Prevalence of and risk factors for FIV and FeLV infection in two shelters in the United Kingdom (2011–2012)

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The aims of this study were to determine the prevalence of feline leukaemia virus (FeLV) and feline immunodeficiency virus (FIV) infections in cats presented to two RSPCA (Royal Society for the Prevention of Cruelty to Animals) animal rehoming centres and to identify risk factors for infection. All cats presented at each centre between August 2011 and August 2012 were subjected to a patient-side test for FeLV/FIV on entry. Kittens under three months and cats euthanased within a short time of presentation were excluded from the study. Univariable and multivariable logistic regression were used to separately determine risk factors for FeLV and FIV infections. At shelter A, the prevalence of FIV infection was 11.4 per cent (54/474) and FeLV infection was 3 per cent (14/473), with two FIV/FeLV coinfections identified. At shelter B, the prevalence of FIV infection was 3 per cent (4/135) and FeLV infection was 0 per cent (0/135). Cats at shelter A were significantly more likely than those at shelter B to test positive for FIV (p=0.0024) and FeLV (p=0.048). Male cats were more likely to be infected with FIV (odds ratio 27.1, p=0.001), and thin body condition and musculoskeletal disease were associated with risk of FeLV. Overall, FIV-positive and FeLV-positive cats were significantly older (median ages 5.1 and 4.75 years, respectively) than the uninfected populations (median ages 3.4 and 3.5 years, respectively). This study shows that the prevalence of these diseases varies between shelter populations. Local knowledge combined with the risk factors identified may be useful in focusing resources for population testing strategies.

Introduction

Feline immunodeficiency virus (FIV) and feline leukaemia virus (FeLV) are diseases of domestic cats and related species. FIV is commonly spread by fighting and biting (blood-to-blood contact), although sexual and vertical transmissions are also possible. Once acquired, FIV infection is lifelong, and there is no known recovery or cure. FeLV is considered to be a ‘friendly cat’ disease, with transmission by mutual grooming and sharing of food and water bowls considered to be the most prominent routes of transmission, although transmission by fighting and biting may also occur. Exposure may result in a variety of outcomes, including abortive, regressive and progressive infections. If a sufficient humoral and cell-mediated immune response is mounted, the virus will be eliminated, termed ‘abortive infection’. However, it has become clear that apparently ‘recovered’, antigen-negative cats may retain proviral DNA in bone marrow progenitor cells. Such cats, termed ‘regressively infected’, will test negative for circulating antigen and are at low risk of FeLV-associated disease. Some studies have suggested that regressive infected cats may be at increased risk of FeLV-associated disease, such as lymphoma and anaemia; however others have not found a link, and the potential role of FeLV in such circumstances is as yet unclear. It has also been shown that regressive cats can be a source of FeLV infection via blood transfusion. Progressive FeLV infection occurs when there is an inadequate immune response and a permanent viraemia results, with affected cats typically dying of FeLV-associated disease including lymphoma or aplastic anaemia within three years of infection. Within domestic cat populations, prevalence of these two viruses is variable. Male sex, outdoor access, a history of aggressive behaviour or fight wounds, and evidence of ill-health on presentation have been consistently associated with increased risk of both diseases. A variety of clinical presentations have been linked with increased risk of infection, with gingivitis linked most consistently with FIV, and anaemia with FeLV. Both FIV and FeLV have been linked with an increased risk of neoplasia, particularly lymphomas. As both diseases can cause immunosuppression and reduced immunosurveillance, recurrent or relapsing presentations of common diseases such as feline upper respiratory tract infection (‘cat flu’) have also been suggested to be potential indicators of infection. Adult cats have been identified as being at greater risk than juveniles for FIV, probably due to greater cumulative opportunities to perform risky behaviours such as fighting and mating. Adult cats have been identified as at greater risk of FeLV infection than juveniles; however, it has been suggested that a degree of age-related immunity occurs, meaning that when infection does occur in later life, it may be more likely to be regressive. Feral cats have been suggested to be at greater risk of infection from FeLV positive individuals. A degree of age-related immunity has been shown in feral cats, meaning that when infection occurs in later life, it can be more likely to be regressive. It has also been suggested that progression to full infection in feral cats is reduced by environmental factors such as host density and competition between individuals.
risk of FIV infection, while cats from multicat households are at increased risk of FeLV infection. It has been suggested that the prevalence of FeLV has decreased over recent years, possibly due to an increase in vaccination. Data for trends over time suggest that FeLV prevalence has either remained stable or possibly dropped over the past 30 years at least in specific populations; however, definitive local trends are often difficult to identify, as there are relatively few studies repeated within the same population, and improvements in diagnostic tests over time limit comparison between them. Current trends in UK prevalence for both diseases are hard to establish as relatively few data are available, and none recent. Prevalence in owned cats varies widely across the world. Infection prevalence in stray and shelter cats has been shown in different studies to be both higher and lower than the corresponding pet cat populations. It may also be possible that pockets of transmission occur between subpopulations, governed by localised risk factors such as neutering or vaccination.

Many cat shelters perform FIV and/or FeLV testing on some or all of their animals, as part of health screening for the individual, population healthcare, and also to provide reassurance to prospective owners. These typically utilise patient-side tests, which detect FIV antibody and FeLV antigen, respectively. FIV and FeLV infections have been shown to be among the most common reasons for death or euthanasia in shelters. However, if every one of the estimated 130,000 cats passing through rescue shelters in the UK annually was tested, this would add significantly to the cost of caring for and rehoming these animals. Additionally, when the patient-side test is used as a population screening tool, the relatively low population prevalence and subsequently low positive predictive value lead to difficulties in interpretation of the results. Cats that test positive for FeLV may undergo confirmatory tests such as PCR, and further tests to differentiate progressive from regressive infection, which incurs both a financial cost and potentially an extended stay in a rescue facility. It may therefore be desirable to establish known risk factors within this population of cats in order to guide selection of cats for testing, to improve cost-effectiveness and accuracy of testing, and to expedite rehoming of cats.

The aim of this study was to determine the prevalence of FeLV and FIV infection in cats presented to two charities in the UK, as determined by a patient-side test. The secondary aim was to identify risk factors for infection within the populations under study.

Materials and methods

Shelters

The study was a retrospective case-control study conducted at two RSPCA (Royal Society for the Prevention of Cruelty to Animals) rehoming centres. RSPCA BACH (shelter A) is a large charity hospital and rehousing centre in the Midlands region of the UK. Block Fen RSPCA (shelter B) is a rural animal rehousing centre in the east of England. Both organisations accept animals generated by RSPCA animal inspectors, which may be stray, injured or confiscated for welfare reasons. In addition, RSPCA BACH provides charitable veterinary care to owners with low incomes, and members of the public also present sick and injured stray animals.

Study population

The population included any unowned cat presented for admission to the shelters or hospital over the year August 2011–August 2012 that was tested for FIV/FeLV. Publicly owned animals were excluded (ie, those visiting for treatment at BAH). At both shelters, during the study period, the operating policy stated that every cat admitted was tested for FeLV/FIV as soon after entry as practicable, with the exception of those cats euthanased for welfare reasons on entry, and kittens under 6 months (shelter A) or under 4 months (shelter B).

All tests were carried out using either VetLab FASTest FeLV-FIV Combination Test (shelter A) or IDEXX SNAP FeLV/ FIV Combo (shelter B) patient-side tests, using anticoagulated whole blood (shelter A) or separated serum (shelter B). The SNAP Combo detects p27 antigen for FeLV (sensitivity 98.6 per cent, specificity of 98.2 per cent), and antibodies directed against p24 and gp40 for FIV (sensitivity 93.5 per cent, specificity of 100 per cent). Similarly, the VetLab FASTest detects p27 antigen for FeLV (sensitivity 95 per cent, specificity 99 per cent) and antibodies directed against gp40 for FIV (sensitivity 96 per cent, specificity of 9 per cent) (Vetlab Supplies 2012).

Data collection

Computerised clinical records for every cat presented at both shelters during the study period were extracted, along with estimated age, sex, neuter status (if known) and test result. Details of clinical presentation were extracted by manually searching the free text records. All information was stored using Microsoft Excel V10.

Data cleaning

Estimated age was provided at shelter A by calculating the difference between the date of consultation and the estimated date of birth on the record. Age was recorded in shelter B in categories (0–3 months, >3–6 months, >6–9 months, and yearly categories from then on), and therefore age from one year was treated as a categorical variable to ensure consistency within the dataset. For cats of less than one year of age, interpolation was used to estimate age; for example, cats assigned to the three to six months age group were nominally assigned an age of 157 days to enable comparison between the two data-sets.

Where neuter status was not directly recorded in patient records, description within the records such as ‘spay scar present’ or ‘no uterus on surgery’ was used to assign neuter status. Animals for which a neuter procedure was recorded subsequent to the test were assigned the status of entire, as were pregnant or lactating animals. Pregnancy or admission with a litter was also evaluated separately as a risk factor.

In order to determine the health of each cat at the point of entry, the clinical notes for the first clinical consultation were interrogated by MHH, from date of admission to up to three days after admission. Cats were considered healthy if ‘clinical exam NAD’ (no abnormality detected) or similar phrasing was found. Lack of recorded signs was treated as missing data. Each clinical sign recorded was categorised by body system (eg, limb fracture would be coded as ‘musculoskeletall’). In order to investigate a link with feline upper respiratory tract disease (‘cat flu’), a separate variable was created where free text mentioned ‘cat flu/URTD’, or one or more of sneezing, ocular or nasal discharge. Similarly, ‘fight wounds’ and ‘abscess(es)’ were collapsed into a single category, as were ‘dental disease’, ‘gingivitis’ and ‘stomatitis’. Body condition was dichotomised into ‘thin’ (<5/5) or ‘not-thin’ (>5/5); again where body condition was not recorded this was treated as missing data.

Case definition

Any cat with a positive test result recorded for FeLV, FIV or both was treated as a case. Analysis for each disease was conducted...
Data analysis
Analyses were carried out in Statistical Package for the Social Sciences (SPSS) V.22. Continuous data such as age were non-normal and therefore described in terms of medians and interquartile ranges (IQRs).

Associations between each of the potential risk factors and FeLV and FIV test status were performed separately using univariable binomial regression. Factors with a P<0.2 in univariable analysis were considered for inclusion in a multivariable regression model, which was constructed using backwards elimination. Terms with a plausible biological association were tested for interaction and the most parsimonious model selected, using Pearson’s correlation to determine whether to include or reject terms with the appearance of correlation. Rejected terms were rechecked individually against the final model. Age (in days) was non-linear and therefore log-transformed. Goodness of fit was assessed using the Hosmer and Lemeshow test. Significance was set at P<0.05 throughout.

Results
Overall, data were obtained from a total of 726 cats, 523 from shelter A and 203 from shelter B. Although the minimum age for testing differed between shelter A and shelter B, in practice, the majority of kittens of under three months from both shelters were not tested (41/57, 71.9 per cent). Of the 16 kittens aged under three months which were tested, all were from shelter B, and one tested positive for FIV and none for FeLV. The majority of kittens aged three to six months from both shelters were tested (35/44, 79.5 per cent) for both FeLV and FIV. Therefore, 57 kittens aged under three months were excluded from the analysis, while kittens of three to six months were included. The median age for shelter A was three years (IQR: 1–5), and for shelter B was three years (IQR: 1–6.5). Test results were missing from a further 60 cats (28 from shelter A, 52 from shelter B), giving a total of 609 cats in the final dataset, 474 from shelter A and 135 from shelter B. Of these, four cats had only an FIV result (of which one was positive) and no FeLV result recorded. Therefore the final dataset was 609 cats for FIV and 605 for FeLV (Table 1).

Disease prevalence

| TABLE 1: Overall demographics and test results for cats from shelter A and shelter B |
|-----------------------------------------------|
| Number of cats (%) | Shelter A | Shelter B |
| Sex | | |
| Male | 295 (62.2) | 65 (48.1) |
| Female | 169 (35.7) | 70 (51.9) |
| Unknown/not recorded | 10 (2.1) | 0 |
| Neuter status | | |
| Neutered | 61 (12.9) | 5 (3.7) |
| Entire | 313 (66) | 61 (45.2) |
| Unknown/not recorded | 100 (21.1) | 69 (51.1) |
| Feline immunodeficiency virus status | | |
| Positive | 54 (11.4) | 4 (3) |
| Negative | 420 (88.6) | 131 (97) |
| Feline leukaemia virus status | | |
| Positive | 14 (3) | 0 |
| Negative | 459 (96.8) | 132 (97.8) |
| Missing | 1 (0.2) | 3 (2.2) |

The overall prevalence of FIV was 9.5 per cent (95 per cent confidence interval (CI) 7.4 to 12.1 per cent) and of FeLV was 2.3 per cent (95 per cent CI 1.4 to 3.9 per cent). Cats at shelter A were significantly more likely to be infected with FIV (P=0.0024) or FeLV (P=0.048) than cats at shelter B. Two cats (both from shelter A) were coinfected with FIV and FeLV.

Age
Cats that tested positive for FIV were significantly older than those that tested negative (P<0.001), with positive cats having a median age of 1864 days (5.1 years; 95 per cent CI 1627 to 2101 days) as compared with 1244 days (3.4 years; 95 per cent CI 1157 to 1131 days) for negative cats. Likewise, FeLV-positive cats were significantly older than FeLV-negative cats, with positive cats having a mean age of 1755 days (4.75 years; 95 per cent CI 1273 to 2197), as compared with 1289 days (3.5 years; 95 per cent CI 1204 to 1373 days) for FeLV-negative cats (P=0.06).

Univariable analysis
Risk factors that were eligible for inclusion in the multivariable logistic regression model for FIV are shown in Table 2. The final multivariable model for FIV suggested that male sex, clinical signs of cat flu and shelter were associated with an increased risk of infection. Increasing age was also associated with increased risk of positive test status (Table 3). Presence of fight wounds or abscesses was considered for model inclusion but found to be strongly correlated with sex (Pearson’s correlation 0.251, P<0.001) and was therefore removed from the final model.

Table 4 shows the factors from the univariable analysis that were eligible for the model for FeLV. The final multivariable model retained only thin body condition score and signs of musculoskeletal disease as risk factors for a positive FeLV test result (Table 5).

Discussion
This study has shown a variable prevalence of FeLV and FIV in two populations of animals entering charity hospital and rehoming services. Despite the similar criteria for admission to these two sites, the difference in the disease prevalence in these two populations suggests there must be some critical distinctions between

| TABLE 2: Risk factors for feline immunodeficiency virus infection from univariable analysis which were considered for inclusion in the multivariable analysis |
|-----------------------------------------------|
| Factor (reference category is disease absence) | Significance | OR Lower | Upper |
| Sex (reference category female) | <0.001 | 43.8 | 6.03 | 319.0 |
| Neurological signs | 0.035 | 2.6 | 1.07 | 6.2 |
| Fight wounds/abscess | <0.001 | 5.8 | 3.1 | 10.7 |
| Cat flu | 0.016 | 2.4 | 1.2 | 4.7 |
| Dental disease/stomatitis | 0.172 | 1.6 | 0.8 | 3.2 |
| Fleas | 0.138 | 1.8 | 0.8 | 4.1 |
| Log age (days) | <0.001 | 9.5 | 3.9 | 23.5 |
| Body condition (low or not low) | 0.177 | 1.8 | 0.8 | 4.2 |
| Shelter | <0.001 | 4.2 | 1.5 | 11.8 |

95% CI, 95% confidence interval; OR, odds ratio.

Nagelkerke R² value 0.261, Hosmer and Lemeshow P=0.773. 95% CI, 95% confidence interval; OR, odds ratio.

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them. Both populations of cats consisted of those presented by RSPCA inspectors as stray, injured or confiscated for reasons of animal welfare, as well as those directly relinquished by owners (shelter B only). It is possible that the proportions of these subcategories differed between the two shelters, or that factors such as inferred greater population density in the urban environment may have contributed to this variation in risk; cats from inner city environments have previously been found to be at increased risk of FIV infection. Additionally, the proportion of male cats was higher in shelter A than shelter B (62.2 per cent as compared with 48.1 per cent), which could have also contributed to the higher prevalence of FIV. Although these specific results cannot be generalised across the whole feline population, the disparity between the prevalences found does reinforce the importance of knowledge of local patterns of infection when designing and administering a testing policy.

Interestingly, the prevalence of both FeLV and FIV at RSPCA BACH seems to be remarkably similar to the prevalence revealed in 2002, in the same hospital, also using patient-side testing. It is uncertain why this may be the case, especially given that no FeLV or FIV prevalence data have been collected in subsequent years. This incompleteness is reflected in the relatively low R² values for both models, which suggests the importance of other, unmeasured factors is significant.

The prevalence of FeLV in this study was low, limiting the statistical power to examine risk factors; a larger study would be required to more fully investigate the impact of risk factors. Finally, the combination of a relatively low population prevalence and imperfect test specificity could have led to some false-positives, inflating the apparent FeLV prevalence. However, without the use of PCR tests, regressive infections would have been missed, increasing uncertainty around the FeLV prevalence estimates.

**Conclusions**

These findings suggest that within the cats at BACH (shelter A), neither FIV nor FeLV prevalence markedly changed over the ten years before data collection. This implies that factors such as FeLV vaccination and neutering coverage could be improved on in this population of cats, although it is also important to note that in both populations, FeLV infection was relatively uncommon. Initiatives to improve feline welfare and control overpopulation have been instigated over recent years, including a move to prepubertal neutering and multiagency approaches to engage hard-to-reach owners, and outcomes from such projects should be closely monitored to determine where resources can be used for maximum impact. In the study population, being male, presence of fight wounds and abscesses and clinical signs of cat flu were associated with seropositivity for FIV infection. Thin body condition and signs of musculoskeletal disease were associated with increased risk of testing FeLV-positive. These factors could be used to prioritise at-risk cats for testing, informing the use of FIV and FeLV tests within a charity context, to maximise clinical signs consistent with cat flu were also associated with increased risk of FIV seropositivity, presumably due to immunosuppression in the presence of near-ubiquitous respiratory pathogens. This factor was eventually excluded from the multivariable model; however this may be worthy of further investigation, as an association with cat flu would agree with previous findings and may be useful in guiding choices about which cats to test.

For cats testing positive for FeLV, being thin on presentation (Body Condition Score [BCS] <3/5) was significantly associated with infection (odds ratio (OR) 11.8, 95 per cent CI 3.8 to 37.1). Presence of musculoskeletal disease, such as lameness or fractures, was also identified as a risk factor (OR 4.0, 95 per cent CI 1.3, 12.5) and again may reflect a link with risky behaviours such as roaming and fighting. Again, FeLV-positive cats were typically older than the remainder of the study population, with a mean age of 4.75 years. While a little older than FeLV-positive populations in previous studies, this finding is broadly consistent with previous data showing the highest FeLV prevalence to be in young to middle-aged adults. However, the complex interplay of the risk of infection, a cat’s immune response and the curtailed lifespan of progressively infected cats make it difficult to generalise about the interaction between risk of FeLV infection and age on a population basis.

Limitations must be considered when interpreting these data. The results were collected over a year, from two shelters recruited on a convenience basis. Therefore, they may not be representative of all such organisations. Data were collected retrospectively, meaning that some information was missing. This may have caused an underestimation of prevalence, as animals sick enough to be euthanased without testing, soon after presentation, may have been at increased risk of infection. Similarly, missing data, either due to incomplete recording of test results or regarding specific clinical signs, could have potentially affected study power, although the effect of this is difficult to quantify. Animal origin (stray, relinquished, etc) was too inconsistently recorded to be included in the analysis. This incompleteness is reflected in the relative low R² values for both models, which suggests the importance of other, unmeasured factors is significant.

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Competing interests None declared.

Ethics approval This project has been ethically reviewed and approved by a panel at The University of Nottingham School of Veterinary Medicine and Science.

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