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**PREVALENCE OF FELINE IMMUNODEFICIENCY VIRUS AND  
FELINE LEUKEMIA VIRUS IN SHELTER CATS IN ESTONIA AND IN  
FINLAND: RETROSPECTIVE SURVEY FROM 2019-2023**

KASSIDE OMANDATUD IMMUUNPUUDULIKKUSE VIIRUSE JA  
KASSIDE LEUKOOSI VIIRUSE LEVIMUS EESTI JA SOOME  
VARJUPAIKADE KASSIDEL: RETROSPEKTIIVNE UURING 2019-2023

Final Thesis

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<p>Feline leukemia virus (FeLV) and feline immunodeficiency virus (FIV) are infectious diseases of felines. These retroviral diseases occur worldwide and cause immune suppression in domestic and wild cats. These diseases are mainly transmitted via saliva when cats fight, and therefore older intact male cats having access outdoors, are in higher risk for having these infections. Diagnosis is mainly based on point-of-care (POC) tests taken from blood. There is no effective vaccine available in Europe, but testing cats with higher risks is important for detecting the FIV- or FeLV- positive cats. The aim of this study was to find out the prevalence of FIV and FeLV in shelter cats in Estonia and in Finland with retrospective survey. Information from 2296 FIV and FeLV tested cats from years 2019-2023 was received from 5 different animal welfare associations and animal shelter. 912 cats from Finland and 1384 cats from Estonia. The results from this study found out high prevalence of FIV (19.73%) in Estonia (95% CI 17.66; 21.92), where 273 cats were tested positive. Prevalence of FIV in Finland was (1.56%) where 14 cats were tested positive (95% CI 0.84; 2.56). Prevalence of FeLV was 0.11% (95% CI 0.0; 0.61) in Finland (1/912) and 1.30% (95% CI 0.77; 2.05) in Estonia (18/1384). Previous studies have given results with low prevalence of FIV in northern Europe, therefore further studies with bigger population size and confirming the test result with other test methods would be beneficial for finding out the real situation of these transmissible diseases of cats in Estonia and in Finland.</p>			
Keywords: FIV, FeLV, prevalence, animal shelter, animal welfare association			

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<p>Õppetool: kliinilise veterinaarmeditsiini õppetool  ETIS-e teadusvaldkond ja CERC S-i kood: 3. Terviseuuringud, 3.2. Veterinaarmeditsiin  B750 Veterinaarmeditsiin, kirurgia, füsioloogia, patoloogia, kliinilised uuringud  Juhendaja(d): Julia Jeremejeva ja Toomas Orro  Kaitsmiskoht ja -aasta: Tartu 2025</p>			
<p>Kasside leukeemiaviirus (FeLV) ja kasside immuunpuudulikkuse viirus (FIV) on kasside nakkushaigused. Need retroviirushaigused esinevad kogu maailmas ja põhjustavad kodukasside ja teistel kasslastel immuunsupressiooni. Mõlemad haigused levivad peamiselt sülje kaudu, eriti kakluste käigus, mistõttu on vanematel kastreerimata isastel kassidel, kellel on juurdepääs õue, nakatumise risk on suurem. Diagnoos põhineb peamiselt vereproovide testimisel kiirtestidega (POC). Euroopas ei ole saadaval tõhusat vaktsiini, kuid kõrgema riskiga kasside testimine on oluline FIV- või FeLV-positiivsete kasside tuvastamiseks. Käesoleva uuringu eesmärk oli välja selgitada FIV-i ja FeLV-i levimus varjupaigakasside seas Eestis ja Soomes retrospektiivse uuringu abil. Aastatel 2019–2023 koguti andmed 2296 testitud kassi kohta viielt erinevalt loomakaitseorganisatsioonilt ja loomade varjupaigalt — 912 kassi Soomest ja 1384 kassi Eestist. Uuringu tulemused näitasid kõrget FIV-i levimust (19,73%, 95% UV: 17,66; 21,92) Eestis, kus 273 kassi olid positiivsed. Soomes leiti FIV 14 kassil (1,56%, 95% UV: 0,84; 2,56). FeLV levimus Soome varjupaikade kassidel oli 0,11% (1/912, 95% UV 0,0; 0,61) ja 1.30% (95% UV: 0.77; 2.05) Eesti uuritud kassidest (18/1384) oli positiivsed. Varasemad uuringud on näidanud madalamat FIV-i levimust Põhja-Euroopas, mistõttu oleks edasised uuringud suurema valimimahu ja täiendavate (tulemust kinnitavate) testimeetoditega vajalikud, et saada täpsem ülevaade nende kasside nakkushaiguste tegelikust olukorrast.</p>			
Märksõnad: FIV, FeLV, levimus, varjupaik, loomakaitse ühing			

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## **LIST OF ABBREVIATIONS**

AAFP – American Association of Feline Practitioners

ABCD Europe – Advisory Board on Cat Diseases Europe

AVMA – American Veterinary Medical Association

CI – confidence interval

DNA – deoxyribonucleic acid

ELISA – enzyme-linked immunosorbent assay

FAIDS – feline acquired immunodeficiency syndrome

FelineVMA – Feline Veterinary Medical Association

FeLV – feline leukemia virus

FIV – feline immunodeficiency virus

HIV – human immunodeficiency virus

PCR – polymerase chain reaction

POC – point-of-care

qPCR – quantitative polymerase chain reaction

RNA – ribonucleic acid

RT-qPCR – reverse transcriptase quantitative polymerase chain reaction

SEY – Suomen eläinsuojelu

WW – wavy whiskers

# INTRODUCTION

Feline immunodeficiency virus (FIV) and feline leukemia virus (FeLV) are globally occurring pathogens. Both FIV and FeLV are common diseases infecting domestic cats and suppressing the immune system in infected cats. In case of FIV, infected cats may stay healthy and not reach terminal stage, but in case of FeLV the disease itself is considered more fatal (Levy *et al.*, 2008; Hartmann, 2011; Hartmann and Hofmann-Lehmann, 2020; Little *et al.*, 2020; Bęczkowski and Beatty, 2022). Both diseases usually spread in cat populations where cats have possibility to roam free in outdoor environment, and studies have shown male cats to be more predisposed to get the infection than females (Kokkinaki *et al.*, 2021; Korkulu *et al.*, 2023). Therefore, based on guidelines provided by European Advisory Board on Cat Diseases and Feline Veterinary Medical Association cats infected with these retroviral diseases should be kept separate from uninfected individuals and not allowed to have free access to outside (Lutz *et al.*, 2009; Little *et al.*, 2020). Point-of-care (POC) tests are mainly used to diagnose these diseases. POC is based on enzyme-linked immunosorbent assay (ELISA), which detects FeLV antigen and FIV antibodies (Little *et al.*, 2020; Westman *et al.*, 2022).

Aim of this thesis is to find out prevalence of FIV and FeLV in shelter cats in Estonia and in Finland by retrospective survey from years 2019-2023. Information is collected from tested cats living in animal shelters and animal welfare associations. Structure of this thesis includes literature review which covers information about these two transmissible diseases, testing, diagnosing, treatment and management. In this part previous studies of prevalence of FIV and FeLV are discussed. After literature review is the research section which explains the aim of the thesis, materials and methods, results and discussion. The thesis ends with conclusion which gives the brief summarization of this work.

# 1. LITERATURE REVIEW

## 1.1 Feline immunodeficiency virus

Feline immunodeficiency virus, more commonly known as FIV, is infectious disease of domestic and wild felines. This disease is distributed all over the globe. FIV is a lentivirus belonging to a family of retroviruses and it is mainly transmitted via biting. FIV is one of the most common infectious diseases of domestic cats causing immunodeficiency in infected cats (Hartmann, 2011; Little *et al.*, 2020; Bęczkowski and Beatty, 2022).

FIV has been identified with seven subtypes (A, B, C, D, E, F and U-NZenv) based on their difference in nucleotide sequences. From European countries only subtypes A and B have been identified. Subtype A is common in Germany, Switzerland and United Kingdom where it has been the only subtype detected. Subtype A is also common in northwestern Europe. Subtype B has been detected from cats in Southern Europe such as in Italy and Portugal (Perharić *et al.*, 2016; ABCD Europe, 2017; Bęczkowski and Beatty, 2022; Westman *et al.*, 2022).

### 1.1.1 Risk factors and transmission of FIV

Older male cats having access to outdoors have higher risk of FIV infection. This finding is confirmed by the study made in Brazil, where cats were tested in Veterinary Teaching Hospital from Universidade Federal Rural do Semi-Árido located in Mossoró, Brazil. Data was collected from medical records of felines between 2011 to 2016. During this time period 159 cats were submitted to the test of FIV and FeLV. Total of 32 male cats and 7 female cats were tested positive for FIV. Results showed that 60% of FIV positive cats had access outdoors and most of the positive cats were older than 6 years (Barros *et al.*, 2017). Also other studies like Burling *et al.* (2017) and Bezerra *et al.* (2024) have shown that outdoor access and male sex are a risk factor for FIV. Intact cats have higher risk of having the disease. Other risk factors are breed and health status, meaning mixed breed cats and cats having already some disease or sickness are categorised as in high-risk for getting FIV infection (Burling *et al.*, 2017; Bęczkowski and Beatty, 2022; Bezerra *et al.*, 2024).

According to Bęczkowski and Beatty, (2022) FIV is mainly transmitted via bite wounds. Cat which is positive for FIV-infection bites another cat and transmits the saliva containing the virus and FIV-infected white blood cells into the new host. Vertical transmission from queen to kittens through colostrum and milk is possible, but uncommon. Also, virus spreading in cats

living together but not fighting together is unlikely (Hartmann 2011; Little *et al.*, 2020; Bęczkowski and Beatty, 2022).

Vertical transmission of FIV-positive queens to kittens and transmission of FIV in cohabiting mixed household of eight FIV-positive cats and 130 FIV-negative cats were studied in two cat-only rescue shelters. According to Litster, (2014) cats were divided into Rescue 1 and Rescue 2. In Rescue 1, cats cohabited in multi-cat households. Cats shared the same litter boxes, water/food dishes and bedding. Before the start of the study cats were tested for FIV, FIV-tests were repeated also during the studies for few times. In Rescue 2, five FIV-positive queens and their 19 kittens were placed to foster homes. Queens and kittens did not have any contact with other FIV-positive cats. The results from Rescue 1 did not show any evidence of transmission of infection from FIV-positive cats to FIV-negative cats. Also Rescue 2 did not give any evidence of vertical transmission of FIV from queens to kittens since all the kittens were tested FIV-negative after weaning (Litster, 2014).

### **1.1.2 Pathogenesis and clinical signs of FIV**

Over the years FIV has been divided into different stages or phases. According to Bęczkowski and Beatty, (2022) clinical stages of FIV can be divided to acute, silent and terminal stages, however Australian guidelines for diagnosing FIV divides FIV infection to three phases; primary (acute), subclinical and clinical phase (Bęczkowski and Beatty, 2022; Westman *et al.*, 2022).

FIV infection starts with acute stage, also known as primary phase, which is associated with transient fever, lymphopenia and lymphadenopathy (Westman *et al.*, 2022). During this stage the virus replicates in CD4<sup>+</sup> (helper) and CD8<sup>+</sup> (cytotoxic-suppressor) T lymphocytes, in dendritic cells and macrophages. Virus is detected in high concentrations in the blood and can be determined by culture and polymerase chain-reaction (PCR). Plasma virus load reaches its peak at 8 to 12 weeks after the infection (Little *et al.*, 2020; Bęczkowski and Beatty, 2022). Primary phase can last from 1 to 3 months (Westman *et al.*, 2022).

Suppression of plasma viral load indicates the silent or subclinical stage, when cats might be asymptomatic or with mild clinical signs such as reduced appetite, lethargy, intermittent fever and lymphadenopathy, which usually means enlarged lymph nodes (Bęczkowski and Beatty, 2022). During this subclinical stage, which can last for many years, production of FIV antibodies is high and free virus circulating in the host is suppressed. CD8<sup>+</sup> T lymphocyte levels start to increase (Westman *et al.*, 2022).

The third phase, also known as terminal or clinical stage is characterized with progressive immunosuppression. This stage is sometimes referred as “feline acquired immunodeficiency syndrome” shortly known as FAIDS. FIV infection is similar to human immunodeficiency virus infection (HIV) in people. During this terminal stage, both CD4+ and CD8+ T lymphocyte levels decrease, and the host animal is predisposed to atypical and refractory bacterial, viral, fungal, and parasitic infections. Permanent neutropenia has been reported frequently (Hartmann, 2012; Bęczkowski and Beatty, 2022; Westman *et al.*, 2022).

## **1.2 Feline leukemia virus**

Feline leukemia virus, shortly known as FeLV, is one of the most common globally occurring chronic infectious diseases of domestic cats. FeLV belongs to the family of retroviruses similar to FIV, but it is a gammaretrovirus. Gammaretroviruses are also known as onco-retroviruses, and these viruses are specifically known by their leukemia-inducing properties (Hartmann, 2011; Hunter *et al.*, 2017; Hartmann and Hofmann-Lehmann, 2020; Hofmann-Lehmann, 2020; Little *et al.*, 2020). FeLV is known to predispose the infected cat to lethal diseases, mainly associated with immune suppression, lymphoma and anemia (Lutz *et al.*, 2009; Beall *et al.*, 2021). Even though FIV and FeLV have a lot of similarities, they differ in potential to cause disease, and FeLV has been considered to be more pathogenic (Hartmann; 2011; Hartmann, 2012).

### **1.2.1 Transmission and pathogenesis of FeLV**

FeLV is commonly transmitted horizontally in close contact among cats. For example, infected queens can transmit the virus to their kittens horizontally, also vertical transmission is possible. And horizontal transmission occurs in cats which are living together or fighting together (Little *et al.*, 2020; Beall *et al.*, 2021). Virus is primarily transmitted via saliva (Hartmann and Hofmann-Lehmann, 2020). Risk factors for FeLV are similar than in FIV, including outdoor access, age and intact male sex. Unneutered male cats are commonly associated with fighting and aggressive behavior, this could increase the likelihood of contact with infected cats. Also, one risk factor is multi-cat households where cats have possibility to roam free in the neighborhood (Burling *et al.*, 2017; Studer *et al.*, 2019; Rungsuriyawiboon *et al.*, 2022; Khalife and Kassaa, 2023).

Just like FIV, FeLV can have long asymptomatic phase, where infected cats do not show any clinical signs. In general, FeLV has been classified into different stages or courses defined as abortive, regressive and progressive infection. Also focal, referred to as atypical infection, has

been differentiated to its own stage (Hartmann, 2012; Hartmann and Hofmann-Lehmann, 2020). Cats with progressive infection are persistently viremic, whereas cats with abortive infection are never viremic. In case of regressive infection primary viremia occur before the host immune response fights back, but regressive infection can be reactivated (Hartmann and Hofmann-Lehmann, 2020; Hofmann-Lehmann and Hartmann, 2020; Little *et al.*, 2020; Westman *et al.*, 2023).

Immune response of FeLV-infected cat determines the outcome. For example, immunosuppression, coinfections and stress are factors which can influence the immune response and therefore the course of infection (Hofmann-Lehmann and Hartmann, 2020). Ineffective immune response to viruses is characteristic for progressive infection, this course of infection is easy to identify in routine clinical practice, since progressive infection can be tested by either using rapid diagnostic tests or polymerase chain reaction (PCR) (Biezus *et al.*, 2023). In abortive infection infected cats eliminate the virus with adequate immune response before the infection progresses (Westmann *et al.*, 2017).

### **1.2.2 Clinical signs of FeLV**

Tumors, immunosuppression, hematologic disorders, immune-mediated diseases and other syndromes like neuropathy, fading kitten syndrome and reproductive disorders, are classified as clinical signs associated with FeLV (Hartmann, 2011). In case of FeLV, immune suppression is more complex and severe than in case of immune suppression in FIV. There has been reported lymphopenia, neutropenia, neutrophil function abnormalities, loss of CD4<sup>+</sup> cells and CD8<sup>+</sup> lymphocytes (Lutz *et al.*, 2009).

One study has shown, wavy changes of whiskers, to be one external sign of FeLV infection. This study was made in Japan and data was collected between 2006-2013 in Niihama Animal Hospital in Ehime Prefecture. Associations of presence or absence of wavy changes of whiskers and serological FeLV infection was examined from total of 358 cats. 56 cats had wavy whiskers (WW). This external sign was defined as positive when there is more than two regions with bends in one whisker and a cat has more than two wavy whiskers. The results showed significant correlation with WW and serological FeLV positivity, from 56 WW positive cats, 50 cats were also positive for FeLV (Morishita *et al.*, 2023).

### **1.3 Testing and diagnosing of FIV/FeLV**

For the diagnosis of FIV or FeLV, blood sample is used most frequently, but using saliva would provide more cat-friendly method in the future. Rapid diagnostic tests such as point-of-care

(POC) tests, which are based on enzyme-linked immunosorbent assay (ELISA) are commonly used in veterinary medicine. In this test method FIV antibodies and FeLV antigens are detected in whole blood, serum or plasma. However, these tests might give false-positive results or in case of FeLV ELISA can detect antigens from progressive infection, since regressive infections are antigen -negative, thus true prevalence of FeLV infection can't be determined. Some studies suggest that FeLV cannot be accurately detected and diagnosed using single test method nor single point in time test (Willett and Hosie, 2013; Beall *et al.*, 2019; Hofmann-Lehmann and Hartman, 2020; Little *et al.*, 2020; Westman *et al.*, 2022; Biezus *et al.*, 2023; Westman *et al.*, 2023).

Confirming the result with other tests, commonly with PCR, is highly recommended especially in low-risk cats. Cats, which are apparently healthy, or living only indoors, are considered low-risk cats. Testing is not always wise, for example if queen is tested negative and the litter is living indoors with no contact with untested cats, then kittens especially under 6 months of age will not require testing for FIV/FeLV. However, cats with unexplained neutropenia, anaemia, lymphoma or opportunistic infections, should be tested (Westman *et al.*, 2023).

### **1.3.1 Point-of-care tests and polymerase chain reaction**

Usually, diagnosing and testing starts with rapid testing, using POC kit. There are different testing kits available, but testing should always be based on kits which are independently validated under local conditions and not blindly trust testing kits which have not been tested by independent researchers (Westman *et al.*, 2022). In case of FeLV ELISA detects antigen, more specifically p27 protein. For FIV this method detects antibodies for capsid protein p24 and/or the transmembrane glycoprotein gp40. And diagnosis of FIV is initially based on detecting circulating antibodies, which can be detected with POC tests based on ELISA (Westman *et al.*, 2019; Little *et al.*, 2020; Bęczkowski and Beatty, 2022).

But there are no 100% reliable POC tests (100% sensitive and 100% specific) so confirmatory tests are recommended for all positive test results, because the result might lead to management changes and/or euthanasia of the cat in animal shelters. Also, antigenic tests are not able to detect regressive FeLV infection (Battilani *et al.*, 2022; Westman *et al.*, 2022).

PCR is molecular method, which in case of FeLV detects proviral deoxyribonucleic acid (DNA) and viral ribonucleic acid (RNA) (Willett and Hosie, 2013; Biezus *et al.*, 2023). However, PCR should not be used to screen FIV infection, because it might produce false-negative results.

However, it can be helpful in situations where serologic test results are questionable (Bęczkowski and Beatty, 2022; Westmann *et al.*, 2022).

## **1.4 Treatment and management of FIV/FeLV**

European Advisory Board on Cat Diseases, shortly as ABCD Europe and American Association of Feline Practitioners (AAFP) have published guidelines for the prevention and management of FeLV and FIV, based on available data from these infectious diseases. ABCD Europe is self-governing organisation with leading veterinary expertise of feline medicine including immunology and vaccinology, diagnostics and feline infectious diseases in Europe. AAFP has been similar association in America, however based on American Veterinary Medical Association (AVMA) AAFP has renamed itself in 2024 as part of rebranding effort and is nowadays known as Feline Veterinary Medical Association shortly known as FelineVMA. Goal of FelineVMA is to be the leader in the field of feline medicine providing Practice Guidelines and peer-reviewed scientific researched based on evidence-based medicine and in generally to improve the wellbeing of cats (ABCD Europe, 2024; AVMA, 2024; FelineVMA, 2025).

Based on these guidelines, both FeLV- and FIV-infected cats should be kept separately from uninfected cats. Infected cats should not have free access to outdoors for prevention of spread of the disease in the area. FeLV-infected but healthy cats should have regular veterinary examination. ABCD Europe recommend these clinical check-ups for every 6-12 months. Also infected cats should be neutered or spayed. This reduces the two most important modes of transmission: in case of FeLV transmission from queens to kittens and fighting among males in both FIV and FeLV (Lutz *et al.*, 2009; Little *et al.*, 2020).

In case of sick cats with FeLV infection, accurate diagnosis is important. Medical therapy is usually effective, however FeLV-infected cats might need longer or aggressive course of medication. Good veterinary care is important, many FeLV-infected cats may require fluid therapy. However, use of corticosteroids and other immunosuppressive drugs should be avoided (Lutz *et al.*, 2009; Little *et al.*, 2020).

### **1.4.1 Vaccination**

According to Bęczkowski and Beatty, (2022) the first commercial FIV vaccine became available approximately 20 years ago, however this vaccine had limited availability and poor efficacy. And on this day, there is still not yet safe and effective vaccine for FIV, but the knowledge about viral immunology might help to create next-generation lentiviral vaccines (Bęczkowski and Beatty, 2022). ABCD Europe recommends vaccination of uninfected cats in

countries with high prevalence of FeLV, particularly in Southern Europe, such as in Italy and Portugal (Studer *et al.*, 2019). However, according to Bezerra *et al.* (2024) there is commercial vaccine currently available only in Australia, New Zealand and Japan (Bezerra *et al.*, 2024).

#### **1.4.2 Prognosis of FIV and FeLV**

According to study from 2023 made in southern Brazil, where reports of 1470 necropsied cats were reviewed from years 2010-2020, indicates that cats infected with FIV and/or FeLV will die younger when comparing to cats without FIV or FeLV infection (de Mello *et al.*, 2023). However, in case of FIV-infected cats, the prognosis seems more promising. Better understanding through studies has taught us that many cats with FIV-infection can live a healthy life without the disease progressing to terminal stage (Bęczkowski and Beatty, 2022). ABCD Europe recommends euthanasia for sick FeLV-positive cats living in animal shelters, but euthanasia based on diagnose alone without signs of sickness is not recommended (Lutz *et al.*, 2009; Little *et al.*, 2020).

#### **1.5 Prevalence of FIV and FeLV**

Prevalence of FeLV has been studied recently in domestic cats from Turkey. 550 domestic cats were tested in animal clinics and hospitals located in Ankara. From 550 cats 112 were tested positive for FeLV and the results showed that FeLV infection is gradually increasing in Ankara, Turkey (Korkulu *et al.*, 2023).

In Europe there are few studies from previous years focusing on the prevalence of FeLV infection; most recent studies are the pan-European study which was published 2019 and study from 2023 where true prevalence was determined from four European countries, countries for this study were selected according to the pan-European study (Studer *et al.*, 2019; Giselbrecht *et al.*, 2023).

The pan-European study is the first of a kind study in Europe associated with FeLV. This study included cats from 30 different European countries in 861 different veterinary facilities. Some smaller countries were groups in country groups and Estonia, Latvia and Lithuania were grouped as one country group. Countries were classified into “Northern Europe”, “Western Europe”, “Southern Europe” and “Eastern Europe” according to United Nations geoscheme. Estonia and Finland were included into “Northern Europe”. Forty veterinarians from each county/country group were instructed to collect samples from September 2016 to March 2017. Each veterinarian collected 10 saliva swabs from 10 cats during consecutive veterinary appointments, but only one cat from household, breeder or shelter was to be sampled. Total

number of 6720 samples were sent to the laboratory in Switzerland for further analysis. Complete data were provided from 6005 samples and included 290 samples from Finland and 55 samples from Estonia. Result from Finland and Estonia showed no FeLV-positive samples, and in general the prevalence in “Northern Europe” was lowest and highest in “Southern Europe”. Highest prevalence of FeLV viremia were detected from Portugal (8.8%), Hungary (5.9%), Italy and Malta (5.7%). Italy and Malta were as one country group, but no FeLV positive cats were detected from Malta (Studer *et al.*, 2019).

Giselbrecht *et al.*, (2023) investigated the overall FeLV infection in European countries. The aim was to determine the prevalence of progressive, regressive, abortive and focal infection. This is first study in Europe, which determines the prevalence from all of the four courses of FeLV infection in multiple countries. Total of 934 cats from four countries; two countries with suspected high prevalence of FeLV infection (Italy and Portugal) and two countries with suspected low prevalence, which were Germany and France. For progressive infection (antigen-positive, provirus-positive) they evaluated p27 antigen by ELISA and confirmed it with reverse transcriptase - quantitative polymerase chain reaction (RT-qPCR) detecting viral RNA. Since ELISA can't detect regressive infection (antigen-negative, provirus-positive), quantitative polymerase chain reaction (qPCR) was evaluated in all 934 cats. For abortive infection (antigen- and provirus-negative, antibody-positive) they tested antibodies against FeLV by indirect ELISA. Focal infection was categorised as antigen-positive, provirus-negative (Biezus *et al.*, 2023; Giselbrecht *et al.*, 2023).

Results showed that overall prevalence of FeLV infection was highest in Italy (21.2%) and Portugal (20.4%), and lowest in Germany (9.5%) and France (9.3%), this was in correlation with the pan-European study conducted by ABCD Europe, where Southern Europe had higher prevalence of FeLV infection. In the pan-European study prevalence of FeLV was 0.3% in Germany and 1.0% in France (Studer *et al.*, 2019; Giselbrecht *et al.*, 2023).

First study of FIV and FeLV prevalence in Finland was published in 1992. In the study 192 free-roaming cats were tested for using ELISA. 6.6% were positive for FIV and 1% positive for FeLV (Sukura *et al.*, 1992). In recent years, prevalence of FIV has been estimated globally by meta-analysis, which gathered data from different studies between 1992 to 2023. In this research total of 175'890 cats were evaluated for FIV from 43 different countries. The results showed that highest FIV prevalence was reported in Asia (14.34%) and lowest North America (5.93%). Europe had second lowest FIV prevalence (8.98%) (Bezerra *et al.*, 2024). In

retrospective study from Italy, during time period of 14 years 1834 cats were tested for FIV and FeLV. Results showed that 13.1% of cats were tested positive for FIV antibodies and 5% were tested positive for FeLV antigen and showed high prevalence of these infectious diseases in Italy (Battilani *et al.*, 2022). Relatively high prevalence of FIV (9.9%) was estimated also in Greece, where total of 435 cats were included in the study (Kokkinaki *et al.*, 2021).

### **1.5.1 Prevalence of FIV and FeLV in animals shelters**

In animal shelters in United States it has been estimated that approximately 5% of cats are tested positive for either FIV or FeLV. This is more than 100'000 positive cats in each year (Dezubiria *et al.*, 2023). Similar estimation animal shelter has been done also in New Zealand. Cats entering the Royal New Zealand Society for the Prevention of Cruelty to Animals animal shelter in Auckland, were tested for FIV and FeLV in 2014. Total of 388 cats were tested using ELISA, overall, 53 cats (13,7%) tested positive for FIV and 4 cats (1%) tested positive for FeLV. However, the POC test, which was used in this study, was mentioned to not be able to distinguish if the antibodies are formed from exposure to natural infection or vaccination. Therefore, all the positive samples were sent to laboratory for real-time PCR (Gates *et al.*, 2017).

## **2. AIM OF THE THESIS**

Aim of this retrospective survey study is to determine the prevalence of FIV and FeLV in domestic cats (*Felis catus*) living in animal welfare associations in Finland and animal shelters in Estonia. Data is collected from cats tested during the years 2019-2023.

## **3. MATERIALS AND METHODS**

### **3.1 Animals, animal welfare associations and animal shelters**

In this study shelter cat is defined as, domestic cat which lives in animal shelter or in animal welfare association.

In Finland questionnaire was sent to multiple different animal welfare associations. For some welfare associations questionnaire was sent directly, but most of the animal welfare associations were reached through the head organization Suomen eläinsuojelu (SEY) in English known as Animal Welfare Finland. SEY has approximately 40 member associations throughout Finland where the practical animal welfare work is done (SEY, 2025). In Estonia questionnaire was sent to eight animal shelters.

### **3.2 Questionnaire**

Data was collected from Finland and Estonia by retrospective survey. Set of questions were sent via email to animal welfare associations and animal shelters. The small questionnaire was translated into four different languages including English, Finnish, Estonian and Russian (Appendix 1.) Questions included total amount of cats tested for FIV/FelV during years 2019-2023, test result, sex and estimated age of the animal. In case of positive cats, further information was asked, this included neuter status of the tested animal before testing, location from the animal before arriving to the animal shelter/welfare association, and was the cat caught alone or were there other cats coming from the same place. Information about confirming the test result with other testing methods and if animal has been euthanized based on the test results were asked. There were also questions about health status, cause of possible euthanasia and testing methods.

### **3.3 Test methods used for diagnosing FIV and FeLV**

Most used testing method for diagnosing FIV and FeLV was POC test. In Estonia Snap FIV/FelV Combo test was used. From Finland no specific POC tests were identified. However, some welfare associations used veterinary practice where they sent blood samples to laboratory called Movet. Movet, located in Kuopio (Finland) is a part of global IDEXX laboratories group and in Movet they use also Snap FIV/FelV Combo test. Because of the false positive results in rapid tests the laboratory recommends testing the positive results with PCR method (Movet, 2025). In this study PCR was used in Finland for confirmation of the positive test result in some animal welfare associations.

### **3.4 Statistical analysis**

The data was combined and analyzed using Microsoft Office Excel 365. Also, tables and figures were created by Microsoft Office Excel and Word tools. For calculating prevalences and exact 95% confidence intervals (CI) Simple Size Calculators for designing clinical research were used. Proportions of cats positive for a certain virus out of all tested cats were calculated as percentage from binomial “exact” calculation.

### **3.5 Declaration of ethical considerations**

The data for this study was collected retrospectively from already existing data. No samples were collected solely for the purpose of this study. Data was kept anonymous. There is no conflict of interest.

## 4. RESULTS

Data of 2296 FIV and FeLV tested cats were received from the years 2019-2023. From Finland number of cats was 912 and they were tested in four different animal welfare associations. 1384 cats were from one Estonian animal shelter. Total number of animals and distribution between Finland and Estonia based on each year are shown in Table 1. Animal welfare associations from Finland are named in alphabetical order from A to D, since there were results from four different animal welfare associations. One animal welfare association (B) started testing cats for FIV and FeLV in 2022, therefore no results from 2019-2021 were available.

**Table 1.** Number of tested cats during 2019-2023 in Estonia and in Finland. Letters from A to D represent four different animal welfare associations from Finland.

Year	2019	2020	2021	2022	2023	Total
Finland						
A	18	29	47	58	51	203
B	0	0	0	23	126	149
C	7	31	81	99	100	318
D	43	55	55	35	54	242
Total of Finland	68	115	183	215	331	<b>912</b>
Estonia						
Total of Estonia	232	275	319	279	279	<b>1384</b>
<b>Total number of cats</b>	300	390	502	494	610	<b>2296</b>

Based on Table 1. the highest number of tests were performed in 2023 with 610 tested cats. Sex distribution of tested cats in Table 2. shows that most of tested cats were males (1083 cats) and 1068 were females. However, one animal welfare association from Finland did not have information about sex from cats tested negative, therefore in Table 2. 145 cats are marked as sex unknown.

**Table 2.** Sex distribution of tested cats. Feline immunodeficiency virus (FIV) and feline leukemia virus (FeLV).

	FIV& FeLV Negative	FIV Positive	FeLV Positive	FIV& FeLV Positive	Total
Females	1004	52	12	0	1068
Males	842	234	6	1	1083
Unknown*	145	0	0	0	145
<b>Total</b>	1991	286	18	1	<b>2296</b>

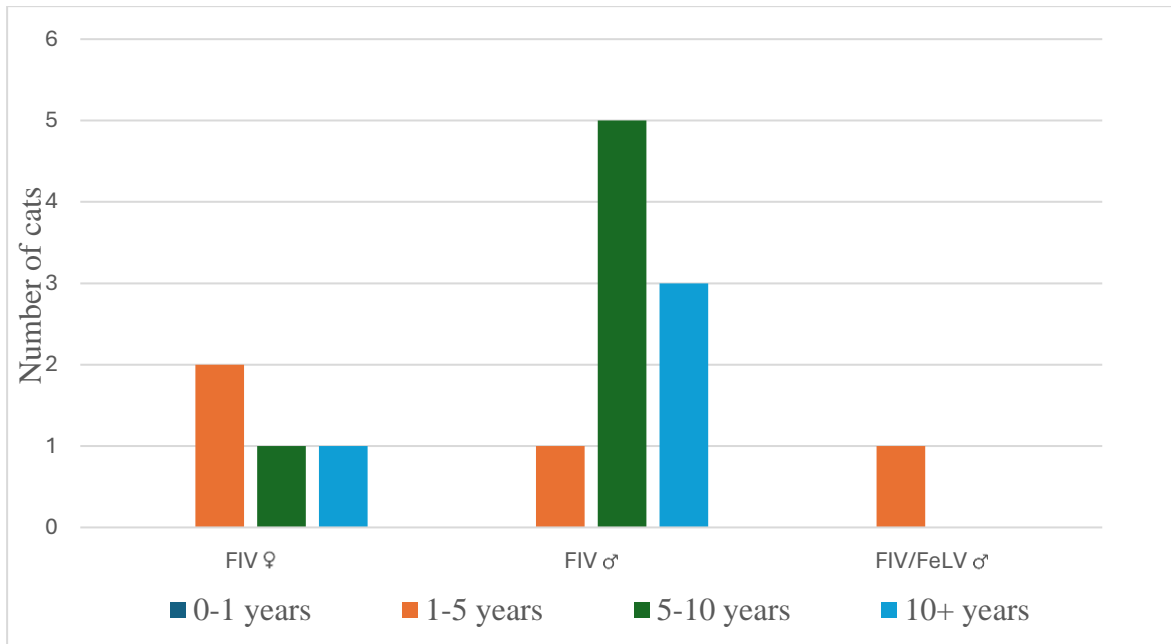
\* sex from 145 cats is marked unknown since one animal welfare association did not have this information from cats which were tested negative.

Results, which are presented in Table 2. show that from total of 2296 tested cats 286 (12.46%) cats were positive for FIV (95% CI 11.13; 13.88), 18 (0.78%) were positive for FeLV (95% CI 0.47; 1.24) and one cat was positive for both FIV and FeLV. After adding this one cat which was positive for both FIV and FeLV, the prevalence is 12.50% (95% CI 11.17; 13.92) positive for FIV (287 cats) and 0.83% (95% CI 0.50; 1.29) positive for FeLV (19 cats).

In Finland total of 912 cats were tested and 14 had positive test results for either FIV, FeLV or both. This information is available in Figure 1. All the cats from Finland were FIV-positive except one cat was positive for both FIV and FeLV. The prevalence of FIV was 1.43% (95% CI 0.76; 2.43) with 13 FIV-positive cats. However, one cat was positive for both FIV and FeLV, and after adding this cat to both FIV and FeLV positives the results are; prevalence of FIV was 1.56% (95% CI 0.84; 2.56) with 14 FIV-positive cats. prevalence of FeLV was 0.11% (95% CI 0.0; 0.61) with one positive cat. In Finland positive test results were confirmed by PCR in some animal welfare associations. However, there is no quantitative data available from this information.

In Estonia total of 1384 cats were tested. From tested cats 273 were positive for FIV and 18 were positive for FeLV. The prevalence of FIV was 19.73% (95% CI 17.66; 21.92) and the prevalence of FeLV was 1.30% (95% CI 0.77; 2.05). In Estonia the test results were based on single snap test (Snap FIV/FeLV Combo test) no confirmatory tests were performed.

In Figure 1. below, is shown the sex distribution of positive cats from Finland and their estimated ages, which were categorized into four different age categories. Most of the FIV-positive cats were males (71.43%) 10 from 14 cats if one cat positive for both diseases is included into the distribution. From 14 FIV-positive cats four were females (28.57%). Most of the FIV-positive cats (6 out of 14 cats) were in age group of 5-10yrs. From Finland there was no only FeLV-positive cats.



**Figure 1.** Sex and estimated ages of feline immunodeficiency virus (FIV) and feline leukemia virus (FeLV) positive cats from Finland. Total number of positive cats is n=14. Symbol ♀=female and ♂=male. Colors represent different age scales.

Information from Estonia did not include estimated age, but sex distribution which is presented in Table 3. below. From the total of 273 FIV-positive cats majority (82.42%) were males (225/273). From 273 FIV-positive cats 48 were females (17.58%). Distribution between sex with all tested cats in Estonia was 727 males and 657 females. Results from FeLV were vice versa, FeLV-positive females were 12 out of 18 (66.67%) and from males 33.33% (6/18) were FeLV-positive. The result from sex distribution of FIV-positive cats in Estonia and Finland are similar, majority of FIV-positive cats are male cats.

**Table 3.** Sex distribution from feline immunodeficiency virus (FIV) and feline leukemia virus (FeLV) tested cats in Estonia from each year. The number of tested cats in total is n=1384. Number of FIV-positive females is n=48. Number of FIV-positive males is n=225.

<b>Year</b>		<b>Females</b>	<b>Males</b>	<b>Total</b>
<b>2019</b>	Negative	99	89	188
	FIV	8	35	43
	FeLV	0	1	1
<b>2020</b>	Negative	115	86	201
	FIV	11	54	65
	FeLV	7	3	10
<b>2021</b>	Negative	147	105	252
	FIV	15	50	65
	FeLV	1	1	2
<b>2022</b>	Negative	117	103	220
	FIV	11	43	54
	FeLV	4	1	5
<b>2023</b>	Negative	119	113	232
	FIV	3	43	46
	FeLV	0	0	0
<b>Total</b>		<b>657</b>	<b>727</b>	<b>1384</b>

In Estonia all FIV and/or FeLV-positive cats were euthanized, tests were performed once using Snap FIV/FeLV Combo test. In Finland most of the cats were adopted (no numerical data available), cats with serious health problems were euthanized but the reason for euthanasia was not solely based on positive test result, but the health condition in general. Some of the questions, for example from which county animal was collected, was it found, from population (stray) or from home and if the animal was already castrated /sterilized before coming to animal shelter/animal welfare association, were excluded from the study because of the lack of information.

## 5. DISCUSSION

This is the first known research studying the prevalence of both viruses in shelter cats in Estonia and in Finland. In this present study 286 cats, from total of 2296 tested cats, were positive for FIV. Prevalence for FIV was 12.50%. There have not been similar test results from previous studies from northern Europe in recent years. According to Bezerra *et al.*, (2024) the prevalence of FIV in Europe was 8.98%. This study did not evaluate prevalence in different regions, but Buch *et al.*, (2017) released the results where prevalence of FIV in Northern Europe was 7.5% and in Southern Europe 12.4% (Buch *et al.*, 2017; Bezerra *et al.*, 2024). However, these studies did not estimate the prevalence of FIV and FeLV only in shelter cats, but shelter cats were included in these studies. Some studies such as Bezerra *et al.*, (2024) did estimate that probability of being infected is higher in shelter cats, even higher than in cats having access to the outdoors (Bezerra *et al.*, 2024). In United States and Canada prevalence of FIV and FeLV were estimated in shelter cats. From total of 62 301 cats, prevalence of FIV was 3.6% and FeLV 3.1% (Burling *et al.*, 2017). According to Bezerra *et al.*, (2024) North America had the lowest prevalence of FIV and FeLV compared to other continents (Bezerra *et al.*, 2024).

Latest study found from Finland was already from decades ago, back then the prevalence of FIV was estimated as 6.6%. The cats used in this study came from animal welfare association which took care of free-roaming cats (Sukura *et al.*, 1992). However, when test results were analyzed in country level FIV prevalence in Finland was 1.56% were 14 cats from 912 tested positive. Based on this result, Finland has low prevalence of FIV among shelter cats. However, the number of organizations and the total number of cats from Finland included into this thesis can not represent the prevalence in country level.

Test results in Estonia tell the different story, 19.73% is high prevalence and based on previous prevalence studies discussed already in literature review, there is no single European country that has as high prevalence of FIV than now in this study (Korkulu *et al.*, 2021; Battilani *et al.*, 2022). Of course, in every study there is possibility of human error. The material for this study was already existing. Also testing methods did change in country level. Cats were tested using POC or PCR, in Finland most of the positive test results were confirmed using PCR. The results from Estonia contained only one test with POC kit. Most used POC test was Snap FIV/FELV Combo test.

According to Movet laboratory (2025) specificity for FIV is 100% meaning that negative results are 100% reliable. Sensitivity for FIV was 93,5%, therefore false-positive results are possible.

In case of FeLV this test has almost equal sensitivity (98.6%) and specificity (98.2%), but the difference between detecting FIV antibody and FeLV antigen is that false-negative results are possible in case of FeLV, but this test is more sensitive for detecting FeLV antigen than FIV antibodies (Movet, 2025). However, POC tests can only detect antigen from progressive course of FeLV. For detecting regressive form PCR is needed (Westman *et al.*, 2022).

Results of FeLV were lower than results from FIV. Prevalence of FeLV in Finland was estimated less than 1% (0.11%) with only one FeLV-positive cat from 912 tested cats. The result from Estonia was higher 1.3% prevalence of FeLV (18/1384). Previous studies from Finland have suggested low prevalence, according to Sukura *et al.*, (1992) prevalence of FeLV was 1% (Sukura *et al.*, 1992). In the pan-European study from 2019, northern Europe had lowest prevalence of FeLV. From 290 samples taken from Finland no FeLV-positive cats were presented. In this study also Estonian result was 0% (0/55) however in Lithuania 4 cats were positive for FeLV and samples were taken from 143 cats. In this pan-European study rule was to not to allow more than one sample from each household, shelter or breeder (Studer *et al.*, 2019). Therefore, the results in this thesis and the pan-European study are not fully comparable. From Estonia results were received from only one animal shelter and therefore can not represent the situation in whole country.

Male sex and outdoor access have been shown to be a risk factor for these transmissible diseases (Barros *et al.*, 2017; Burling *et al.*, 2017; Bezerra *et al.*, 2024). In the present thesis the number of males (1083) and females (1068) were almost equal, exception was 145 cats from one welfare association with no information of sex from negative cats. But results especially from Estonia showed that male cats are more predisposed to FIV. From 273 FIV-positive cats 225 were males and only 48 were females. From Estonia estimated ages of FIV-positive cats were not available, because the estimation of the age of a stray cat is sometimes very difficult. But according to the site where these results came from estimated ages for positive cats were around 3 to 9 years.

There were also other questions asked in the questionnaire sent to the animal shelters and animal welfare associations, but due to lack of information these were ruled out from the thesis and therefore not discussed.

## **CONCLUSIONS**

In the present thesis, results from Finland with the prevalence of FIV (1.56%) and FeLV (0.11%) were expected and in accordance with previous studies suggesting low prevalence of FIV and FeLV in northern Europe. However, results from Estonia where the prevalence of FIV was 19.73% did not follow the previous studies of the prevalence in northern Europe. FeLV prevalence from Estonia was 1.3%. POC tests, especially in case of FIV, are considered effective way of diagnosing, but these tests are not 100% reliable. In general, the sample size in Finland and in Estonia does not represent the whole cat population in these countries. This topic needs further investigation.

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## **APPENDICES**

## Appendix 1. Questionnaire from four different languages

### In Finnish:

Hei, olen Annika Åman, 5. vuosikurssin eläinlääkäriopiskelija Virossa (Estonian University of Life Sciences) ja teen lopputyötä aiheena kissojen FIV (kissan immuunikatovirus) ja FeLV (kissan leukemiavirus) populaatio-/löytökissoissa. Olen kartoittamassa kissojen tilannetta näiden sairauksien osalta Suomessa sekä Virossa. Kerään tietoja testatuista kissoista vuosilta 2019-2023 ja pyytäisin ystävällisesti teitä osallistumaan tietojen kartoittamiseen, jotta saataisiin mahdollisimman luotettava kuva Suomen tilanteesta, näiden tarttuvien tautien osalta. Tällaista kartoitusta ei ole aiemmin tehty Suomesta. Näiden kahden tarttuvan taudin osalta FIV- ja FeLV- positiivisten kissojen tunnistaminen mahdollisimman aikaisessa vaiheessa ja lisätartuntojen ennaltaehkäisy olisi tärkeää.

Kartoitukseen tarvittaisiin seuraavia tietoja vuosilta 2019-2023:

- Joka vuodelta erikseen kaikkien FIV ja FeLV testattujen kissojen lukumäärä, sukupuoli ja ikärvio.
- Miltä paikkakunnalta kissa on vastaanotettu? Onko se löydetty, loukuttettu vai vastaanotettu suoraan omistajalta? Onko kissalla populaatiokissatausta? Onko samasta paikasta vastaanotettu muita kissoja? Oliko eläin kastroidu/sterilisoitu ennen saapumista yhdistykselle?
- Erityisesti FIV ja FeLV positiivista kissoista on tärkeää saada kaikki yllä mainitut tiedot sekä millä testillä sairaus on todettu esim. pikatesti ja onko se varmistettu PCR menetelmällä. Myös millainen kissan terveystilanne on vai onko se lopetettu ja syy lopetukseen.

Olisin todella kiitollinen, jos voisitte lähettää tarvittavat tiedot minulle. Mikäli teillä on valmis tietokanta, voitte lähettää sen suoraan sähköpostiini [annika.aman@emu.ee](mailto:annika.aman@emu.ee) Kerään tietoja heinäkuun loppuun asti, mikäli tarvitsette lisää aikaa tietojen lähettämiseen tai teillä herää kysymyksiä lopputyöhön liittyen, olkaa rohkeasti yhteydessä minuun sähköpostitse.

Kiitos yhteistyöstä!

Ystävällisin terveisin:  
Annika Åman

### In English:

Hello, I am Annika Åman, 5<sup>th</sup> year veterinary medicine student from Estonian University of Life Sciences (Eesti Maaülikool). I am doing my final thesis which topic is focusing on FIV (feline immunodeficiency virus) and FeLV (feline leukemia virus) in shelter cats in Estonia and in Finland. For my study I plan to collect data from FIV/FeLV -tested cats from 2019-2023. I would kindly ask you to participate to this survey, so we could get as reliable results as possible from the situation of these infectious diseases in Estonia. There is no previous research about FIV and FeLV cats in Estonia and for these infectious diseases of cats, early testing of FIV- /FeLV – positive cats would be important for prevention of further infections.

Information I please you to send me for my final thesis:

- From each year: number of cats tested for FIV and FeLV, sex and age estimate.

- From which county cat was collected? Was it found, from population (stray) or from home? Were there other cats in the same place? Was animal castrated/sterilized or not before coming to animal shelter?
- Above information is needed especially from FIV or FeLV positive cats.
- Additional information is needed from which test FIV/FeLV positive cat was tested and was the disease confirmed using PCR?
- Health status of the positive cats and was animal euthanised and what was the cause for euthanasia.

I would be very grateful if you could send me database with above information to my email: [annika.aman@emu.ee](mailto:annika.aman@emu.ee) before end of July, if you need more time or there are some questions related to this final thesis, please contact me by email.

Thank you for participation!

Kind regards:  
Annika Åman

### **In Estonian:**

Tere!

Olen Annika Åman, Eesti Maaülikooli 5. kursuse veterinaarmeditsiini üliõpilane. Uurin oma lõputöös FIV (kasside immuunpuudulikkuse viirus) ja FeLV (kasside leukeemiaviirus) esinemist Eestis ja Soome varjupaikade kassidel. Vaatluse all on aastatel 2019–2023 neile viirustele testitud kassid. Kuna Eestis pole sellesisulist uuringut varem läbi viidud, loodan saada viiruste levikust tegeliku pildi tänu teie panusele. Viiruste varajane tuvastamine annab võimaluse edasiste haiguste ennetamiseks.

Oma uurimistööks ootan teilt järgnevat infot.

- Testitud kasside arv, sugu ja (eeldatav) vanus iga aasta kohta eraldi.
- Millisest maakonnast oli kass pärit? Kas tegemist oli kodu- või tänavakassiga? Kas samas kohas oli ka teisi kasse? Kas kass oli enne varjupaika jõudmist kastreeritud/steriliseeritud?
- Millise testiga viirus tuvastati ja kas diagnoos sai kinnituse PCR testiga?
- Milline oli viirusega kassi tervislik seisund ja kas ta eutaneeriti? Kui jah, mis põhjusel?

Põhjalik info on eriti oluline viirustega kasside puhul. Ma olen väga tänulik, kui saadaksite andmed koos palutud informatsiooniga e-mailile: [annika.aman@emu.ee](mailto:annika.aman@emu.ee) enne juuli lõppu. Kui vajate rohkem aega või tekib lisaküsimusi, võtke julgelt ühendust.

Aitäh uurimistööle kaasa aitamast!

Heade soovidega

Annika Åman

## **In Russian:**

Добрый день!

Меня зовут Анника Аман, я студентка 5-го курса ветеринарной медицины Эстонского Университета Естественных Наук. В своей дипломной работе я изучаю распространённость кошачьей лейкемии (FeLV) и вируса иммунодефицита (FIV) у кошек в приютах Эстонии и Финляндии. Для моего исследования я собираю данные тестирования на FeLV и FIV в период 2019 – 2023.

Буду Вам очень признательна за участие в исследовании для получения реалистичной картины распространённости этих вирусов в Эстонии, поскольку подобных исследований не проводилось, а раннее выявление FeLV и FIV чрезвычайно важно для предотвращения распространения инфекции.

Буду Вам очень признательна за следующую информацию:

- Ежегодное количество протестированных кошек, их пол и возраст (предполагаемый).
- Из какого уезда кошки прибыли к вам в приют? Это домашние кошки или выловленные с улицы? Были ли в этом месте другие кошки? Был ли кот (кошка) кастрирован(а) до прибытия в приют?
- С помощью какого теста был поставлен диагноз FeLV и/или FIV? Был ли диагноз подтверждён с помощью PCR?
- Каким было состояние инфицированных кошек? Были ли они усыплены? Если да, то по какой причине?

Подобная информация особенно важна о FeLV/FIV позитивных кошках. Я буду Вам очень благодарна, если Вы сможете прислать мне необходимую для исследования информацию на мой e-mail: [annika.aman@emu.ee](mailto:annika.aman@emu.ee) до конца июля. Вы можете смело писать мне в случае вопросов или если вам потребуется больше времени для отправки информации.

Благодарю за участие в исследовании!

С наилучшими пожеланиями,

Анника Аман

