics were more likely to have a positive test result than were cats tested in animal shelters.

ABBREVIATIONS
CI Confidence interval

Guidelines developed for the prevention of FeLV and FIV infections through the use of point-of-care diagnostic tests, vaccines, and protocols for segregation of infected cats have been available for several decades.[3] The purpose of the study reported here was to update current seroprevalence information and to identify risk factors associated with seropositivity for FeLV antigen and anti-FIV antibody in cats in the United States and Canada.

Materials and Methods

Selection of participants

Veterinary clinics and animal shelters located in the United States and Canada were invited to participate in the study through a letter addressed to purchasers of diagnostic test kits, animal shelters listed in internet directories, members of the American Association of Feline Practitioners, and members of the

Association of Shelter Veterinarians. Facilities were eligible to participate if they performed ≥ 25 tests/mo. Facilities participating in the study were provided with a data reporting form and a copy of the American Association of Feline Practitioners retrovirus testing guidelines,[3] which recommend testing unhealthy cats, cats with a suspected or unknown history of exposure to retroviruses, cats about to be vaccinated against FeLV or FIV, and cats newly acquired as pets. Invitations were sent by postal mail on March 1, 2010. Study enrollment was closed on September 30, 2010.

Data collection for evaluation of potential risk factors

Participating clinics and shelters submitted data to study investigators via fax transmission of a standardized reporting form. Data were collected from cats tested between March 1, 2010, and September 30, 2010, and compiled by investigators (JKL, MMC, SJT, EGW, and JDF).

Information collected on the data reporting form included the reason for the test (new pet, cat at risk for infection, disease evaluation, or recheck examination), ownership duration (≤ 30 days or > 30 days) or unowned cat status (stray, feral, or owner-relinquished), whether the cat had outdoor access (yes, no, or unknown), and the cat's age (juvenile [≤ 6 months] or adult [> 6 months]), sex, neuter status (if known), FeLV and FIV test results (positive or negative), and current health status. Health status options included the following: healthy, respiratory disease, oral disease, abscess or bite wound, and a free-text entry space for other conditions. Georegion was determined by the location of the clinic or shelter and was grouped as Northeast, West, Midwest, and South within the United States on the basis of US Census Bureau definitions,[4] with Canada coded as a separate georegion. The Northeast was defined as New Hampshire, New York, Massachusetts, Connecticut, New Jersey, Pennsylvania, Maine, Rhode Island, and Vermont. The West was defined as Washington, Oregon, Idaho, Montana, Colorado, Utah, Arizona, California, Alaska, New Mexico, Nevada, Wyoming, and Hawaii. The Midwest was defined as Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, Ohio, North Dakota, and South Dakota. The South was defined as Delaware, Maryland, West Virginia, Virginia, Kentucky, North Carolina, South Carolina, Tennessee, Georgia, Florida, Alabama, Arkansas, Louisiana, Oklahoma, Texas, Mississippi, and the District of Columbia. All testing was performed as a component of routine patient care, and results were submitted without owner identification to protect client confidentiality.

Testing protocol

All testing was performed by staff at participating facilities with a commercially available point-of-care ELISA test kit.[a] Blood, serum, or plasma was tested. Published sensitivity and specificity values were 100% and 98.6%, respectively, for FeLV antigen and 99.2% and 100%, respectively, for anti-FIV antibody.[5] Confirmatory testing was not included in the study.

Statistical analysis

Seroprevalence (sometimes described as apparent prevalence) was defined as the proportion of cats that had a positive test result for FeLV antigen and anti-FIV antibody as determined by ELISA test breakpoints. Unadjusted estimates of FeLV seroprevalence and FIV seroprevalence were first calculated for the study population as a whole and then for subpopulations of cats grouped according to facility type (veterinary clinic or animal shelter).

Univariable mixed logistic regression was used to test for bivariate associations between each of the putative risk factors and seropositivity for each of the 2 viruses. Cluster-adjusted (random effect) ORs and their 95% CIs were calculated.

All explanatory variables (or sets of indicators thereof) were subjected to initial screening for strength of association with each of the outcome variables (FIV and FeLV seropositivity). Several variables were forced into all models regardless of strength of statistical association because of their primary importance to the hypotheses being tested. These included facility type (clinic vs shelter) and georegion. Cat demographic data (age, sex, neuter status, whether it had outdoor access, and reason for testing) as well as health status were subjected to initial bivariate screening. Later, a manual backward selection process was used in a fully parameterized main-effects model to remove variables deemed to have no significant association with the outcome at $P > 0.05$; however, when such removal resulted in a > 20% change in the coefficients (ie, β) of remaining model variables, the variable in question was reassessed and retained if the clinical relevance and interpretation were affected. Finally, the 2-way interaction effects of all variables retained in the final main effects models were assessed, and sets of interaction variables were retained at $P < 0.05$.

Marginal means (proportions) for combinations of key variables (eg, clinic vs shelter, by cat health status) were predicted and graphically presented with conservative CIs by adjusting models to the mean of the remaining covariates in the model, including interaction terms.[6] These estimates of adjusted predicted prevalence were valid because the study design was cross-sectional in nature; that is, the exposure and outcome variables were not fixed in the margins, and estimates of the prevalence proportion were thus derived as a function of the following equation:

$$\frac{e^{(\beta_0+\Sigma\beta_j X_j)}}{1+e^{(\beta_0+\Sigma\beta_j X_j)}}$$

where e is the base of the natural logarithm and $\beta_0 + \Sigma\beta_j X_j$ is the fixed-effect linear predictor consisting of an intercept and explanatory variables[7] in a lo-

Table 1—Results of bivariate analyses of risk factors for FeLV antigen seropositivity in 62,301 cats tested at veterinary clinics and animal shelters in the United States and Canada between March 1, 2010, and September 30, 2010.

Factor	Category	No. of cats tested	No. (%) with positive results	OR (95% CI)	*P* value
Facility type					< 0.001
	Shelter	16,895	435 (2.6)	Referent	NA
	Clinic	45,406	1,523 (3.4)	1.3 (1.2–1.5)	< 0.001
Region					< 0.001
	Canada	881	21 (2.4)	Referent	NA
	Northeast	14,701	359 (2.4)	1.0 (0.7–1.6)	0.913
	South	22,131	693 (3.1)	1.3 (0.9–2.1)	0.211
	West	7,165	238 (3.3)	1.4 (0.9–2.2)	0.138
	Midwest	17,423	647 (3.7)	1.6 (1.0–2.5)	0.042
Age					< 0.001
	Juvenile	26,941	668 (2.5)	Referent	NA
	Adult	35,360	1,290 (3.6)	1.5 (1.4–1.6)	< 0.001
Sex					< 0.001
	Spayed female	12,724	309 (2.4)	Referent	NA
	Castrated male	14,664	387 (2.6)	1.1 (0.9–1.3)	0.269
	Sexually intact female	17,307	525 (3.0)	1.3 (1.1–1.5)	0.002
	Sexually intact male	16,556	684 (4.1)	1.7 (1.5–2.0)	< 0.001
	Unknown*	1,050	53 (5.0)	NA	NA
Outdoor access					< 0.001
	No	25,440	517 (2.0)	Referent	NA
	Yes	36,147	1,421 (3.9)	2.0 (1.8–2.2)	< 0.001
	Unknown*	714	20 (2.8)	NA	NA
Owned					0.521
	Yes	38,741	1,204 (3.1)	Referent	NA
	No	23,560	754 (3.2)	1.0 (0.9–1.1)	0.521
Duration of ownership					< 0.001
	≤ 30 days	16,366	399 (2.4)	Referent	NA
	> 30 days	22,375	805 (3.6)	1.5 (1.3–1.7)	< 0.001
Unowned cat status					< 0.001
	Owner-relinquished	6,071	127 (2.1)	Referent	NA
	Stray	15,469	514 (3.3)	1.6 (1.3–2.0)	< 0.001
	Feral	2,020	113 (5.6)	2.8 (2.1–3.6)	< 0.001
Test reason (owned cats [at clinics] only)					< 0.001
	New pet	19,015	318 (1.7)	Referent	NA
	Recheck	3,761	72 (1.9)	1.1 (0.9–1.5)	0.296
	At risk	7,093	206 (2.9)	1.8 (1.5–2.1)	< 0.001
	Disease evaluation	8,872	608 (6.9)	4.3 (3.8–5.0)	< 0.001
Health status (all)					< 0.001
	Healthy	45,260	751 (1.7)	Referent	NA
	Oral disease	1,611	76 (4.7)	2.9 (2.3–3.7)	< 0.001
	Abscess or bite wound	1,983	110 (5.5)	3.5 (2.8–4.3)	< 0.001
	Respiratory disease	4,835	385 (8.0)	5.1 (4.5–5.8)	< 0.001
	Other	8,612	636 (7.4)	4.7 (4.2–5.3)	< 0.001

Model estimates and 95% CIs are adjusted for within-clinic or within-shelter dependencies via random effects.
*Data not included in odds ratio analysis.
NA = Not applicable.

gistic regression analysis (in this case, a mixed model accounting for the clustering effects of clinic or shelter). All statistical analyses were performed with standard software.[b] Marginal mean estimates (adjusted for all retained main effects and significant interaction terms) and 95% CIs for FeLV and FIV seroprevalences were generated across multiple variables at 1 time for the purposes of providing bidirectional graphical rep-

Table 2—Results of bivariate analyses of risk factors for anti-FIV antibody seropositivity in 62,301 cats tested at veterinary clinics and animal shelters in the United States and Canada.

Factor	Category	No. of cats tested	No. (%) with positive results	OR (95% CI)	*P* value
Facility type					< 0.001
	Shelter	16,895	444 (2.6)	Referent	NA
	Clinic	45,406	1,798 (4.0)	1.5 (1.4–1.7)	< 0.001
Region					< 0.001
	Canada	881	11 (1.2)	Referent	NA
	Northeast	14,701	480 (3.3)	2.7 (1.5–4.9)	0.001
	Midwest	17,423	582 (3.3)	2.7 (1.5–5.0)	0.001
	West	7,165	277 (3.9)	3.2 (1.7–5.8)	< 0.001
	South	22,131	892 (4.0)	3.3 (1.8–6.0)	< 0.001
Age					< 0.001
	Juvenile	26,941	428 (1.6)	Referent	NA
	Adult	35,360	1,814 (5.1)	3.3 (3.0–3.7)	< 0.001
Sex					< 0.001
	Sexually intact female	17,307	314 (1.8)	Referent	NA
	Spayed female	12,724	290 (2.3)	1.3 (1.1–1.5)	0.005
	Castrated male	14,664	739 (5.0)	2.9 (2.5–3.3)	< 0.001
	Sexually intact male	16,556	845 (5.1)	2.9 (2.5–3.3)	< 0.001
	Unknown*	1,050	54 (5.1)	NA	NA
Outdoor access					< 0.001
	No	25,440	437 (1.7)	Referent	NA
	Yes	36,147	1,793 (5.0)	3.0 (2.7–3.3)	< 0.001
	Unknown*	714	12 (1.7)	NA	NA
Owned					0.008
	Yes	38,741	1,334 (3.4)	Referent	NA
	No	23,560	908 (3.9)	1.1 (1.0–3.8)	0.008
Duration of ownership					< 0.001
	≤ 30 days	16,366	379 (2.3)	Referent	NA
	> 30 days	22,375	955 (4.3)	1.9 (1.7–2.1)	< 0.001
Unowned cat status					< 0.001
	Owner-relinquished	6,071	108 (1.8)	Referent	NA
	Stray	15,469	566 (3.7)	2.1 (1.7–2.6)	< 0.001
	Feral	2,020	234 (11.6)	7.2 (5.7–9.1)	< 0.001
Test reason (owned cats [at clinics] only)					< 0.001
	New pet	19,015	301 (1.6)	Referent	NA
	Recheck	3,761	149 (4.0)	2.6 (2.1–3.1)	< 0.001
	At risk	7,093	335 (4.7)	3.1 (2.6–3.6)	< 0.001
	Disease evaluation	8,872	549 (6.2)	4.1 (3.6–4.7)	< 0.001
Health status (all)					< 0.001
	Healthy	45,260	924 (2.0)	Referent	NA
	Respiratory disease	4,835	308 (6.4)	3.3 (2.9–3.7)	< 0.001
	Oral disease	1,611	157 (9.7)	5.2 (4.3–6.2)	< 0.001
	Abscess or bite wound	1,983	247 (12.5)	6.8 (5.9– 7.9)	< 0.001
	Other	8,612	606 (7.0)	3.6 (3.3–4.0)	< 0.001

See Table 1 for key.

resentations that compared results for cats tested in veterinary clinics with those for cats tested in shelters.

Results

A total of 1,376 veterinary clinics and 127 animal shelters in the United States enrolled in the study and submitted complete information for 61,420 cats. A total of 20 veterinary clinics and 3 animal shelters in Canada submitted data for 881 cats. Of 62,301 cats tested, 58,101 (93.3%) tested negative for both viruses; 1,958 (3.1%) were seropositive for FeLV antigen, and 2,242 (3.6%) were seropositive for antibodies against FIV **(Tables 1 and 2)**. Seropositivity for both viruses was identified in 210 (0.3%) of those cats. Comparison among georegions revealed that the odds of FeLV seropositivity were significantly ($P < 0.05$; bivariate model adjusted for within-clinic or within-shelter dependencies) higher only in the Midwest, compared with Canada (the referent), whereas the odds of FIV seropositivity were significantly higher in all regions of the United States, compared with Canada, with slightly higher proportions of cats having positive results in the South and West than in other georegions.

Risk factors significantly ($P < 0.05$) associated with seropositivity for each virus included outdoor access, being a sexually intact male, adult age, and the presence of disease (Tables 1 and 2). Among 36,147 cats with outdoor access, 3,030 (8.4%) cats were seropositive for 1 or both viruses, compared with 909 of 25,440 (3.6%) indoor cats. Among male cats, 2,559 of 31,220 (8.2%) tested positive for ≥ 1 of the viruses, compared with 1,439 of 30,031 (4.8%) female cats. Of 35,360 adult cats tested, 2,928 (8.3%) were seropositive for ≥ 1 of the viruses, whereas 1,062 of 26,941 (3.9%) juvenile cats had this result. Seropositivity for 1 or both viruses was identified in 214 of 1,611 (13.3%) cats with oral disease, 651 of 4,835 (13.5%) cats with respiratory disease, and 326 of 1,983 (16.4%) cats with abscesses or bite wounds. Overall, FeLV or FIV (or both) was identified in 2,368 of 17,041 (13.9%) unhealthy cats and in 1,621 of 45,260 (3.6%) healthy cats. The odds of FeLV or FIV seropositivity were significantly ($P < 0.001$) greater for cats in each disease category than for healthy cats.

The odds of seropositivity of each virus were significantly ($P < 0.001$ for both comparisons) higher for cats tested at veterinary clinics, where cats were more commonly determined to be unhealthy at the time of testing, than for those tested at animal shelters. Of 45,406 cats tested at veterinary clinics, 15,198 (33.5%) were deemed unhealthy, compared with 1,843 of 16,895 (10.9%) cats tested at animal shelters. In veterinary clinics, 1,028 of 15,198 (6.8%) and 1,106 of 15,198 (7.3%) unhealthy cats tested were seropositive for FeLV and FIV, respectively, whereas in animal shelters, 178 of 1,843 (9.7%) unhealthy cats were seropositive for FeLV and 215 of 1,843 (11.7%) were seropositive for FIV. All of these differences between veterinary clinics and animal shelters were significant ($P < 0.001$).

Among unowned cats classified as feral, the odds of seropositivity for each virus were significantly ($P < 0.001$) higher than that for other types of unowned cats, with 113 of 2,020 (5.6%) and 234 of 2,020 (11.6%) feral cats seropositive for FeLV and FIV, respectively (Tables 1 and

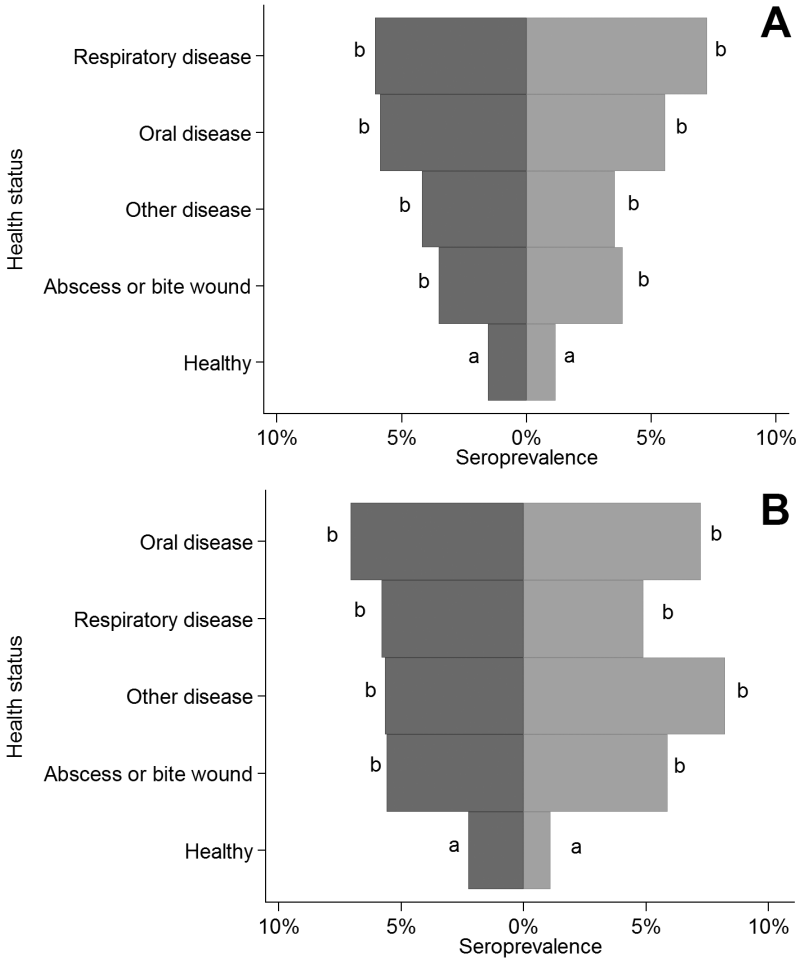

Figure 1—Bidirectional bar plots of model-adjusted marginal mean FeLV (A) and FIV (B) seroprevalence estimates (percentage) by health status for 60,548 of 62,301 cats tested at veterinary clinics (dark gray bars; n = 44,161) or animal shelters (light gray bars; 16,387) between March 10, 2010, and September 30, 2010. Model estimates were adjusted for main fixed effects of age (juvenile or adult), sex and neuter status, georegion (Canada or Northeast, South, Midwest, or West United States) outdoor access (yes or no), whether owned or unowned, and the primary reason for testing as well as all significant 2-way interactions among the primary variables of interest. Cats with missing sex and neuter status information, outdoor access data, or both were excluded from the analysis (n = 1,753). Different letters (a, b) indicate prevalence estimates that differ significantly ($P < 0.05$) among health status categories within the given facility type (shelter or clinic).

2). Among feral cats, 11 of 82 (13.4%) with oral disease, 20 of 133 (15.0%) with respiratory disease, and 10 of 102 (9.8%) with bite wounds or abscesses were seropositive for FeLV, whereas 26 of 82 (31.7%) with oral disease, 31 of 133 (23.3%) with respiratory disease, and 41 of 102 (40.2%) with bite wounds or abscesses were seropositive for FIV.

The final model indicated significant contributions of the random effects for clinic and shelter to the overall model variance components, indicating preference for the mixed-model framework over other alternatives. All tested main effects were significantly associated with FeLV and FIV outcome in mixed-effect logistical regression models. For each FeLV and FIV outcome, significant ($P < 0.05$) 2-way interactions were identified among the following variables: clinic or shelter with outdoor status and health status, age with sex and neuter status and outdoor status, sex and neuter status with health status, and outdoor status with health status. These terms were retained in the final models (data not shown). Bidirectional bar plot graphs depicting final mixed-model–adjusted prevalence estimates for FeLV and FIV seropositivity among cats of each health status tested in a clinic versus shelter setting are shown **(Figure 1)**. Records for 60,548 of 62,301 cats were included in the final multivariable models owing to the exclusion of records for missing explanatory data fields (eg, neuter status was often unknown for cats tested at shelters). Significant differences in the relative odds of FeLV and FIV seropositivity were detected between healthy and unhealthy cats. These appeared to vary somewhat among cats tested in clinics versus shelters, although these were not compared directly, and their relative order of importance at the 2 facility types differed only for FIV.

Discussion

Results of the present study revealed that the seroprevalences of 2 important feline infectious diseases, FeLV and FIV, have not declined in North America over the past decade. We found that 3.1% and 3.6% of cats were seropositive for FeLV antigen and anti-FIV antibody, respectively, compared with 2.3% and 2.5%, respectively, for tests performed in 2004.[1] Cats with diseases including oral disease, respiratory disease, and abscesses or bite wounds had significantly greater odds of testing positive for either virus than did healthy cats. Other risk factors identified were consistent with results of previous studies[1,8,9] and included adult age and having outdoor access; sex was also significantly associated with these outcomes, with sexually intact males and females having greater odds of FeLV seropositivity than spayed females, and spayed females and sexually intact or castrated males having greater odds of FIV seropositivity than sexually intact females.

Oral disease was associated with retroviral seropositivity, particularly with FIV. This was consistent with results of a study[10] of 5,179 cats in the United States and Canada for which the presence of oral disease was documented at the time of retroviral testing. In that study,[10] seropositivity for FeLV, FIV, or both was identified in 7.7% of cats with gingivitis, 18.9% of cats with periodontitis, and 22.5% of cats with stomatitis, whereas in cats with healthy mouths, seropositivity was only 2.2% for FeLV and 1.3% for FIV.

The present study found that respiratory disease was also associated with increased odds of seropositivity for each of the viruses. Although textbooks and reviews frequently list upper respiratory coinfection as a common finding in retrovirus-infected cats, there is little published information regarding the magnitude of this risk. In the present study, the odds of cats with respiratory disease testing positive for FeLV or FIV were 5 and 3 times as great, respectively, as those for healthy cats.

The presence of an abscess or bite wound was also associated with increased odds of retroviral seropositivity, particularly for FIV. It has long been known that the primary mode of FIV infection is through inoculation with contaminated saliva via bite wounds.[11] Bite wounds are considered a high-risk event that should be followed in 60 days by another test for retroviral infection.[3] However, seropositivity for FeLV or FIV at the time of initial treatment of a wound likely indicates a cat's previous exposure or ongoing high-risk lifestyle, not a 1-time event tied to the present injury needing treatment. Despite the known risks of infection in cats that fight, compliance with testing recommendations among veterinarians and cat owners is low. In a previous study[11] of 967 cats with bite wounds, only 10% of these high-risk cats had been tested for evidence of retroviruses prior to the wound treatment. In that study,[11] a total of 19% of tested cats were seropositive for FeLV, FIV, or both at the time of treatment, similar to the 357 of 1,983 (18%) cats with bite wounds or abscesses in the present study. Financial incentives and free tests were provided in the previous study[11] to encourage compliance with the American Association of Feline Practitioners' guidelines for retesting in 60 days to determine whether the bite resulted in a new infection; despite these incentives, only 54% of veterinarians recommended follow-up tests, and only 13% of cats were ultimately retested. The failure to identify infected cats with a propensity to fight likely hampers progress in reducing overall disease prevalence. Of cats for which vaccination status was known in that study,[11] only 31% were vaccinated against FeLV. Importantly, the investigators reported a 2% seroprevalence for FeLV antigen among cats that had been vaccinated against FeLV and had wounds, compared with 14% for unvaccinated cats (OR, 8.2; $P < 0.01$). Those results suggested that FeLV vaccination was associated with reduced risk of FeLV infection in cats brought to clinics with bite wounds.

In the present study, cats newly acquired by an owner (≤ 30 days before testing) had lower odds of seropositivity for each virus than did cats owned for a longer period. This may have reflected younger ages of such cats or the removal of seropositive cats from adoption pools prior to acquisition and retesting in veterinary clinics. The higher odds of seropositivity in cats owned for > 30 days may have reflected the cumulative risk of acquiring infection over time in unprotected cats. In a related finding, the reason for testing at veterinary clinics was also associated with varying odds of seropositivity. Cats tested as part of a new pet examination had the lowest odds of seropositivity for each virus, followed by cats having a recheck health examination (odds of FeLV seropositivity did not differ significantly from the referent of new pet testing for this group).

Cats perceived as being at risk for infection and cats being evaluated because of clinical signs of disease had greater odds of seropositivity for each virus than did new pets. Considering that the odds of seropositivity were increased among cats after placement in a new home, continuing to screen owned cats with risk factors for infection, such as outdoor access, exposure to other cats of unknown infection status, and development of disease, remains important. In addition, cats at risk for exposure to FeLV should be vaccinated for protection.

In previous reports[1,12–16] that included test results for feral cats in the United States and Canada, FeLV seroprevalence ranged from 0% to 6.5%, compared with 5.6% in the present study, and FIV seroprevalence ranged from 3.9% to 7.6%, compared with 11.6% in the present study. Although the size of the feral cat population is unknown, it is estimated to range in the tens of millions in the United States.[17] Because the number of free-roaming feral cats is large, it has been reported that control of retroviral infections in this population is likely to be facilitated most effectively by concerted neutering efforts, rather than testing and removal of cats with positive results, which can be an effective approach for subpopulations of confined cats.[16] Streamlining trap-neuter-return programs for maximum efficiency to allow treatment of larger numbers of cats can result in both population control and reduction of retroviral transmission through control of breeding, reproduction, and fighting.[3,18]

Results of a previously published study[19] of cats in the United States revealed minor regional variations in the seroprevalence of FeLV and FIV, despite the 2 viruses sharing similar risk factors. In that study,[19] the odds of seropositivity for FeLV in the West and Midwest were higher than those for FIV. In a previous North American study,[1] seroprevalence of FeLV and FIV was lowest in some regions of the United States, whereas in the present study, seroprevalence was lowest in Canada. Differences in regional seroprevalence observed in the current and previous studies were small and likely represented differences in sample populations rather than true shifts in regional seroprevalence over time. Overall, seroprevalences of FeLV and FIV have remained below 6% in the United States and Canada, regardless of the region where testing was performed.[1,2,12,14,16]

As in previous studies, the cat population in the present study was not selected at random. Testing of cats was performed at the discretion of the veterinarian and would have been influenced by published guidelines,[3] clinical judgment, facility policies, and owner discretion. In the present study, 15,198 of 45,406 (33.5%) cats tested in veterinary clinics were deemed unhealthy, whereas 1,843 of 16,895 (10.9%) of those tested in animal shelters were considered unhealthy. Therefore, it is not surprising that the odds of seropositivity for FeLV and FIV were greater in veterinary clinics than in shelters, a pattern that has been reported previously.[1,9] The finding that the odds of seropositivity for each retrovirus were higher among unhealthy cats tested at animal shelters than among unhealthy cats tested at veterinary clinics (interaction term of clinic or shelter by health status; $P < 0.05$) could reflect more targeted testing (selection of cats with more severe disease) in the shelter environment. Importantly, a mixed-model approach was used to estimate seroprevalences of FeLV and FIV, adjusting both the modeled estimate for seroprevalence and the 95% CI for unknown aspects of clinic and shelter testing protocols that could not be measured or otherwise determined. This helped ensure that the estimates and associated SEs would be robust to unspecified dependencies among cats within a single practice and shelter, especially when compared with those tested at other facilities.

Confirmatory testing was not performed in this study. Even though the test used was highly specific, the low prevalence of infection reduces the positive predictive value in any particular test-positive cat. In addition, the potential for presence of anti-FIV antibodies owing to previous FIV vaccination or for presence of maternal anti-FIV antibodies in kittens limits the ability to interpret seroprevalence results for this virus. However, FIV vaccines are not widely used, especially in cats with lifestyles that put them at risk for entering an animal shelter. Previous vaccination against FeLV does not affect antigen-based diagnostic test results such as those used in the present study.[3] False-negative results can occur in cats recently infected with either virus because there is a lag in development of detectable circulating concentrations of FeLV antigen or anti-FIV antibody.

The objective of the present study was to estimate seroprevalence of FeLV antigen and anti-FIV antibody among cats in the United States and Canada, and modeled results were unadjusted for imperfect test accuracy. Interested readers can readily calculate estimates of true prevalence, if desired, on the basis of the data presented in this report.

Seroprevalences for FeLV and FIV in the United States in the present study were slightly higher than those reported previously with a similar sampling technique.[1] It would not be possible to draw conclusions about changes in seroprevalence over time without additional sampling to determine whether a trend exists beyond chance fluctuation. However, results of the present study indicated that, at best, seroprevalences for these preventable infections have not declined. Addressing the lack of progress identified in this investigation will require the concerted efforts of organized veterinary medicine to improve education and awareness. Together with the results of previous studies, these results indicate a need for veterinarians and shelter managers to improve compliance with existing guidelines for the management of FeLV and FIV, which include testing of all owned cats, retesting of cats that develop disease or may have been exposed to infected cats, vaccination against FeLV for all kittens and for adult cats at risk for exposure, segregation of infected cats, and neutering of unowned free-roaming cats.

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Footnotes

a. SNAP Feline Triple FeLV antigen-FIV antibody-Heartworm antigen test, IDEXX Laboratories Inc, Westbrook, Me.
b. XTLOGIT (mixed logistical modeling), STATA, version 12.1 for Windows, StataCorp LP, College Station, Tex.

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From this month's *AJVR*

Use of gadoxetic acid for computed tomographic cholangiography in healthy dogs

Jennifer Chau et al

OBJECTIVE
To evaluate the effect of gadoxetic acid (contrast) dose on biliary tract enhancement, determine the optimal time after contrast injection for CT image acquisition, and assess the feasibility of CT cholangiography in sedated dogs.

ANIMALS
8 healthy dogs.

PROCEDURES
The study had 2 parts. In part 1, 4 dogs were anesthetized and underwent CT cholangiography twice. Gadoxetic acid was administered IV at a low dose (0.025 mmol/kg) for the first procedure and high dose (0.3 mmol/kg) for the second procedure. Serial CT scans were obtained at predetermined times after contrast injection. In part 2, 4 dogs were sedated and underwent CT angiography 85 minutes after IV administration of the high contrast dose. Contrast enhancement of the biliary tract on all scans was objectively assessed by measurement of CT attenuation and qualitatively assessed by use of a subjective 4-point scoring system by 3 independent reviewers. All measurements were compared over time and between contrast doses for the dogs of part 1. Subjective measurements were compared between the sedated dogs of part 2 and anesthetized dogs of part 1.

RESULTS
Enhancement of the biliary tract was positively associated with contrast dose and time after contrast injection. Optimal enhancement was achieved 65 minutes after contrast injection. Subjective visualization of most biliary structures did not differ significantly between sedated and anesthetized dogs.

CONCLUSIONS AND CLINICAL RELEVANCE
Results indicated CT cholangiography with gadoxetic acid was feasible in sedated dogs. The high contrast dose provided better visualization of biliary structures than the low dose; CT scans should be obtained 65 minutes after contrast injection. (*Am J Vet Res* 2017;78:828–839)

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