Journal of Feline Medicine and Surgery (2008) **10**, 300–316
doi:10.1016/j.jfms.2008.03.002

ELSEVIER

jfms

2008 American Association of Feline Practitioners' feline retrovirus management guidelines

Julie Levy DVM, PhD, Dipl ACVIM[1]*, **Cynda Crawford** DVM, PhD[1], **Katrin Hartmann** Dr Med Vet, Dr Habil, Dipl ECVIM-CA[2], **Regina Hofmann-Lehmann** Dr Med Vet, Dr Habil, FVH[3], **Susan Little** DVM, Dipl ABVP (Feline Practice)[4], **Eliza Sundahl** DVM, Dipl ABVP (Feline Practice)[5], **Vicki Thayer** DVM, Dipl ABVP (Feline Practice)[6]

[1]*Department of Small Animal Clinical Sciences, College of Veterinary Medicine, University of Florida, Gainesville, FL 32610, United States*
[2]*Clinic of Small Animal Medicine, Ludwig Maximilian University Munich, Veterinaerstrasse 13, 80539 Munich, Germany*
[3]*Vetsuisse Faculty, University of Zurich, Zurich, Switzerland*
[4]*Winn Feline Foundation, 1805 Atlantic Avenue, PO Box 1005, Manasquan, NJ 08736-0805, United States*
[5]*KC Cat Clinic, 7107 Main Street, Kansas City, MO 64114, United States*
[6]*Purrfect Practice PC, PO Box 550, Lebanon, OR 97355, United States*

Feline leukemia virus (FeLV) and feline immunodeficiency virus (FIV) are among the most common infectious diseases of cats. Although vaccines are available for both viruses, identification and segregation of infected cats form the cornerstone for preventing new infections. Guidelines in this report have been developed for diagnosis, prevention, treatment, and management of FeLV and FIV infections. All cats should be tested for FeLV and FIV infections at appropriate intervals based on individual risk assessments. This includes testing at the time of acquisition, following exposure to an infected cat or a cat of unknown infection status, prior to vaccination against FeLV or FIV, prior to entering group housing, and when cats become sick. No test is 100% accurate at all times under all conditions; results should be interpreted along with the patient's health and risk factors. Retroviral tests can diagnose only infection, not clinical disease, and cats infected with FeLV or FIV may live for many years. A decision for euthanasia should never be based solely on whether or not the cat is infected. Vaccination against FeLV is highly recommended in kittens. In adult cats, antiretroviral vaccines are considered non-core and should be administered only if a risk assessment indicates they are appropriate. Few large controlled studies have been performed using antiviral or immunomodulating drugs for the treatment of naturally infected cats. More research is needed to identify best practices to improve long-term outcomes following retroviral infections in cats.

Date accepted: 14 March 2008

Epidemiology

Feline leukemia virus (FeLV) and feline immunodeficiency virus (FIV) are among the most common infectious diseases of cats. In the United States, prevalence of both infections is less than 2% of healthy cats and is between 6 and 33% of high-risk cats and cats that are tested during illness (O'Connor et al 1991, Moore et al 2004, Levy et al 2006b). Risk factors for infection include male gender, adulthood, and outdoor access, whereas indoor lifestyle and sterilization are associated with reduced infection rates (Hoover and Mullins 1991, O'Connor et al 1991, Levy 2000, Levy and Crawford 2005, Levy et al 2006b).

The prevalence of FeLV infection has reportedly decreased during the past 20 years, presumably as a result of implementation of widespread testing programs and development of effective vaccines (O'Connor et al 1991, Moore et al 2004, Levy et al 2006b). In contrast, the prevalence of FIV has not changed since the virus was discovered in 1986. Testing for FIV infection is less common, and a vaccine against FIV was not introduced until 2002. Whether the prevalence of FIV infection will change in the future is unknown.

In a study of more than 18,000 cats tested in 2004, 2.3% were positive for FeLV and 2.5%

*Corresponding author. E-mail: levyj@vetmed.ufl.edu

1098-612X/08/030300+17 $34.00/0

were positive for FIV (Levy et al 2006b). For both viruses, prevalence was higher among cats tested at veterinary clinics (FeLV 2.9% and FIV 3.1%) than among cats tested at animal shelters (FeLV 1.5% and FIV 1.7%) and among pet cats that were allowed outdoors (FeLV 3.6% and FIV 4.3%) than among pet cats that were kept strictly indoors (FeLV 1.5% and FIV 0.9%). Infections were higher among sick cats than healthy cats and were highest among sick feral cats (FeLV 15.2% and FIV 18.2%) followed by sick pet cats allowed access to the outdoors (FeLV 7.3% and FIV 8.0%). In contrast, positivity in healthy feral cats (FeLV 1.0% and FIV 3.3%) was less common or similar that in to healthy outdoor pet cats (FeLV 2.6% and FIV 3.2%).

Although infected cats may experience a prolonged period of clinical latency, a variety of disease conditions are associated with retroviral infections, including anemia, lymphoma, chronic inflammatory conditions, and susceptibility to secondary and opportunistic infections (Hoover and Mullins 1991, Levy 2000). Specific disease syndromes are associated with a very high prevalence of retroviral infections, such as cutaneous abscesses (FeLV 8.8% and FIV 12.7%) (Goldkamp et al 2008) and oral inflammation (FeLV 7.3% and FIV 7.9%) (Bellows, unpublished data).

Identification and segregation of infected cats is considered to be the single most effective method for preventing new infections with FeLV and FIV. Despite the availability of point-of-care testing for FeLV and FIV infections and of FeLV and FIV vaccines, less than one quarter of all cats have ever been tested, and infections with these viruses are still common. Although characteristics such as gender, age, lifestyle, and health status can be used to assess the likely risk of FeLV and FIV infections, most cats have some degree of infection risk.

While FeLV and FIV can be life-threatening viruses, proper management and treatment can give infected cats longer, healthier lives. The following guide reflects the recommendations of the American Association of Feline Practitioners (AAFP) on managing these infections.

Pathogenesis

FeLV pathogenesis

FeLV is commonly spread vertically from infected queens to their kittens and horizontally among cats that live together or that fight. The susceptibility of cats to FeLV is believed to be age dependent, but the degree of natural resistance is unknown. In one study, all newborn kittens and the majority of cats up to 2 months of age experimentally infected with FeLV developed progressive FeLV infection, but only 15% of cats inoculated when they were 4 months or older became infected (Hoover et al 1976). More recent studies, however, have demonstrated efficient natural and experimental infection of adult cats (Grant et al 1980, Lehmann et al 1991).

FeLV pathogenesis has been studied for decades using virus culture, immunofluorescent antibody (IFA) assays, and antigen detection (Hoover et al 1975, Hardy et al 1976a, Pedersen et al 1977, Rojko et al 1979, Lutz et al 1980, 1983, Hoover and Mullins 1991, Rojko and Kociba 1991). In most cats, antigenemia (presence of viral proteins in the blood) correlates with viremia (presence of infectious virus that can be cultured from the blood), although a few cats have circulating virus without detectable antigens or antigens without viremia (Jarrett et al 1982). Cats typically acquire FeLV via the oronasal route by mutual grooming but can also acquire the virus through bites. Viremic cats shed infectious virus in multiple body fluids, including saliva, nasal secretions, feces, milk, and urine (Hardy et al 1976b, Pacitti et al 1986). After virus exposure, FeLV can be found first in the local lymphoid tissues; it then spreads via monocytes and lymphocytes into the periphery (Rojko et al 1979).

The outcome of infection with FeLV is currently controversial. In the past, approximately one third of cats were believed to become persistently viremic and up to two thirds to eventually clear the infection (Hoover and Mullins 1991). Newer research suggests that most cats remain infected for life following exposure but may revert to an aviremic state (regressive infection) in which no antigen or culturable virus is present in the blood but in which FeLV proviral DNA can be detected in the blood by polymerase chain reaction (PCR) (Hofmann-Lehmann et al 2001, Torres et al 2005, Pepin et al 2007). The clinical relevance of PCR-positive, antigen-negative cats is not yet clear. The provirus is integrated into the cat's genome, so it is unlikely to be cleared over time (Cattori et al 2006). Although these cats are unlikely to shed infectious virus in saliva, proviral DNA might be infectious via blood transfusion (Chen et al 1998). The continuous presence of provirus might explain the long persistence of virus-neutralizing antibodies in

'recovered' cats. Prior to the development of PCR, a status of 'latent' infection was described in which the absence of antigenemia was accompanied by persistence of culturable virus in bone marrow or other tissues but not in blood (Post and Warren 1980, Rojko et al 1982, Madewell and Jarrett 1983, Pedersen et al 1984, Pacitti and Jarrett 1985, Hofmann-Lehmann et al 2007). The 'latent' infection may be a phase through which cats pass during regressive infection (Boretti et al 2004).

FeLV provirus (DNA) and plasma viral RNA are usually detectable by PCR within 1 week of FeLV exposure, even if FeLV antigen is not. All cats with progressive and regressive infection seem to undergo this phase and to develop similar proviral and plasma viral RNA loads in the peripheral blood during early infection (Hofmann-Lehmann et al 2008). Following FeLV exposure, FeLV infection has four possible outcomes (Torres et al 2005, Hofmann-Lehmann et al 2007, 2008).

In cats with progressive infection, FeLV infection is not contained during early infection, and extensive virus replication occurs first in the lymphoid tissues and then in the bone marrow and in mucosal and glandular epithelial tissues in most infected cats (Rojko et al 1979). Mucosal and glandular infection is associated with excretion of infectious virus in cats with progressive infection. Progressive infection is characterized by insufficient FeLV-specific immunity, and cats frequently succumb to FeLV-associated diseases within a few years.

Regressive infection is accompanied by an effective immune response, and virus replication is contained prior to or at the time of bone marrow infection. Cats with regressive infection are at little risk of developing FeLV-associated diseases. FeLV is integrated into the cat's genome, but viral shedding does not occur (Pedersen et al 1977, Lutz et al 1983, Flynn et al 2000, 2002).

Following infection, regressive and progressive infections can be distinguished by repeated testing for viral antigen in peripheral blood (Torres et al 2005). Most infected cats initially become antigen positive within 2–3 weeks after virus exposure. They may then test negative for viral antigen 2–8 weeks later or, in rare cases, even after many months (regressive infection). Both progressive and regressive infections are almost always accompanied by persistent FeLV proviral DNA in blood. Some infected cats never develop detectable antigenemia. In this case, real-time PCR is more sensitive than antigen detection to detect FeLV exposure.

Abortive exposure has been observed infrequently following experimental FeLV inoculation and is characterized by negative test results for culturable virus, antigen, viral RNA, and proviral DNA after FeLV exposure (Torres et al 2005, 2006).

Focal infections have been reported in early studies. They are rare and occur in cats with FeLV infection restricted to certain tissues, such as the spleen, lymph nodes, small intestine, or mammary glands (Pacitti et al 1986, Hayes et al 1989).

A summary of the various outcomes of FeLV exposure is provided in Table 1.

FIV pathogenesis

FIV is shed in high concentrations in the saliva, which also contains infected leukocytes. The major mode of transmission is via bite wounds. Transmission of FIV from infected queens to their kittens has been reported in laboratory-reared cats (O'Neil et al 1995, Allison and

Table 1. Outcomes of FeLV infection

Outcome of FeLV exposure	FeLV p27 antigen in blood	Viral blood culture	Viral tissue culture	Viral RNA in blood	Proviral DNA in blood	Viral shedding	FeLV-associated disease
Progressive infection	Positive	Positive	Positive	Positive	Positive	Positive	Likely
Regressive infection	Negative or transiently positive	Negative or transiently positive	Negative or transiently positive	Transiently or persistently positive	Positive	Negative	Unlikely
Abortive exposure	Negative	Negative	Negative	Not tested	Negative	Negative	Unlikely
Focal infection	Negative	Negative	Positive	Not tested	Not tested	Variable	Unlikely

Hoover 2003), but this appears to be an uncommon event in nature (Ueland and Nesse 1992, Pu et al 1995). Although transmission among household cats that do not fight is uncommon, it is still possible. In one household of 26 cats that were not observed to fight, FIV infection was originally diagnosed in nine cats, but spread to six other cats during a 10-year observation period (O'Neil et al 1995, Addie et al 2000). Sexual transmission, the most common mode of transmission of human immunodeficiency virus (HIV), appears to be unusual in FIV, even though the semen of infected cats frequently contains infectious virus (Jordan et al 1998).

Acute FIV infection is associated with transient fever, lymphadenopathy, and leukopenia but frequently goes unnoticed by cat owners. Virus is detected in high concentrations in the blood by culture and PCR within 2 weeks of infection. Within the first few weeks of FIV infection, both CD4+ (helper) and CD8+ (cytotoxic-suppressor) T-lymphocytes decline (Egberink and Horzinek 1992, Yamamoto et al 2007). The initial lymphopenia is followed by a robust immune response characterized by the production of FIV antibodies, suppression of circulating viral load, and a rebound in CD8+ T-lymphocytes in excess of preinfection levels. This results in inversion of the CD4+:CD8+ T-lymphocyte ratio that is likely to persist for the rest of the cat's life. Over time, both CD4+ and CD8+ T-lymphocytes gradually decline. The immune response is unable to eliminate infection, and the cat remains infected for life.

Following the primary illness, cats enter a prolonged asymptomatic period that may last for years. During this time, progressive dysfunction of the immune system occurs. Although chronic inflammatory conditions and opportunistic infections are more common in cats with low CD4+ T-lymphocyte counts, some cats with severe CD4+ T-lymphocytopenia remain healthy. That cell-mediated immunity is more profoundly affected than humoral immunity is generally recognized. Chronic inflammatory conditions, neoplasia, and infections with intracellular organisms, therefore, are more common than infections controlled by antibodies in FIV-infected cats. FIV-infected cats also appear to respond adequately to vaccination. Polyclonal hyperglobulinemia characteristic of non-specific stimulation of humoral immunity is common in cats with chronic FIV infection. In human HIV infections, distinctive clinical stages can be defined based on absolute CD4+ T-lymphocyte counts and plasma viral RNA load. Similar systems have been attempted for staging FIV infections but are not as clearly defined (Walker et al 1996, Goto et al 2002).

Diagnosis of FeLV and FIV

The retroviral status of all cats should be known because the serious health consequences of infection influence patient management both in illness and wellness care. Accurate diagnosis of infection is important for both uninfected and infected cats. Identification and segregation of infected cats is considered to be the most effective method for preventing new infections in other cats. Failure to identify infected cats may lead to inadvertent exposure and transmission to uninfected cats. Misdiagnosis of infection in uninfected cats may lead to inappropriate changes in lifestyle or even euthanasia.

Cats may require retrovirus testing at different times in their lives. For example, cats that meet the following criteria should be tested for FeLV and FIV infections:

- Sick cats should be tested even if they have tested negative in the past.
- Cats and kittens should be tested when they are first acquired.
  - Even cats that are not expected to live with other cats should be tested for several reasons, including the impact on their health, the possibility of other cats joining the household, and the possibility that cats confined indoors may escape and be exposed to other cats.
  - Tests should be performed at adoption, and negative cats should be retested a minimum of 60 days later.
- Cats with known recent exposure to a retrovirus-infected cat or to a cat with unknown status, particularly via a bite wound, should be tested regardless of previous test results.
  - Testing should be carried out immediately and, if negative, should be repeated after a minimum of 30 days for FeLV and after a minimum of 60 days for FIV. When the type of possible viral exposure is unknown, retesting for both viruses after 60 days is most practical.
- Cats living in households with other cats infected with FeLV or FIV should be tested on an annual basis unless they are isolated.
- Cats with high-risk lifestyles (eg, cats that have access to the outdoors in cat-dense neighborhoods and cats with evidence of

fighting such as bite wounds and abscesses) should be tested on a regular basis.
- Cats should be tested before initial vaccination against FeLV or FIV.
- Cats used for blood or tissue donation should have negative screening tests for FeLV and FIV in addition to negative real-time PCR test results.
- Intermittent retesting is not necessary for cats with confirmed negative infection status unless they have an opportunity for exposure to infected cats or they become ill.

Diagnosis of FeLV

Routine diagnostic screening for FeLV relies on detection of the core viral antigen p27, which is produced abundantly in most infected cats. In-clinic test kits detect soluble circulating antigen in peripheral blood. In the early days of testing, results were more reliable when serum or plasma rather than whole blood was tested (Barr 1996). However, with improvements in test technologies, anticoagulated whole blood now appears also to be a suitable sample for testing (Hartmann et al 2007). Antigen tests should not be performed on tears or saliva because these tests are prone to more errors (Hawkins et al 1986, Lutz and Jarrett 1987, Hawkins 1991). Soluble antigen tests can detect infection during the early primary viremia phase. Most cats will test positive with soluble antigen tests within 30 days of exposure (Jarrett et al 1982), however, development of antigenemia is extremely variable and may take considerably longer in some cats. When the results of soluble antigen testing are negative but recent infection cannot be ruled out, testing should be repeated a minimum of 30 days after the last potential exposure. Alternatively, PCR can be performed on anticoagulated whole blood to detect provirus. PCR is usually positive sooner than p27 antigen detection. Kittens may be tested at any time because passively acquired maternal antibody does not interfere with testing for viral antigen. However, kittens infected as a result of maternal transmission may not test positive for weeks to months after birth (Levy and Crawford 2005).

IFA tests on blood or bone marrow smears detect viral p27 antigen within infected blood cells. IFA tests do not detect infection until secondary viremia is established once bone marrow is infected. False-negative IFA results may occur in leukopenic cats. Cats that have regressive infection and cats that resist bone marrow infection also have negative IFA test results. False-positive results may occur when smears are too thick, when background fluorescence is high, and when the test is prepared and interpreted by inexperienced personnel.

Because the consequences of a positive screening test are significant, confirmatory testing is recommended, especially in low-risk and asymptomatic patients in which the possibility of a false-positive result is higher (low positive predictive value) (Jacobson 1991). Negative screening test results are highly reliable due to the high sensitivity of the tests and low prevalence of infection (high negative predictive value).

Several options for confirmation of a positive screening test are available. Virus culture is the gold standard for identification of progressive FeLV infection but is not routinely available in North America. A second soluble antigen test can be performed, preferably using a test from a different manufacturer (Barr 1996, Hartmann et al 2001). Some cats may be only transiently antigenemic and may revert to negative status on soluble antigen tests (regressive infection) (Barr 1996). A positive IFA test on blood or bone marrow indicates a cat is likely to remain persistently antigenemic.

Discordant antigen test results may occur when results of soluble antigen tests and/or IFA tests do not agree and may make determination of the true FeLV status of a cat difficult. The most common scenario is with a positive soluble antigen test and a negative IFA test. In most cases, such cats are truly infected. Discordant results may be due to the stage of infection, the variability of host responses, or technical problems with testing. The status of the cat with discordant results may eventually become clear by repeating both tests in 60 days and annually thereafter until the test results agree. Cats with discordant test results are best considered potential sources of infection for other cats until their status is clarified.

PCR testing is offered by a number of commercial laboratories for the diagnosis of FeLV. Technical errors can reduce the sensitivity and specificity of PCR results. At this time, no comparative studies of the diagnostic accuracy of different commercial laboratories offering FeLV PCR have been completed. When performed under optimal conditions, real-time PCR can be the most sensitive test methodology for FeLV and can help resolve cases in which discordant serological test results have been obtained. Depending on how the PCR is performed, it can detect

viral RNA or cell-associated DNA (provirus) and can be performed on blood, bone marrow, and tissues. In addition, PCR testing of saliva has been shown to have high correlation with blood antigen tests (Gomes-Keller et al 2006a,b). Recent studies using real-time PCR have shown that 5–10% of cats negative on soluble antigen tests were positive for FeLV provirus by PCR (regressive infection) (Hofmann-Lehmann et al 2001, Gomes-Keller et al 2006a). Although the clinical significance of antigen-negative, PCR proviral DNA-positive status is still unknown, most such cats appear to remain aviremic and nonantigenemic, do not shed virus, and are unlikely to develop FeLV-associated diseases. Because FeLV provirus is infectious (Chen et al 1998), all feline blood donors should be tested for FeLV antigen by serology and for provirus by real-time PCR.

Vaccination against FeLV does not generally compromise testing, because FeLV tests detect antigen and not antibodies. However, blood collected immediately following vaccination may contain detectable FeLV antigens from the vaccine itself, so diagnostic samples should be collected prior to FeLV vaccine administration (Levy, unpublished data). How long this test interference persists is not known.

Diagnosis of FIV

Cats infected with FIV have low viral loads throughout most of their lives. Thus, development of rapid, in-clinic screening assays based on antigen detection has not been possible. FIV produces a persistent, life-long infection, so detection of antibodies in peripheral blood has been judged sufficient for routine diagnostic screening if the cat has not been previously vaccinated against FIV (Hartmann 1998, Levy et al 2004). In-clinic test kits detect antibodies to different viral antigens, most commonly p24. Most cats produce antibodies to FIV within 60 days of exposure, but development of detectable antibodies may be considerably delayed in some cats (Barr 1996). A recent study showed that the performance of a patient-side FIV/FeLV test kit for the detection of FIV infection was highly accurate (Levy et al 2004). When the results of antibody testing are negative but recent infection cannot be ruled out, testing should be repeated a minimum of 60 days after the last potential exposure.

Because the consequences of a positive screening test are significant, confirmatory testing is recommended, especially in low-risk and asymptomatic patients where the possibility of a false-positive result is higher (Jacobson 1991). Negative screening test results are highly reliable due to the high sensitivity of the tests and the low prevalence of infection in most populations. Several options are available for confirmation of a positive screening test. Virus culture is the gold standard for identification of FIV infection but is not routinely available in North America. A second soluble antibody test can be performed, preferably using a test from a different manufacturer (Barr 1996, Hartmann et al 2001). Western blot and IFA detect antibodies against a range of viral antigens but were found to be less sensitive and specific than in-clinic screening tests in one study (Levy et al 2004).

The release of the first FIV vaccine (Fel-O-Vax FIV; Fort Dodge Animal Health) has complicated the ability of veterinary practitioners to diagnose FIV infections. Vaccinated cats produce antibodies that cannot be distinguished, by any current commercially available antibody test, from antibodies induced by natural infection (Levy et al 2004). These antibodies are usually detected within a few weeks of vaccination. Vaccine-induced antibodies have been shown to persist for more than 4 years in some cats (Levy, unpublished data).

In this situation, determining whether a positive FIV antibody test means the cat is truly infected with FIV, is vaccinated against FIV but not infected, or is vaccinated against FIV and also infected might be difficult. Recently, an experimental method of enzyme-linked immunosorbent assay (ELISA) testing that detects antibodies to multiple FIV antigens was developed in Japan (Kusuhara et al 2007). Using this method, researchers were able to distinguish FIV-vaccinated cats from FIV-infected cats with a high degree of accuracy when testing serum samples from cats in both the United States and Canada (Levy et al 2008). This test, however, is not yet commercially available in North America.

PCR has been promoted as a method to determine a cat's true status, but investigation of the sensitivity and specificity of the FIV PCR tests offered by some laboratories has shown widely variable results (Bienzle et al 2004). In one study, test sensitivities (the ability to detect true positives) ranged from 41 to 93%, and test specificities (the ability to detect true negatives) ranged from 81 to 100% (Crawford et al 2005). Unexpectedly, false-positive results were higher in FIV-vaccinated cats than in unvaccinated cats.

Research is being focused on improving the diagnostic accuracy of PCR for FIV.

Positive FIV antibody tests in kittens under 6 months of age must be carefully interpreted. Antibodies from FIV-vaccinated queens are passed to kittens that nurse on vaccinated queens (MacDonald et al 2004). These vaccine-associated antibodies persist past the age of weaning (8 weeks) in more than half of kittens. Kittens born to infected queens or FIV-vaccinated queens also acquire FIV antibodies in colostrum. Because kittens do not commonly become infected with FIV, most kittens that test positive for FIV antibodies are not truly infected and will test negative when re-evaluated several months later. Although FIV infection of kittens is uncommon, it does occasionally occur, and kittens with FIV antibodies when over 6 months of age are considered to be infected. Delaying testing of kittens for FIV until they are over 6 months of age may be tempting. However, the vast majority of kittens test negative at any age and can be declared free of FIV infection. Infected kittens, on the other hand, could be a source of infection for other cats if they are not identified and segregated. Also, compliance by both owners and veterinarians with retroviral testing recommendations remains low, and delaying testing of newly acquired kittens would likely result in a large number of cats never receiving FIV tests (Goldkamp et al 2008).

Prevention of FeLV and FIV

Maximizing prevention of retrovirus infection can be accomplished through a partnership between veterinarians and pet owners. Testing and vaccination protocols, staff education, client reminder programs, and pet owner educational efforts can help contain the spread of these infections.

Traditionally, FeLV infection has been viewed as primarily a concern for cats that are 'friendly' with other cats, because close, intimate contact between cats facilitates transmission. This type of contact occurs among cats as a result of nursing, mutual grooming, and sharing of food, water, and litter pans. In contrast, FIV infection had been viewed as a concern for cats that are 'unfriendly' with other cats, because the major mode of transmission is through bite wounds. In reality, both viruses can be spread among cats that are not known to fight as well as those that are prone to aggressive behavior (Addie et al 2000, Goldkamp et al 2008).

FeLV vaccination

Several injectable inactivated adjuvanted vaccines, a non-adjuvanted recombinant vaccine for transdermal administration (available in the United States), and an injectable non-adjuvanted recombinant FeLV vaccine (a different preparation from the United States product and available in Europe) are commercially available. Reviews of independent studies of vaccine efficacy indicate that the ability of any particular vaccine brand to induce an immune response sufficient to resist persistent viremia varies considerably between studies (Sparkes 1997, 2003). Results of several studies indicate that FeLV vaccine-induced immunity persists for at least 12 months following vaccination, although the actual duration of immunity is unknown and may be longer (Hofmann-Lehmann et al 1995, Hoover et al 1996, Harbour et al 2002).

Because sufficient protection is not induced in all vaccinates, vaccination against FeLV does not diminish the importance of testing cats to identify and isolate those that are viremic. Therefore, the FeLV infection status of all cats, including vaccinated cats, should be determined. In addition, cats should be tested for FeLV infection before initial vaccination and whenever the possibility exists that they have been exposed to FeLV since they were last vaccinated. Administering FeLV vaccines to cats confirmed to be FeLV-infected is of no value.

FeLV vaccines should be considered non-core vaccines and are recommended for cats at risk of exposure (eg, cats permitted outdoors, cats residing in multiple-cat environments in which incoming cats are not tested prior to entry, cats living with FeLV-infected cats). However, vaccination of all kittens is highly recommended because the lifestyles of kittens frequently change after acquisition and they may subsequently become at risk of FeLV exposure (Richards et al 2006). Kittens are also more likely than adult cats to develop progressive infections if exposed to FeLV.

When FeLV vaccination is determined to be appropriate, a two-dose primary series is recommended, with the first dose administered as early as 8 weeks of age followed by a second dose administered 3–4 weeks later. A single booster vaccination should be administered 1 year following completion of the initial series and then annually in cats as long as they remain at risk of exposure.

Although FeLV vaccines have been shown to protect against progressive infection to various

degrees, they do not appear to prevent infection. Using real-time PCR, vaccinated cats were found to become positive for circulating proviral DNA as well as plasma viral RNA subsequent to FeLV exposure, even though they did not develop persistent viremia (Torres et al 2005, Hofmann-Lehmann et al 2006, 2007). Thus, FeLV vaccination does not necessarily induce sterilizing immunity. Nonetheless, efficacious FeLV vaccines are of great clinical importance because protection against persistent viremia may prevent FeLV-associated fatal diseases.

FIV vaccination

FIV has proven to be a difficult agent to immunize against, in part because FIV vaccines do not induce broad cross-protective immunity against viruses from other strains or clades. Only a single vaccine is currently available for prevention of FIV infection. The vaccine is a whole-virus, dual subtype (clades A and D), inactivated product combined with an adjuvant. The vaccine is licensed for the vaccination of healthy cats 8 weeks of age or older as an aid in the prevention of infection with FIV. In licensing trials required by the United States Department of Agriculture, when cats were challenged with a heterologous clade A FIV subtype 1 year after the initial vaccination series, the vaccine yielded a preventable fraction (defined as the proportion of cats protected by vaccination in excess of the proportion that is naturally resistant) of 82% (Huang et al 2004). Results of two subsequent studies indicate 100% protection against infection with two subtype B FIV strains (Kusuhara et al 2005, Pu et al 2005). Results of a third study in which cats were challenged with subtype A FIV indicated that all vaccinated cats and control cats became infected (Dunham et al 2006).

FIV vaccines are non-core vaccines and may be considered for cats whose lifestyles put them at high-risk of infection, such as outdoor cats that fight or cats living with FIV-infected cats. An initial series of three doses is administered subcutaneously 2–3 weeks apart. Annual revaccination is recommended subsequent to the initial series if the risk of infection continues.

Clients should be informed that vaccinated cats will have positive FIV test results, and the decision to vaccinate should be reached only after careful consideration of this implication. If the decision falls in favor of vaccination, cats should test negative immediately prior to vaccination. A permanently placed identification microchip and collar are recommended for all cats to increase the chance of returning lost cats to their owners. Microchip databases can also record FIV vaccination histories. This information can be used by animal shelters to help assess the significance of positive FIV test results when shelters screen cats prior to adoption.

Limiting transmission in the veterinary practice

Retroviruses are unstable outside their host animals and can be quickly inactivated by detergents and common hospital disinfectants (Francis et al 1979, August 1991, van Engelenburg et al 2002, Moorer 2003, Kramer et al 2006, Terpstra et al 2007). However, retroviruses in dried biological deposits can remain viable for more than a week. Simple precautions and routine cleaning procedures will prevent transmission of these agents in veterinary hospitals. All infected patients should be housed in individual cages and may be maintained in this manner in the general hospital population. Because they may be immune-suppressed, they should not be housed in an isolation ward with cats carrying contagious diseases.

Animal caretakers and other hospital staff members should wash their hands between patients and after handling animals and cleaning cages. Both FeLV and FIV can be transmitted in blood transfusions. Therefore, all blood donors should be confirmed free of infection (Wardrop et al 2005).

Dental and surgical instruments, endotracheal tubes, and other items potentially contaminated with body fluids should be thoroughly cleaned and sterilized between uses (Druce et al 1997). Fluid lines, multi-dose medication containers, and food can become contaminated with body fluids (especially blood or saliva), and should not be shared among patients.

Limiting transmission at home

FeLV-infected cats should be confined indoors so they do not pose a risk of infection to other cats and so that they are protected against infectious hazards in the environment. If a FeLV-positive cat is identified in a household, the best method of preventing spread to other cats in the household is to isolate the infected cat in a separate room and to prevent the infected cat from interacting with its housemates. A simple screen or chain-link barrier is adequate to prevent viral transmission in the laboratory setting (Levy, unpublished data).

If owners choose not to separate housemates, uninfected cats should be vaccinated against FeLV in an attempt to enhance their natural level of immunity. The cats should be kept separated until at least 2 months after completion of the primary immunization series to allow time for effective immunity to develop. However, no FeLV vaccine protects 100% of cats against FeLV infection. FeLV can be transmitted vertically from an infected queen to her kittens in utero or via infected milk. Infected queens should not be bred and should be spayed if their condition is sufficiently stable to permit them to undergo surgery.

Generally, cats in households with stable social structures where housemates do not fight are at a low-risk for acquiring FIV infection, but a high rate of transmission within a household without observed fighting has been reported (Addie et al 2000). Therefore, separation of infected cats from uninfected housemates is recommended to eliminate the potential for FIV transmission. If separation is not possible, and to reduce the risk of territorial aggression, no new cats should be introduced in the household. Experimentally, FIV has been shown to be vertically transmitted by infected queens to their kittens (Pu et al 1995, O'Neil et al 1995, Allison et al 2003). Although this is apparently true only for a few specific strains of FIV and is uncommon in nature, infected queens should not be bred and should be spayed if their condition is sufficiently stable to permit them to undergo surgery.

Considerations for breeding catteries

The prevalence of retrovirus infections in the controlled environments of catteries appears to be low, particularly since the advent of test and removal programs for FeLV in the 1970s. However, ongoing vigilance is required to prevent introduction of FeLV or FIV into the cattery. Certain circumstances in catteries facilitate transmission of infectious diseases, such as group living, mingling of kittens with older cats, close contact of cats during mating, the occasional introduction of new cats, and the practice of sending queens to other catteries for breeding.

Only healthy cats should be used for breeding, and the retrovirus status of all cats in the cattery should be known (whether breeding or nonbreeding). When testing is performed in the cattery for the first time, all cats should test negative on two tests, 60 days apart. Infected cats should be removed from the cattery. All newly acquired kittens and cats should be placed in isolation and tested for FeLV and FIV on arrival. Ideally, they should remain isolated until a second negative test is obtained 60 days later, particularly if they originate from a cattery with unknown retrovirus status.

Queens sent to another facility for mating should be tested before leaving the cattery and should be sent to mate only with a tom that has tested negative for FeLV and FIV. Upon return to the home cattery, the queen should be kept in isolation and retested in 60 days.

Cat shows are not significant sources of retrovirus infection, because cats on exhibition are housed separately and the viruses are susceptible to the disinfectants that are commonly employed. In addition, environmental contamination of surfaces is not a risk due to the fragile nature of retroviruses. Therefore, cats that have left the cattery solely for the purpose of a cat show do not need to be retested.

In catteries that follow testing guidelines and maintain retrovirus-negative status, vaccination against FeLV or FIV is not necessary, as long as no cats have access to the outdoors. Time and resources should be focused on maintaining a retrovirus-negative cattery through testing. Some catteries do not maintain breeding toms, and rely totally on stud services from other catteries. In such circumstances, vaccination of queens against FeLV may be considered in addition to testing of queens that leave the cattery for stud service. Vaccination against FIV is not recommended, because the infection is uncommon in catteries and vaccination interferes with current test methodologies.

Considerations for cat shelters

Although the prevalence of FeLV and FIV in shelters mirrors the relatively low rates found in pet cats, thousands of infected cats are likely to pass through shelters each year (Levy et al 2006b). Shelters should have policies in place for testing, prevention, and responding to positive test results.

The sheltering industry is currently in a state of flux as growing support for 'no kill' policies stimulates discussion about what constitutes an 'untreatable' or 'unsavable' animal. Using the strictest definition of euthanasia as an act of mercy for alleviating unremitting suffering, a growing number of shelters are classifying healthy FeLV-infected and FIV-infected cats as adoptable. This has created new challenges for

shelter facilities, because finding homes for infected cats often takes longer. When shelter space is limited, longer resident times may lead to lower overall adoption rates. Sanctuaries devoted to long-term care of infected cats have been developed as an alternative and present their own set of challenges for optimal care and environmental enrichment.

Although this document broadly recommends testing all cats for retroviral infection, an exception exists for feral cats in trap-neuter-return (TNR) programs. The prevalence of infection is similar in outdoor pet cats and feral cats; so feral cats do not present an increased threat to pets (Levy et al 2006b). Additionally, neutering reduces two common modes of transmission: queen to kitten for FeLV and fighting among males for both FeLV and FIV (Levy 2000, Levy and Crawford 2005). Because population control of feral cats requires commitment to neutering the largest number of cats possible, many TNR programs do not routinely test feral cats (Wallace and Levy 2006).

Testing for FeLV and FIV in shelters

Diagnosis of FeLV and FIV in shelter situations follows the same principles as in pet cats. Ideally, all cats would be tested upon entry to the shelter or prior to adoption. All cats entering shelters should be considered potentially infected, regardless of the environment from which they originated. Because the background of most shelter cats is unknown, retesting cats 60 days after the initial test in case of recent exposure is advisable. This also applies to unweaned orphaned kittens, which may have been infected from the queen or another cat but test negative at the time of admission to the shelter. These kittens should be retested prior to adoption. Cats that are returned to the shelter following a failed adoption should also be retested.

Although screening tests are commonly used in shelters, confirmatory tests pose a greater challenge. Increased costs, delays, and difficulty in interpreting discordant results are reasons many shelters do not pursue confirmatory testing. Currently, the inability to distinguish FIV-vaccinated cats from those that are infected or both vaccinated and infected is a major concern for shelters.

Testing at admission is optional for cats that are housed in single-cat cages. Some shelters routinely test cats at the time of adoption instead of at admission, particularly if a substantial proportion of cats are not expected to be adopted. In some situations, limited shelter resources do not permit testing of all cats for both FeLV and FIV prior to adoption. In such cases, shelters may place priorities on testing higher-risk cats such as sick cats, adult males, and cats suspected to be exposed to infected cats. If limited testing or no testing is employed, cats should be housed singly and post-adoption testing recommended. In such cases, the AAFP recommendation to test all newly adopted cats should be clearly explained and documented to the adopter. Arrangements should be made by the adopter to have the new pet tested by his or her own veterinarian as soon as possible. The new pet should be kept separate from other cats until the test result is known and preferably until a second test is performed 60 days later. Although the vast majority of sheltered cats are free of infection, post-adoption testing is likely to result in some new pet owners confronting difficult decisions about what to do with a newly adopted cat that is subsequently diagnosed with a retrovirus infection. If one cat in a litter or group is later reported to be infected, the adopters of other cats with exposure to the infected cat should be contacted and informed.

Cats should have negative test results for both FeLV and FIV prior to being introduced to group housing. A quarantine period of 60 days followed by retesting prior to introduction to the group is ideal but not always practical in a shelter setting. Resident cats in foster homes should be tested before foster cats are added to the household.

In shelters or sanctuaries that group-house large numbers of cats for long periods, annual retesting of resident cats is a good practice. Cats kept in multi-cat environments with cats of unknown background constitute a high-risk population even if all of the cats are tested when they are first added to the group. Because tests are not 100% accurate, a cat could be admitted to the group with an undiagnosed infection.

The presence of infection varies within individual litters, feral cat colonies, and households. Some shelters attempt to conserve resources by testing only a queen and not her kittens or by testing only a few members of a litter or household. Testing one cat as a proxy for another is inappropriate, however, and shelter medical records should individually identify each cat and accurately reflect the actual testing procedures performed. Testing a small number of cats within a colony to determine whether

FeLV or FIV is present is also inappropriate, because the prevalence of retroviral infections is low even among feral cats (Levy et al 2006b).

Because currently no test can distinguish FIV antibodies induced by infection compared to those induced by vaccination, shelters have the difficult task of determining the true infection status of stray cats that are admitted without medical histories and that test positive for FIV antibodies. In some cases, the history of FIV vaccination may be recorded in a microchip database that can be accessed if the cat is microchipped. However, even if cats are known to have been vaccinated against FIV, determining whether they are not also infected is not usually possible. This is a challenge for shelters for which no current solution exists.

Test procedures must be performed as indicated by the manufacturer to maintain accuracy. Procedures such as pooling multiple samples for use in a single test reduce test sensitivity and should not be performed.

Testing recommendations:

- Ideally, all cats in shelters will be tested for FeLV and FIV.
- Testing at admission is optional for singly housed cats.
- Testing is highly recommended for group-housed cats.
- Testing, if not performed prior to adoption, should be recommended to the new owner before the cat is exposed to other cats.
- Testing should be repeated 60 days after the initial test and annually for cats kept in long-term group housing.
- Testing one cat as a proxy for another or pooling samples from multiple cats for testing is inappropriate. Each cat should be individually tested.
- Testing of both foster families' and adopters' own resident cats should occur prior to fostering or adopting a new cat.
- Testing is optional in feral cat TNR programs.

Prevention of FeLV and FIV transmission in shelters

FeLV and FIV differ from other infectious diseases of importance in shelters, such as panleukopenia virus, calicivirus, and herpesvirus, because the retroviruses are easily inactivated with routine disinfection and are not spread by indirect contact. However, FeLV and FIV are efficiently transmitted iatrogenically by small amounts of contaminated body fluids, particularly blood and saliva (Druce et al 1997). For this reason, surgical instruments and needles should never be shared between cats, even those within the same litter, without effective sterilization. Similarly, all endotracheal tubes, breathing circuits, dental instruments, and other potentially contaminated equipment should be disinfected between each patient, even among cats from the same environment or litter.

Vaccination against FeLV is generally not recommended in shelters in which cats are individually housed, because of the low-risk of viral transmission. In such shelters, resources are generally better spent on testing, and the decision to vaccinate is best left to the adopter and the cat's new veterinarian based on the cat's risk profile in its new home. In facilities in which cats are group-housed, such as in some shelters and foster homes, FeLV vaccination is highly recommended. High turnover of cats from multiple unknown backgrounds increases the risk for FeLV transmission in group housing and foster homes, especially when quarantine and retesting at a later time is not possible.

For the same reason, vaccination against FIV is not generally recommended in typical single-cat housing. In addition, vaccine-induced positive antibody test results make future confirmation of the true FIV infection status of vaccinated cats difficult for shelters.

Control recommendations:

- FeLV vaccination is optional for singly housed cats.
- FeLV vaccination is highly recommended for all cats housed in groups and for both foster cats and permanent residents in foster homes.
- Cats should test negative for FeLV prior to vaccination.
- Vaccination is not 100% effective against FeLV and should never be used in place of a test-and-segregate program.
- In contrast to the case for feline panleukopenia, herpesvirus, and calicivirus vaccines, the value of a single FeLV vaccine has not been determined. Therefore, FeLV vaccination is not recommended for feral cat TNR programs if program resources are needed for higher priorities.
- FIV vaccination is not recommended for use in shelters.
- Strict adherence to universal precautions is required to prevent iatrogenic transmission of retroviruses in the shelter environment via contaminated equipment and secretions.

- Cats used for blood donation in shelters should be proved free of retroviral infection prior to donating blood.

Management of retrovirus-infected cats

Both FeLV-infected and FIV-infected cats can live many years with proper care and may succumb at older ages from causes unrelated to their retrovirus infections. Long-term monitoring of a 26-cat household with endemic FeLV and FIV revealed that all FeLV-infected cats died within 5 years of diagnosis, but FIV infection did not affect survival in this group (Addie et al 2000). A large study compared the survival of more than 1000 FIV-infected cats to more than 8000 age- and sex-matched uninfected control cats (Levy et al 2006a). Of cats that were not euthanased around the time of diagnosis, the median survival of the FIV-infected cats was 4.9 years compared to 6.0 years for the control cats. A comparison between more than 800 FeLV-infected cats and 7000 controls revealed that the median survival of FeLV-infected cats was 2.4 years compared to 6.3 years for controls (Levy et al 2006a). With proper care, many retrovirus-infected cats may live for several years with good quality of life. Thus, a decision for treatment or for euthanasia should never be based solely on the presence of a retrovirus infection.

FIV- and FeLV-infected cats are subject to the same diseases that befall cats free of those infections, and a disease diagnosed in a retrovirus-infected cat may not be related to the retrovirus infection (Levy 2000, Levy and Crawford 2005). However, in all cats, healthy or sick, FIV and FeLV status should be known because the presence of a retrovirus infection impacts their health status and long-term management.

Cats infected with FIV, FeLV, or both should be confined indoors to prevent spread to other cats in the neighborhood and exposure of affected cats to infectious agents carried by other animals. Good nutrition, husbandry, and an enriched lifestyle are essential to maintain good health (August 1991, Overall et al 2005). The cats should be fed a nutritionally balanced and complete feline diet. Raw meat and dairy products should be avoided because the risk of food-borne bacterial and parasitic diseases is greater in immunosuppressed individuals. A program for routine control of gastrointestinal parasites, ectoparasites, and heartworms, where applicable, should be implemented (Companion Animal Parasite Council 2007).

Cats infected with a retrovirus should receive wellness visits at least semiannually to promptly detect changes in their health status. Veterinarians should obtain a detailed history to help identify changes requiring more intensive investigation and should perform a thorough physical examination at each visit. Special attention should be paid to the oral cavity because dental and gum diseases are common in retrovirus-infected cats (Bellows, unpublished data). Lymph nodes should be evaluated for changes in size and shape. All cats should receive a thorough examination of the anterior and posterior segments of the eye (Willis 2000). The skin should be examined closely for evidence of external parasitic infestations, fungal diseases, and neoplastic changes. Body weight should be accurately measured and recorded because weight loss is often the first sign of deterioration in a cat's condition.

A complete blood count should be performed annually for FIV-infected cats and at least semiannually for FeLV-infected cats because of the greater frequency of virus-related hematologic disorders in FeLV-infected cats. Serum biochemical analyses and urinalyses should be performed annually for both FeLV and FIV infections; urine samples should be collected by cystocentesis so that bacterial cultures can be performed if indicated. Fecal examinations should be performed for cats with a history of possible exposure to gastrointestinal parasites or pathogens.

'Routine vaccination' of retrovirus-infected cats is a subject of debate. Although little evidence suggests modified live-virus vaccines are problematic, inactivated vaccines are recommended because live-virus vaccines theoretically might regain their pathogenicity in immune-suppressed animals (Buonavoglia et al 1993, Reubel et al 1994, Richards et al 2006). Healthy FIV-infected cats have been shown to have similarly adequate immune responses to vaccination compared to uninfected cats (Dawson et al 1991, Lehmann et al 1991, Fischer et al 2007). Vaccination of FIV-infected cats may lead to stimulation of the immune system and subsequent increased FIV replication, although the clinical significance of this observation is unknown (Lehmann et al 1992, Reubel et al 1994). Some cats infected with FeLV may not adequately respond to vaccination (Franchini 1990). In general, vaccine selection and immunization intervals for cats with FeLV or FIV infection should be selected based

on individual risk assessments using guidelines developed for cats in general (Richards et al 2006).

Sexually intact male and female cats should be neutered to reduce stress associated with estrus and mating behaviors. Neutered animals are also less likely to roam outside the house or interact aggressively with their housemates. Surgery is generally well-tolerated by infected cats that are not showing any clinical signs of disease. A thorough examination and, ideally, pre-anesthetic blood testing should be performed before surgery. Perioperative antibiotic administration should be considered for infected cats undergoing dental procedures and surgeries, because of their potentially immunosuppressed state. Appropriate analgesia should be administered not only to cats undergoing invasive procedures but also to cats with chronic pain due to retroviral-associated conditions such as stomatitis, uveitis, and neoplasia (Hellyer et al 2007).

Clinical illness in cats with FeLV or FIV infection may be a primary effect of retroviral infection (such as lymphoma or pure red cell aplasia), a secondary disease associated with immune dysfunction (such as opportunistic infections or stomatitis), or unrelated to the viral infection. Prompt and accurate diagnosis is essential to allow early therapeutic intervention and a successful treatment outcome. Therefore, more intensive diagnostic testing should proceed earlier in the course of illness for infected cats than that might be recommended for uninfected cats. Many cats infected with FeLV or FIV respond as well as their uninfected counterparts to appropriate medications and treatment strategies, although a longer or more aggressive course of treatment may be needed (Levy et al 2006a)

Corticosteroids and other immune-suppressive drugs should be administered only to those patients for whom their use is clearly indicated. In severe stomatitis, which commonly occurs in retrovirus-infected cats, extraction of all teeth is preferred over long-term use of corticosteroids. Griseofulvin has been shown to cause bone marrow suppression in FIV-infected cats and should not be used for treatment of fungal infections (Shelton et al 1990).

Highly active antiretroviral therapy (HAART) cocktails are the mainstay of treatment in HIV-infected patients and result in longer survivals and improved quality of life. Antiviral therapy has also been used in retrovirus-infected cats, although the drugs available to cats are limited and tend to be more toxic in cats than in human beings (Hartmann 2006). Drugs aimed at modulating the immune system are commonly used in cats and are proposed to restore compromised immune function, thereby allowing the patient to control viral burden and recover from associated clinical syndromes. Unfortunately, only a few large long-term controlled studies in naturally infected cats have shown durable benefit using either antiviral drugs or immunomodulators.

The only antiviral compound routinely used in both retrovirus infections is zidovudine (AZT), a nucleoside analog (thymidine derivative) that blocks the viral reverse transcriptase enzyme. AZT has been shown to effectively inhibit FeLV and FIV replication in vitro and in vivo; it can reduce plasma virus load and improve immunological and clinical status, particularly in cats with neurological signs or stomatitis. AZT is used at a dosage of 5−10 mg/kg PO or SC q 12 h. The higher dose should be carefully used in FeLV-infected cats because side effects, particularly non-regenerative anemia, can develop (Hartmann et al 1992, 1995a,b, Hartmann 2005).

Feline interferon omega (Virbagen; Omega, Virbac Animal Health) has been available for use in a few countries for several years. In a placebo-controlled field study, FeLV-infected cats treated with interferon omega (10^6 IU/kg SC q 24 h for five consecutive days repeated three times with several weeks between treatments) were more likely to be alive at 1 year compared to placebo-treated cats (de Mari et al 2004). The mechanism for the survival advantage is undetermined because no virological parameters were measured. No effect on survival in FIV-infected cats was observed.

Natural human interferon alpha (Alfaferone; Alfa Wasserman, Italy) was used in clinically ill cats naturally infected with FIV (50 IU on the oral mucosa daily for 7 days on alternating weeks for 6 months, followed by a 2-month break, and then repetition of the 6-month treatment). Supportive treatments (eg, antibiotics and parasiticides) were allowed. Of the 53 cats that entered the study results were reported for 30 of the cats. Three cats were co-infected with FeLV. All but one of the 24 cats in the treatment group for which results were reported were alive at 18 months compared to only one of the six placebo-treated cats. The apparent survival benefit associated with interferon alpha treatment could not be explained by improvements in viral burden, CD4+ T-lymphocyte counts, or hematological results (Pedretti et al 2006).

Table 2. Drugs used in the treatment of FeLV and FIV infections

Drug	Category	Target virus	Controlled trials in naturally infected cats
Acemannan	Immunomodulator	FeLV, FIV	No trials reported
Bacille Calmette-Guérin	Immunomodulator	FeLV, FIV	No trials reported
Bovine lactoferrin	Immunomodulator	FeLV, FIV	No trials reported
Didanosine	Antiviral	FeLV, FIV	No trials reported
Diethylcarbamazine	Immunomodulator	FeLV, FIV	No trials reported
Feline interferon omega	Antiviral, immunomodulator	FeLV	Improved survival (de Mari et al 2004)
Feline interferon omega	Antiviral, immunomodulator	FIV	No effect vs placebo (de Mari et al 2004)
Levamisole	Immunomodulator	FeLV, FIV	No trials reported
Lymphocyte T-cell immunomodulator	Immunomodulator	FeLV, FIV	No trials reported
Natural human interferon alpha	Antiviral, immunomodulator	FIV	Improved survival (Pedretti et al 2006)
PIND-AVI, PIND-ORF	Immunomodulator	FeLV	No effect vs placebo (Hartmann et al 1998)
PIND-AVI, PIND-ORF	Immunomodulator	FIV	No trials reported
Propionibacterium acnes	Immunomodulator	FeLV, FIV	No trials reported
Recombinant human interferon alpha	Antiviral, immunomodulator	FeLV	No effect vs placebo (McCaw et al 2001)
Serratia marcescens	Immunomodulator	FeLV, FIV	No trials reported
Staphylococcus protein A	Immunomodulator	FeLV	No effect vs placebo (McCaw et al 2001)
Staphylococcus protein A	Immunomodulator	FIV	No trials reported
Suramin	Antiviral	FeLV, FIV	No trials reported
Zidovudine	Antiviral	FeLV	Improved stomatitis score, reduced p27 antigenemia (Hartmann et al 1992)
Zidovudine	Antiviral	FIV	Improved stomatitis score, improved CD4+:CD8+ ratio (Hartmann et al 1992)

A summary of drugs used in the treatment of FeLV and FIV infections is given in Table 2.

Acknowledgments

Dr Jim Richards was leading the team of experts preparing this update on retroviral infections in cats when he suffered a fatal accident. His loss was felt around the world. These guidelines are dedicated in memory of Jim, one of the greatest advocates cats ever had.

The AAFP gratefully acknowledges IDEXX Laboratories for an educational grant supporting this work. This report was prepared by the AAFP as a guide for veterinary practitioners to optimize the prevention of retroviral infections and the care and management of feline patients with retroviruses.

References

Addie DD, Dennis JM, Toth S, Callanan JJ, Reid S, Jarrett O (2000) Long-term impact on a closed household of pet cats of natural infection with feline coronavirus, feline leukaemia virus and feline immunodeficiency virus. *Veterinary Record* **146**, 419–424.

Allison RW, Hoover EA (2003) Covert vertical transmission of feline immunodeficiency virus. *AIDS Research and Human Retroviruses* **19**, 421–434.

August JR (1991) Husbandry practices for cats infected with feline leukemia virus or feline immunodeficiency virus. *Journal of the American Veterinary Medical Association* **199**, 1474–1477.

Barr MC (1996) FIV, FeLV, and FIPV: interpretation and misinterpretation of serological test results. *Seminars in Veterinary Medicine and Surgery (Small Animal)* **11**, 144–153.

Bienzle D, Reggeti F, Wen X, Little S, Hobson J, Kruth S (2004) The variability of serological and molecular diagnosis of feline immunodeficiency virus infection. *Canadian Veterinary Journal* **45**, 753–757.

Boretti FS, Ossent P, Bauer-Pham K, Weibel B, Meili T, Cattori V, Wolfensberger C, Reinacher M, Lutz H, Hofmann-Lehmann R (2004) Recurrence of feline leukemia virus (FeLV) and development of fatal lymphoma concurrent with feline immunodeficiency (FIV) induced immune suppression. In: *7th International Feline Retrovirus Research Symposium*, Pisa, Italy.

Buonavoglia C, Marsilio F, Tempesta M, Buonavoglia D, Tiscar PG, Cavalli A, Compagnucci M (1993) Use of a feline panleukopenia modified live virus vaccine in cats in the primary-stage of feline immunodeficiency virus infection. *Zentralblatt für Veterinärmedizin. Reihe B* **40**, 343–346.

Cattori V, Tandon R, Pepin A, Lutz H, Hofmann-Lehmann R (2006) Rapid detection of feline leukemia virus provirus integration into feline genomic DNA. *Molecular and Cellular Probes* **20**, 172–181.

Chen H, Bechtel MK, Shi Y, Phipps A, Mathes LE, Hayes KA, Roy-Burman P (1998) Pathogenicity induced by feline leukemia virus, Rickard strain, subgroup A plasmid DNA (pFRA). *Journal of Virology* **72**, 7048–7056.

Companion Animal Parasite Council. (2007) CAPC guidelines: controlling internal and external parasites in US dogs and cats. www.capcvet.org.

Crawford PC, Slater MR, Levy JK (2005) Accuracy of polymerase chain reaction assays for diagnosis of feline immunodeficiency virus infection in cats. *Journal of the American Veterinary Medical Association* **226**, 1503–1507.

Dawson S, Smyth NR, Bennett M, Gaskell RM, Mccracken CM, Brown A, Gaskell CJ (1991) Effect of primary-stage feline immunodeficiency virus infection on subsequent feline calicivirus vaccination and challenge in cats. *AIDS (London, England)* **5**, 747–750.

Druce JD, Robinson WF, Locarnini SA, Kyaw-Tanner MT, Sommerlad SF, Birch CJ (1997) Transmission of human and feline immunodeficiency viruses via reused suture material. *Journal of Medical Virology* **53**, 13–18.

Dunham SP, Bruce J, Mackay S, Golder M, Jarrett O, Neil JC (2006) Limited efficacy of an inactivated feline immunodeficiency virus vaccine. *Veterinary Record* **158**, 561–562.

Egberink H, Horzinek MC (1992) Animal immunodeficiency viruses. *Veterinary Microbiology* **33**, 311–331.

van Engelenburg FA, Terpstra FG, Schuitemaker H, Moorer WR (2002) The virucidal spectrum of a high concentration alcohol mixture. *Journal of Hospital Infection* **51**, 121–125.

Fischer SM, Quest CM, Dubovi EJ, Davis RD, Tucker SJ, Friary JA, Crawford PC, Ricke TA, Levy JK (2007) Response of feral cats to vaccination at the time of neutering. *Journal of the American Veterinary Medical Association* **230**, 52–58.

Flynn JN, Dunham SP, Watson V, Jarrett O (2002) Longitudinal analysis of feline leukemia virus-specific cytotoxic T lymphocytes: correlation with recovery from infection. *Journal of Virology* **76**, 2306–2315.

Flynn JN, Hanlon L, Jarrett O (2000) Feline leukaemia virus: protective immunity is mediated by virus-specific cytotoxic T lymphocytes. *Immunology* **101**, 120–125.

Franchini M. (1990) Die tollwutimpfung von mit FeLV infizierten katzen (thesis). Zurich, University of Zurich.

Francis DP, Essex M, Gayzagian D (1979) Feline leukemia virus: survival under home and laboratory conditions. *Journal of Clinical Microbiology* **9**, 154–156.

Goldkamp CE, Levy JK, Edinboro CH, Lachtara JL (2008) Seroprevalences of feline leukemia virus and feline immunodeficiency virus in cats with abscesses or bite wounds and rate of veterinarian compliance with current guidelines for retrovirus testing. *Journal of the American Veterinary Medical Association* **232**, 1152–1158.

Gomes-Keller MA, Gönczi E, Tandon R, Riondato F, Hofmann-Lehmann R, Meli ML, Lutz H (2006a) Detection of feline leukemia virus RNA in saliva from naturally infected cats and correlation of PCR results with those of current diagnostic methods. *Journal of Clinical Microbiology* **44**, 916–922.

Gomes-Keller MA, Tandon R, Gönczi E, Meli ML, Hofmann-Lehmann R, Lutz H (2006b) Shedding of feline leukemia virus RNA in saliva is a consistent feature in viremic cats. *Veterinary Microbiology* **112**, 11–21.

Goto Y, Nishimura Y, Baba K, Mizuno T, Endo Y, Masuda K, Ohno K, Tsujimoto H (2002) Association of plasma viral RNA load with prognosis in cats naturally infected with feline immunodeficiency virus. *Journal of Virology* **76**, 10079–10083.

Grant CK, Essex M, Gardner MB, Hardy Jr WD (1980) Natural feline leukemia virus infection and the immune response of cats of different ages. *Cancer Research* **40**, 823–829.

Harbour DA, Gunn-Moore DA, Gruffydd-Jones TJ, Caney SM, Bradshaw J, Jarrett O, Wiseman A (2002) Protection against oronasal challenge with virulent feline leukaemia virus lasts for at least 12 months following a primary course of immunisation with Leukocell 2 vaccine. *Vaccine* **20**, 2866–2872.

Hardy Jr WD, Hess PW, Macewen EG, Mcclelland AJ, Zuckerman EE, Essex M, Cotter SM, Jarrett O (1976a) Biology of feline leukemia virus in the natural environment. *Cancer Research* **36**, 582–588.

Hardy Jr WD, Mcclelland AJ, Zuckerman EE, Hess PW, Essex M, Cotter SM, Macewen EG, Hayes AA (1976b) Prevention of the contagious spread of feline leukaemia virus and the development of leukaemia in pet cats. *Nature* **263**, 326–328.

Hartmann K (1998) Feline immunodeficiency virus infection: an overview. *Veterinary Journal* **155**, 123–137.

Hartmann K (2005) FeLV treatment strategies and prognosis. *Compendium on Continuing Education for the Practicing Veterinarian* **27** (Suppl), 14–26.

Hartmann K (2006) Antiviral and immunodulatory chemotherapy. In: Greene CE (ed), *Infectious Diseases of the Dog and Cat*. Philadelphia: WB Saunders, pp. 10–25.

Hartmann K, Block A, Ferk G, Vollmar A, Goldberg M, Lutz H (1998) Treatment of feline leukemia virus-infected cats with paramunity inducer. *Veterinary Immunology and Immunopathology* **65**, 267–275.

Hartmann K, Donath A, Beer B, Egberink HF, Horzinek MC, Lutz H, Hoffmann-Fezer G, Thum I, Thefeld S (1992) Use of two virustatica (AZT, PMEA) in the treatment of FIV and of FeLV seropositive cats with clinical symptoms. *Veterinary Immunology and Immunopathology* **35**, 167–175.

Hartmann K, Donath A, Kraft W (1995a) AZT in the treatment of feline immunodeficiency virus infection: part 1. *Feline Practice* **5**, 16–21.

Hartmann K, Donath A, Kraft W (1995b) AZT in the treatment of feline immunodeficiency virus infection: part 2. *Feline Practice* **6**, 13–20.

Hartmann K, Griessmayr P, Schulz B, Greene CE, Vidyashankar AN, Jarrett O, Egberink HF (2007) Quality of different in-clinic test systems for feline immunodeficiency virus and feline leukaemia virus infection. *Journal of Feline Medicine and Surgery* **9**, 439–445.

Hartmann K, Werner RM, Egberink H, Jarrett O (2001) Comparison of six in-house tests for the rapid diagnosis of feline immunodeficiency and feline leukaemia virus infections. *Veterinary Record* **149**, 317–320.

Hawkins EC (1991) Saliva and tear tests for feline leukemia virus. *Journal of the American Veterinary Medical Association* **199**, 1382–1385.

Hawkins EC, Johnson L, Pedersen NC, Winston S (1986) Use of tears for diagnosis of feline leukemia virus infection. *Journal of the American Veterinary Medical Association* **188**, 1031–1034.

Hayes KA, Rojko JL, Tarr MJ, Polas PJ, Olsen RG, Mathes LE (1989) Atypical localised viral expression in a cat with feline leukaemia. *Veterinary Record* **124**, 344–346.

Hellyer P, Rodan I, Brunt J, Downing R, Hagedorn JE, Robertson SA (2007) AAHA/AAFP pain management guidelines for dogs and cats. *Journal of the American Animal Hospital Association* **43**, 235–248.

Hofmann-Lehmann R, Cattori V, Tandon R, Boretti FS, Meli ML, Riond B, Lutz H (2008 Jan 19) How molecular methods change our views of FeLV infection and

vaccination. *Veterinary Immunology and Immunopathology.* [Epub ahead of print].

Hofmann-Lehmann R, Cattori V, Tandon R, Boretti FS, Meli ML, Riond B, Pepin AC, Willi B, Ossent P, Lutz H (2007) Vaccination against the feline leukaemia virus: outcome and response categories and long-term follow-up. *Vaccine* **25**, 5531–5539.

Hofmann-Lehmann R, Holznagel E, Aubert A, Ossent P, Reinacher M, Lutz H (1995) Recombinant FeLV vaccine: long-term protection and effect on course and outcome of FIV infection. *Veterinary Immunology and Immunopathology* **46**, 127–137.

Hofmann-Lehmann R, Huder JB, Gruber S, Boretti F, Sigrist B, Lutz H (2001) Feline leukaemia provirus load during the course of experimental infection and in naturally infected cats. *Journal of General Virology* **82**, 1589–1596.

Hofmann-Lehmann R, Tandon R, Boretti FS, Meli ML, Willi B, Cattori V, Gomes-Keller MA, Ossent P, Golder MC, Flynn JN, Lutz H (2006) Reassessment of feline leukaemia virus (FeLV) vaccines with novel sensitive molecular assays. *Vaccine* **24**, 1087–1094.

Hoover EA, Mullins JI (1991) Feline leukemia virus infection and diseases. *Journal of the American Veterinary Medical Association* **199**, 1287–1297.

Hoover EA, Mullins JI, Chu HJ, Wasmoen TL (1996) Efficacy of an inactivated feline leukemia virus vaccine. *AIDS Research and Human Retroviruses* **12**, 379–383.

Hoover EA, Olsen RG, Hardy Jr WD, Schaller JP, Mathes LE (1976) Feline leukemia virus infection: age-related variation in response of cats to experimental infection. *Journal of the National Cancer Institute* **57**, 365–369.

Hoover EA, Olsen RG, Hardy Jr WD, Schaller JP, Mathes LE, Cockerell GL (1975) Biologic and immunologic response of cats to experimental infection with feline leukemia virus. *Bibliotheca Haematologica* **43**, 180–183.

Huang C, Conlee D, Loop J, Champ D, Gill M, Chu HJ (2004) Efficacy and safety of a feline immunodeficiency virus vaccine. *Animal Health Research Reviews* **5**, 295–300.

Jacobson RH (1991) How well do serodiagnostic tests predict the infection or disease status of cats? *Journal of the American Veterinary Medical Association* **199**, 1343–1347.

Jarrett O, Golder MC, Stewart MF (1982) Detection of transient and persistent feline leukaemia virus infections. *Veterinary Record* **110**, 225–228.

Jordan HL, Howard J, Barr MC, Kennedy-Stoskopf S, Levy JK, Tompkins WA (1998) Feline immunodeficiency virus is shed in semen from experimentally and naturally infected cats. *AIDS Research and Human Retroviruses* **14**, 1087–1092.

Kramer A, Schwebke I, Kampf G (2006) How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. *BMC Infectious Diseases* **6**, 130.

Kusuhara H, Hohdatsu T, Okumura M, Sato K, Suzuki Y, Motokawa K, Gemma T, Watanabe R, Huang C, Arai S, Koyama H (2005) Dual-subtype vaccine (Fel-O-Vax FIV) protects cats against contact challenge with heterologous subtype B FIV infected cats. *Veterinary Microbiology* **108**, 155–165.

Kusuhara H, Hohdatsu T, Seta T, Nemoto K, Motokawa K, Gemma T, Watanabe R, Huang C, Arai S, Koyama H (2007) Serological differentiation of FIV-infected cats from dual-subtype feline immunodeficiency virus vaccine (Fel-O-Vax FIV) inoculated cats. *Veterinary Microbiology* **120**, 217–225.

Lehmann R, Franchini M, Aubert A, Wolfensberger C, Cronier J, Lutz H (1991) Vaccination of cats experimentally infected with feline immunodeficiency virus, using a recombinant feline leukemia virus vaccine. *Journal of the American Veterinary Medical Association* **199**, 1446–1452.

Lehmann R, Von Beust B, Niederer E, Condrau MA, Fierz W, Aubert A, Ackley CD, Cooper MD, Tompkins MB, Lutz H (1992) Immunization-induced decrease of the CD4+:CD8+ ratio in cats experimentally infected with feline immunodeficiency virus. *Veterinary Immunology and Immunopathology* **35**, 199–214.

Levy JK (2000) Feline immunodeficiency virus update. In: Bonagura J (ed), *Current Veterinary Therapy XIII*. Philadelphia: WB Saunders, pp. 284–288.

Levy JK, Crawford PC (2005) Feline leukemia virus. In: Ettinger SJ, Feldman EC (eds), *Textbook of Veterinary Internal Medicine* (6th edn). Philadelphia: WB Saunders.

Levy JK, Crawford PC, Kusuhara H, Motokawa K, Gemma T, Watanabe R, Arai S, Bienzle D, Hohdatsu T (2008) Differentiation of feline immunodeficiency virus vaccination, infection, or vaccination and infection in cats. *Journal of Veterinary Internal Medicine* **22**, 330–334.

Levy JK, Crawford PC, Slater MR (2004) Effect of vaccination against feline immunodeficiency virus on results of serologic testing in cats. *Journal of the American Veterinary Medical Association* **225**, 1558–1561.

Levy JK, Lorentzen L, Shields J, Lewis H (2006a) Long-term outcome of cats with natural FeLV and FIV infection. In: *8th International Feline Retrovirus Research Symposium*, Washington, DC.

Levy JK, Scott HM, Lachtara JL, Crawford PC (2006b) Seroprevalence of feline leukemia virus and feline immunodeficiency virus infection among cats in North America and risk factors for seropositivity. *Journal of the American Veterinary Medical Association* **228**, 371–376.

Lutz H, Jarrett O (1987) Detection of feline leukemia virus infection in saliva. *Journal of Clinical Microbiology* **25**, 827–831.

Lutz H, Pedersen N, Higgins J, Hübscher U, Troy FA, Theilen GH (1980) Humoral immune reactivity to feline leukemia virus and associated antigens in cats naturally infected with feline leukemia virus. *Cancer Research* **40**, 3642–3651.

Lutz H, Pedersen NC, Theilen GH (1983) Course of feline leukemia virus infection and its detection by enzyme-linked immunosorbent assay and monoclonal antibodies. *American Journal of Veterinary Research* **44**, 2054–2059.

de Mari K, Maynard L, Sanquer A, Lebreux B, Eun HM (2004) Therapeutic effects of recombinant feline interferon-omega on feline leukemia virus (FeLV)-infected and FeLV/feline immunodeficiency virus (FIV)-coinfected symptomatic cats. *Journal of Veterinary Internal Medicine* **18**, 477–482.

MacDonald K, Levy JK, Tucker SJ, Crawford PC (2004) Effects of passive transfer of immunity on results of diagnostic tests for antibodies against feline immunodeficiency virus in kittens born to vaccinated queens. *Journal of the American Veterinary Medical Association* **225**, 1554–1557.

Madewell BR, Jarrett O (1983) Recovery of feline leukaemia virus from non-viraemic cats. *Veterinary Record* **112**, 339–342.

McCaw DL, Boon GD, Jergens AE, Kern MR, Bowles MH, Johnson JC (2001) Immunomodulation therapy for feline leukemia virus infection. *Journal of the American Animal Hospital Association* **37**, 356–363.

Moore GE, Ward MP, Dhariwal J, Al E (2004) Use of a primary care veterinary medical database for surveillance

of syndromes and diseases in dogs and cats. *Journal of Veterinary Internal Medicine* **18**, 386.

Moorer WR (2003) Antiviral activity of alcohol for surface disinfection. *International Journal of Dental Hygiene* **1**, 138–142.

O'Connor Jr TP, Tonelli QJ, Scarlett JM (1991) Report of the National FeLV/FIV Awareness Project. *Journal of the American Veterinary Medical Association* **199**, 1348–1353.

O'Neil LL, Burkhard MJ, Diehl LJ, Hoover EA (1995) Vertical transmission of feline immunodeficiency virus. *Seminars in Veterinary Medicine and Surgery (Small Animal)* **10**, 266–278.

Overall KL, Rodan I, Beaver BV, Carney H, Crowell-Davis S, Hird N, Kudrak S, Wexler-Mitchel E (2005) Panel on feline behavior guidelines: American Association of Feline Practitioners. *Journal of the American Veterinary Medical Association* **227**, 70–84.

Pacitti AM, Jarrett O (1985) Duration of the latent state in feline leukaemia virus infections. *Veterinary Record* **117**, 472–474.

Pacitti AM, Jarrett O, Hay D (1986) Transmission of feline leukaemia virus in the milk of a non-viraemic cat. *Veterinary Record* **118**, 381–384.

Pedersen NC, Meric SM, Johnson L, Plucker S, Theilen GH (1984) The clinical significance of latent feline leukemia virus infection in cats. *Feline Practice* **14**, 32–48.

Pedersen NC, Theilen G, Keane MA, Fairbanks L, Mason T, Orser B, Che CH, Allison C (1977) Studies of naturally transmitted feline leukemia virus infection. *American Journal of Veterinary Research* **38**, 1523–1531.

Pedretti E, Passeri B, Amadori M, Isola P, Di Pede P, Telera A, Vescovini R, Quintavalla F, Pistello M (2006) Low-dose interferon-alpha treatment for feline immunodeficiency virus infection. *Veterinary Immunology and Immunopathology* **109**, 245–254.

Pepin AC, Tandon R, Cattori V, Niederer E, Riond B, Willi B, Lutz H, Hofmann-Lehmann R (2007) Cellular segregation of feline leukemia provirus and viral RNA in leukocyte subsets of long-term experimentally infected cats. *Virus Research* **127**, 9–16.

Post JE, Warren L (1980) Reactivation of latent feline leukemia virus. In: Hardy WD, Essex M, McClelland AJ (eds), *Feline Leukemia Virus*. New York: Elsevier North Holland Inc.

Pu R, Coleman J, Coisman J, Sato E, Tanabe T, Arai M, Yamamoto JK (2005) Dual-subtype FIV vaccine (Fel-O-Vax FIV) protection against a heterologous subtype B FIV isolate. *Journal of Feline Medicine and Surgery* **7**, 65–70.

Pu R, Okada S, Little ER, Xu B, Stoffs WV, Yamamoto JK (1995) Protection of neonatal kittens against feline immunodeficiency virus infection with passive maternal antiviral antibodies. *AIDS (London, England)* **9**, 235–242.

Reubel GH, Dean GA, George JW, Barlough JE, Pedersen NC (1994) Effects of incidental infections and immune activation on disease progression in experimentally feline immunodeficiency virus-infected cats. *Journal of Acquired Immune Deficiency Syndromes* **7**, 1003–1015.

Richards JR, Elston TH, Ford RB, Gaskell RM, Hartmann K, Hurley KF, Lappin MR, Levy JK, Rodan I, Scherk M, Schultz RD, Sparkes AH (2006) The 2006 American Association of Feline Practitioners Feline Vaccine Advisory Panel report. *Journal of the American Veterinary Medical Association* **229**, 1405–1441.

Rojko JL, Hoover EA, Mathes LE, Olsen RG, Schaller JP (1979) Pathogenesis of experimental feline leukemia virus infection. *Journal of the National Cancer Institute* **63**, 759–768.

Rojko JL, Hoover EA, Quackenbush SL, Olsen RG (1982) Reactivation of latent feline leukaemia virus infection. *Nature* **298**, 385–388.

Rojko JL, Kociba GJ (1991) Pathogenesis of infection by the feline leukemia virus. *Journal of the American Veterinary Medical Association* **199**, 1305–1310.

Shelton GH, Grant CK, Linenberger ML, Abkowitz JL (1990) Severe neutropenia associated with griseofulvin therapy in cats with feline immunodeficiency virus infection. *Journal of Veterinary Internal Medicine* **4**, 317–319.

Sparkes AH (1997) Feline leukaemia virus: a review of immunity and vaccination. *Journal of Small Animal Practice* **38**, 187–194.

Sparkes AH (2003) Feline leukaemia virus and vaccination. *Journal of Feline Medicine and Surgery* **5**, 97–100.

Terpstra FG, Van Den Blink AE, Bos LM, Boots AG, Brinkhuis FH, Gijsen E, Van Remmerden Y, Schuitemaker H, van 't Wout AB (2007) Resistance of surface-dried virus to common disinfection procedures. *Journal of Hospital Infection* **66**, 332–338.

Torres AN, Mathiason CK, Hoover EA (2005) Re-examination of feline leukemia virus: host relationships using real-time PCR. *Virology* **332**, 272–283.

Torres AN, O'Hallorant KP, Larson L, Schultz RD, Hoover EA (2006) Insight into FeLV: host relationships using real-time DNA and RNA qPCR. In: *8th International Feline Retrovirus Research Symposium*, Washington, DC.

Ueland K, Nesse LL (1992) No evidence of vertical transmission of naturally acquired feline immunodeficiency virus infection. *Veterinary Immunology and Immunopathology* **33**, 301–308.

Walker C, Canfield PJ, Love DN, Mcneil DR (1996) A longitudinal study of lymphocyte subsets in a cohort of cats naturally-infected with feline immunodeficiency virus. *Australian Veterinary Journal* **73**, 218–224.

Wallace JL, Levy JK (2006) Population characteristics of feral cats admitted to seven trap-neuter-return programs in the United States. *Journal of Feline Medicine and Surgery* **8**, 279–284.

Wardrop KJ, Reine N, Birkenheuer A, Hale A, Hohenhaus A, Crawford C, Lappin MR (2005) Canine and feline blood donor screening for infectious disease. *Journal of Veterinary Internal Medicine* **19**, 135–142.

Willis AM (2000) Feline leukemia virus and feline immunodeficiency virus. *Veterinary Clinics of North America Small Animal Practice* **30**, 971–986.

Yamamoto JK, Pu R, Sato E, Hohdatsu T (2007) Feline immunodeficiency virus pathogenesis and development of a dual-subtype feline-immunodeficiency-virus vaccine. *AIDS (London, England)* **21**, 547–563.