



Prevalence of Feline Panleukopenia Virus, Feline Herpesvirus and Feline Calicivirus Infection in Cats at the Clinic, Ho Chi Minh City, Vietnam

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Abstract | The objective of study was to evaluate the rate of infection, distribution of associated risk factors, clinical signs and effectiveness of treatment of feline panleukopenia virus (FPV), feline herpesvirus (FHV) and feline calicivirus (FCV) in cats at one clinic, Ho Chi Minh City, Vietnam. Digestive and respiratory problems were the most common illnesses among the 528 examined cats. Total of 274 cats with clinical signs related with digestive and respiratory systems recorded on diseased cats were tested by the antigen test kit. Besides, the complete blood count (CBC) was also tested to examine the health status of diseased cats. The results showed that the numbers of positive FPV/FHV/FCV-infected cats were 21, 64, and 7 cases in 142 suspected cats, respectively. The study indicated that FPV was 14.09% digestive disorders, FHV and FCV caused 51.20% and 5.60% of the respiratory diseases in cats. Common clinical signs recorded in the FPV-infected cats were lethargy (100%), anorexia, diarrhea, vomiting (the same rate as 86.71%), dehydration and fever. The study demonstrated that a highly positive rate of FHV and FCV caused the upper respiratory tract disease in cats, with clinical signs including sneezing (73.24%), nasal discharge (45.07%), ocular discharge (36.62%), conjunctivitis (33.8%), coughing and dyspnea. The result of CBC tests of 21 FPV-infected cats revealed a marked leukopenia ($4.6 \pm 1.1 \times 10^9/L$), a slight decrease of lymphocytes ($0.7 \pm 1.0 \times 10^9/L$), and platelets less than normal ranges ($75.7 \pm 52.1 \times 10^9/L$). Significant differences based on age groups, housing conditions, and vaccination status were found ($P < 0.05$). The average recovery rate of FPV, FHV, and FCV-infected cats was 86.96%, the highest rate with FCV 100%, FHV 98.44%, and FPV 47.62%.

Keywords | Cats, Digestive disease, Feline calicivirus, Feline herpesvirus, Feline panleukopenia virus, Respiratory disease

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As cat patients came to the clinic, they would be obtained into its own digital veterinary registration form that owners filled out to complete the following information: name, age, sex (male or female), breed and weight. Detailed medical histories as well as previous diseases and/or surgery of patients were reviewed by asking owners specific questions to identify the abnormalities of diseased cats.

DIAGNOSTIC METHODS

Cats brought to the veterinary clinic had their medical information such as breed, age, gender, vaccination status, deworming program, lifestyle, household, recorded by the clinic's management software.

The order of examination was followed step by step. Physical examination consisted of general observation, such as body condition, mentation, posture and gait, and hands-on examination including head (eyes, ears, nose, and mouth), temperature, heart rate and respiratory rate, then they would be written on their medical report. Perfusion indicators were evaluated using mucous membrane color and capillary refill time (normal: <1 - 2 seconds). Additionally, abdominal palpation was done to inspect for distention, deformity, displacement, symmetry, and bruising (Tagesu, 2018). Dehydration examination: A fold of skin was picked up between the thumb and forefinger to evaluate its thickness and the ease could be raised. How quickly it returned to its place when released gave an impression of its elasticity (Rijnberk and Vries, 1995). Respiratory examination: Listen for noisy breathing at mouth and nares without stethoscope, then auscultate at least 4 different areas of the chest, then using stethoscope to hear the sound of the flow of air in the lung (soft, breezy/rusting sounds). Abnormal lung sounds included wheezes, rale/crackles, rhonchi, dull and absence of breath sounds. Besides, watching degree of chest movement was also needed to evaluate the depth of the lung (normal, shallow, deep) (Sharp and Rozanski, 2013).

Based on the clinical signs, if cats were suspected with viral infection such as diarrhea, anorexia combined with depression or sneezing combined with nasal and ocular discharge, they would be only tested with suitable antigen test kits. The rapid test was from Gen Action Company in Vietnam. If they had positive result, their signs were recorded everyday carefully in a case-report that help to follow medical condition to treat the diseases. With FPV-infected cats, they were continually tested with complete blood count test to know the health status. After 5 - 7 days of treatment, the evaluation of effectiveness was based on the clinical signs by the improvement of the health status with 3 stages: (1) Recovery: cats were normal and did not have any clinical signs; (2) Reduction: clinical signs decreased; (3) Non-re-

Research on feline viruses served to protect cat's health, as viral infections had a significant impact on the feline health (Beatty and Hartmann, 2021) and showed the common clinical signs to help the owners as well as veterinarians ease to realize diseases. There were three most common viruses in cats including feline panleukopenia virus (FPV), feline herpesvirus (FHV) and feline calicivirus (FCV) (Povey, 1976; Barrs, 2019; Radford *et al.*, 2007). FPV had been known as the enteric virus, while FHV and FCV affected the respiratory system in cats (Povey, 1976). FPV belonged to *Protoparvovirus 1*, and caused 95% of cases by this genus (Barrs, 2019), and had a huge problem with enteritis and panleukopenia in domestic and wild cats worldwide (Sykes, 2014). Cats under one year old had the highest morbidity rate of FPV at 23.26% (Hien *et al.*, 2022), and the common signs were depression, vomiting, diarrhea, and dehydration (Awad *et al.*, 2018). Moreover, FPV-infected cats had the high mortality rate of 50-80%, even with treatment (Barrs, 2019). Meanwhile, FHV and FCV affected the upper respiratory tract in cats. FHV-infected cats show signs of sneezing, ocular and nasal discharges. Severe ocular signs were chemosis, keratitis, and corneal ulceration, which could be seen in FCV-infected cats (Povey, 1976). Stiles (2003) showed that FHV infection resulted in high morbidity, low mortality rate and no clinical signs after primary infection. Whereas highly virulent strains of FCV were associated with outbreaks of the disease with high mortality (Radford *et al.*, 2007). The objective of this study was to evaluate the rate of infection, distribution of associated risk factors, clinical signs and treatment effectiveness of FPV, FHV, and FCV diseased cats at one clinic, Ho Chi Minh City, Vietnam which is one of of popular clinics in Ho Chi Minh City with three branches.

MATERIALS AND METHODS

LOCATION AND TIME

The comprehensive study was conducted from June 2022 to December 2022 at one clinic, Ho Chi Minh City, Viet Nam. The most common cats came from Go Vap district, Tan Binh, and Phu Nhuan district. Other districts that could be concerned were district 3, Binh Thanh,... and only 3 cats were from Binh Duong.

ANIMALS

Cats regarding to any breeds and either gender came to the clinic with digestive problems including diarrhea, vomiting, anorexia, dehydration, and depression. and respiratory problems with common clinical signs such as sneezing, coughing, ocular and nasal discharge, others as chemosis, keratitis, and corneal ulceration in some cases.

covery: clinical signs did not decrease, they could be worse or dead.

The clinic used the rapid test named FHV/FPV/FCV antigen tests of Gen Action Company Limited in Cu Chi district, Ho Chi Minh city, Vietnam. Rapid test was a sandwich lateral flow immunochromatographic assay (Ching *et al.*, 2015; Koczula and Gallotta, 2016). The kit contained snap device, a sterile cotton swab, a buffer solution that was different from each disease, and a sterile pipette dropper. Following the manufacturer's instruction, the cotton swab was used to collect stool via the rectum with FPV-infected cats. A cat with FHV and/or FCV, swabs were taken from the nose, pharynx, tongue and conjunctiva. Then the sample was mixed with the buffer solution. After that, 4–5 drops of supernatant were added into the device hole. The flow was observed to move across the result window in the center and the result was interpreted within 5–10 minutes (Figure 1).



Figure 1: FPV, FHV and FCV antigen test kit. One-color band (C) on device means negative. Two color bands (C and T) on device mean positive.

Clinical signs (anorexia, diarrhea, vomiting, fever) were observed by clinic's veterinarians. In all cats with FPV clinical suspicion, the infection was then confirmed by direct virus detection (using point-of-care (POC) antigen test) (Barrs, 2019; Sykes and Greene, 2023). Other clinical signs, such as lethargy, dehydration, hypersalivation, pale mucous membrane, were also observed. In this study, only cats infected with one virus at a time were recored, while cats with co-infection of 2 or more viruses, or with other infectious factors (endoparasite, protozoa, bacteria) were ruled out.

We informed and received the permission of the owners of cats included in this study for taking samples used in this

study. Samples were collected as per standard sample collection procedure without any harm to animals.

The Animal Care and Use Committee of Nong Lam University, Ho Chi Minh City, Vietnam, approved the procedures and protocols for the animal sampling.

DATA ANALYSIS

Data were analyzed by Minitab 19 software. Chi-square test were used to check if two variables are related or independent. P-value < 0.05 showed significant difference of variables.

RESULTS AND DISCUSSION

THE DIAGNOSIS OF DIGESTIVE AND RESPIRATORY PROBLEMS IN CATS

Total of 528 cats came to the clinic for many reasons including problems of digestion, respiratory, dermatology, urinary tract, neurological disorders, traumatic injuries and others. These problems were diagnosed based on clinical examination first, then veterinarian used suitable methods to find out the exact causes such as ultrasound, diff-quick stain and using microscope, x-ray machine, quick tests as well as endoscopy.

Table 1: Percentage of diseases that cats came to the clinic (n=528).

Causes	Number of cats	Percentage (%)
Digestive problems	149	28.22
Respiratory problems	125	23.67
Dermatological	63	11.93
Urinary problems	21	3.98
Neurological disorders	7	1.33
Traumatic injuries	27	5.11
Others	136	25.76

The results in Table 1 showed that the percentage of cats suffering from digestive problems was the highest at 28.22%, following respiratory problems at 23.67%. Sarker *et al.* (2015) carried out the study at the Central Veterinary Hospital in Dhaka, Bangladesh, clinical signs of digestive problems in cats took 24.00% and respiratory problems were 25.33%. In addition, digestive disorders were also the highest percentage which was 26% in the total of 64 cats found in Douala city, Cameroon (Kouamo *et al.*, 2021). Looking at other aspects, it showed the rate of cats with dermatological, urinary problems and traumatic injuries were 11.93%, 3.98%, and 5.11%, respectively (Table 1). The lowest proportion was found in cats undergoing neurological disorders at 1.33%. The comparison was done with other survey diagnosing the same method.

In this study, FPV-infected cats held 14.09% (21/149 cats) in total of digestive problems (Table 2). The cause of digestive problems could be infectious or non-infectious agents, and other problems could be caused by bacteria, parasite, poison or trauma. According to Oh *et al.* (2021) carried out the survey in the Republic of Korea revealed that the single infected rates of bacteria and viruses examined from 1,620 diarrhetic cats were 48.75%, 46.44%, respectively.

Table 2: Detection of FPV infection in diseased cats with digestive problems by using FPV antigen test kit.

	Number of cats	Percentage (%)
FPV infected cats / Surveyed cats	21/149	14.09
FPV infected cats / Suspected cats	21/48	43.75

In 149 surveyed cats of digestive problems, total 48 suspected cats of clinical signs included lethargy, anorexia, fever ($> 39.5^{\circ}\text{C}$) and dehydration ($> 6\%$) were detected by using FPV antigen test. The results showed that 43.75% of cats (21/48) tested positive for FPV and 14.09% of FPV-infected cats compared to surveyed cats (21/149 cats). In Bao Minh Chau Veterinary Hospital, Can Tho City, Vietnam, 43 FPV-positive cats held 34.68% compared to suspicious cats (Dang *et al.*, 2023). Compared to a survey at the Laboratory of Veterinary Hospital of Can Tho University, 28.26% cats with FPV infection were found in total suspicious cases (Dang *et al.*, 2022). Variations in FPV prevalence rates could stem from diagnostic methods or regional differences in vaccination uptake.

THE DISTRIBUTION OF ASSOCIATED RISK FACTORS OF FPV-INFECTED CATS

The associated risk factors including age, gender, breed, lifestyle, household and vaccination status were recorded to find out the relationship between them and the infected rate. Total of 48 cats of FPV suspected disease were collected for analysis. Table 3 showed the percentage of factors relating to the FPV-diseased cats.

As presented in Table 3, the age was divided into 2 groups including less than 6 months old, and over 6-month-old cats. The proportion of positive cats under 6 months of age was 63.16% higher than the older group at 31.03% ($P < 0.05$). In fact, young cats less than 6 months old were 3.81 times more likely to be susceptible to FPV infection than older cats. This result was consistent with previous reports, which showed a higher prevalence in young cats at a higher risk of FPV infection than in old cats. In the study at Veterinary Clinic of the School of Ahvaz University, the FPV infection was more prevalent in cats less than 6 months of age (37%) compared with animals older than 6 months of

age (31%) (Mosallanejad *et al.*, 2009). After doing a survey in the veterinary hospital in Ho Chi Minh, it showed the cats under a year old had the highest morbidity rate (23.26%) (Hien *et al.*, 2022). Likewise, 174/219 FPV-infected cats were under 1 year of age, 56.7% of cats were less than 6 months, and 10.7% were over 5 years according to Kruse *et al.* (2010). Generally, adult cats were more resistant than kittens because they had either received vaccinations or developed their own immunity through exposed to the virus in the living environment (Themes, 2016).

Table 3: The percentage of FPV infection based on associated risk factors in diseased cats ($n = 48$).

Factors	Group	No. of cats	Positive cases	No. of Positive (%)	P-value	Odds ratio
Age (months)	< 6	19	12	63.16	< 0.05	3.81
	≥ 6	29	9	31.03		
Gender	Male	26	13	50.00	> 0.05	1.75
	Female	22	8	36.36		
Breed	Exotic	30	11	36.67	> 0.05	0.46
	Domestic	18	10	55.56		
Lifestyle	Outdoor	13	9	69.23	< 0.05	4.31
	Indoor	35	12	34.29		
Household	Multi-cat	27	16	59.26	< 0.05	4.65
	Single cat	21	5	23.81		
Vaccination status	Non	17	11	64.71	< 0.05	3.85
	Vaccinated	31	10	32.26		

Regarding the gender of cats, our study found that the percentage of positive cases in males was 50% and in females was 36.36%. However, there was no significant difference between gender groups, which might be due to more exposure from behavior patterns, and selective preference for keeping males by owners. The study in Germany revealed the result of FPV-infected cats were 59.5% males and the rest was females (Kruse *et al.*, 2010). Discussing the breed, the rate of cats infected with FPV in the exotic group was lower (36.67%) than the domestic group (55.56%). Contrary to our study, the prevalence of FPV infection was greater in exotic breed (37.5%) compared to the domestic breed cats (31.43%) (Nguyen *et al.*, 2021) and 74.42% exotic cats got infection in 100% of 2 breeds (Hien *et al.*, 2022).

About lifestyle, the percentage of FPV-infected cats kept outdoor (69.23%) was higher than the percentage of living indoor (34.29%) with a significant difference ($P < 0.05$). In Vietnam, the result of the survey in 2022 revealed the higher rate of outdoor cats (76.74%) compared to the others (23.26%) (Hien *et al.*, 2022). The incidence of FPV in these groups appeared in free living cats (64.5%) more prevalent than indoor cats (41.6%) in total of 95 FPV-infected cats in Iraq. These results might be due to frequent prone to the virus in the environment because the virus was more

resistant to adverse environmental condition. In addition, the stray cats might be pathogenic carriers and transfer the virus when they were roaming in the house seeking on feed (Bayati, 2016). Moreover, our study indicated that household was also a factor that should be considered because a higher percentage of FPV infection in multi-cat household (59.26%) was found higher than single-cat household (23.81%) ($P < 0.05$) (Table 3). The risk of this disease due to cross infection in multi-cat households increased 2.49% compared to single living. Two groups of housing condition were also measured in the study in the Clinic of Small Animal Medicine, 85.5% multi-cat household and 14.5% single-cat households were showed to be infected with FPV (Kruse *et al.*, 2010). This difference was because it increased the risk of exposure when the cat expanded scope of activity, they met more cats and could contact with exposed surface.

The final factor was vaccination program, which was an important factor in the infection. According to Table 3, a significant difference was found ($P < 0.05$) between cats without vaccination (64.71%) and with vaccination (32.26%). The rate of cats infected with FPV remained high in some unvaccinated cat population (Richard, 2022). In kitten cases of early vaccination, the vaccine had little or no effect on stimulating immunity due to maternal antibody residue (Barrs, 2019). Besides, a study in Austria found that 52.4% of FPV-infected cases were non-vaccinated, and only 23.3% infected cats were fully vaccinated (Wolfesberger *et al.*, 2012).

Table 4: The percentage of clinical signs of FPV-infected cats (n=21).

Clinical signs	Number of cats	Frequency (%)
Lethargy	19	90.48
Anorexia	18	85.71
Abnormal temperature	15	71.43
- Fever ($> 39.5^{\circ}\text{C}$)	14	
- Hypothermia	1	
Fecal condition	18	85.71
- Bloody diarrhea	4	
- Watery diarrhea	14	
Vomiting	18	85.71
Dehydration ($> 6\%$)	16	76.19
Hypersalivation	3	14.29
Pale mucous membrane	1	4.76

DETECTION OF CLINICAL SIGNS OF DISEASED CATS INFECTED WITH FPV

The clinical presentation of FPV positive cats showed lethargy containing slightly over 90% cases (Table 4, Figure 2). Anorexia, vomiting, and diarrhea were the second appearance in infective cats at 85.71%. Abnormal temperature (71.43%) and dehydration (76.19%) were the next position. Other signs that could be talked were hypersali-

vation, pale mucous membrane, low body weight and body condition (Table 4, Figure 2). Lethargy got 90.48% in total cases in our study that had higher than the average rate of a study at University of Munich, Germany was 54.9% of cats with lethargy (Kruse *et al.*, 2010). However, the survey of FPV in Hanoi and vicinities found 100% cats got this sign (Nguyen *et al.*, 2021), the same with an investigation in Can Tho City (Dang *et al.*, 2023).

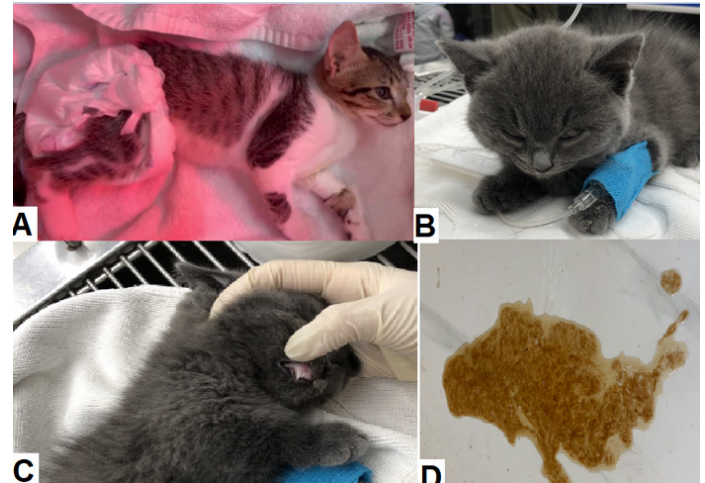


Figure 2: Some clinical signs in FPV-infected cats. A: Hypothermia; B: Lethargy; C: Pale mucous membrane; D: Vomiting.

A hypothermia case with 36.8°C (Figure 2) and 14 fever cases ($> 39.5^{\circ}\text{C}$) in total 15/21 cases (71.43%) were measured at the first visit to our clinic, while normal temperature was range from $38.5-39^{\circ}\text{C}$. Riya *et al.* (2020) recorded total of 34 FPV-infected cats showed the abnormal temperature with pyrexia in 26.4% cases and hypothermia 23.5% cases in India. In contrast, the previous study in Ha Noi and its vicinities found the fever sign at 93.1% of cats (Nguyen *et al.*, 2021), and 23.2% of FPV-infected cats had high fever in Germany (Kruse *et al.*, 2010). This contraction could be because pyrexia occurred only in the initial stages of the disease and subsides with advancement of the disease. However, the result of fever symptom was difference may due to the progression of FPV disease was very complex and depended on the response of infected cats. Besides, the climate, weather and time of each survey were different.

Vomiting (85.71%) occurred frequently in the day, 2-3 times at least, and infected cats usually vomited with the saliva (2/18 cases appeared yellow color, other cases were white) in this study (Table 4, Figure 2). Gastritis-induced stimulation of the emetic centre manifested as vomiting that led to bile-tinged vomitus in FPV-infected cats. This percentage was almost the same as the date in India, which was 85% of the cases (Riya *et al.*, 2020). The differences from the study in Austria and Ha Noi city were 80.8% (Wolfesberger *et al.*, 2012), but only 4.65% of FPV-infected cats had vomiting in Ho Chi Minh city (Hien *et al.*, 2022).

In general, vomiting was a common sign of feline panleukopenia. Besides, diarrhea (85.71%) resulting damaged intestinal villi appeared in most of the infected cats ($n=18$), 4 bloody diarrheic cases (22.2%) presented among them (Table 4). According to the study of Kruse *et al.* (2010), 69.3% of patient had diarrhea, in which 14.1% cases were bloody diarrhea which might develop as consequence of severe enteritis with serious mucosal damage, disseminated intravascular coagulation or co-infection with other pathogens. In contrast, all of FPV-positive cases were observed with watery, mucoid feces (Riya *et al.*, 2020). And the dehydration (76.19%) in our study as resulted from vomiting and diarrhea were reported in 16/21 cases that was assessed by skin tent test which revealed 56.25%, 25.00%, 31.25% cats to 10-12 %, 8-10%, 6-8% dehydration, respectively. Hyper-salivation and pale mucous membrane were also noted but it was not much in cats recorded in the study.

Table 5: Hematological parameter results in FPV-infected cats ($n=21$).

Parameters	Unit	Reference range	Mean $\pm$ SD
White Blood Cells	$10^9/L$	5.5 – 19.5	4.6 ± 1.1
Lymphocytes	$10^9/L$	0.8 – 7.0	0.7 ± 1.0
Monocytes	$10^9/L$	0.0 – 1.9	0.1 ± 0.1
Granulocytes	$10^9/L$	2.1 – 15.0	2.7 ± 1.3
Red Blood Cells	$10^{12}/L$	4.6 – 10.0	7.5 ± 1.3
Hemoglobin	g/L	93.0 – 153.0	108.4 ± 15.2
Hematocrit	%	28.0 – 49.0	35.8 ± 10.3
Platelets	$10^9/L$	100.0 – 514.0	75.7 ± 52.1

(Reference range is based on URIT-3000Plus Automated Hematology Analyzer Operation Manual of URIT Medical Electronic Co., Ltd).

After being confirmed, 21 FPV-infected cats were checked up with complete blood count (CBC) test. As the results, total cats showed the low results of white blood cell count ($4.6 \pm 1.1 \times 10^9/L$); lymphocytes ($0.7 \pm 1.0 \times 10^9/L$) and platelets ($75.7 \pm 52.1 \times 10^9/L$), while other parameters were in normal range (Table 5). In previous study, median of leukocytes and platelets at day of presentation between non-survivors and survivors was $1.2 - 4.4 \times 10^9/L$ and $195 - 260 \times 10^9/L$, respectively (Kruse *et al.*, 2010). Besides, median lymphocyte in infected cats was $1.8 \pm 0.09 \times 10^9/L$ in 83 cases in Ha Noi and its vicinities (Nguyen *et al.*, 2021).

THE TREATMENT EFFECTIVENESS OF FPV DISEASE IN CATS

The effectiveness depended on factors such as the incubation period and the time between the onset of clinical signs and presentation to the clinic, as well as the status, time of treatment. Frequently, the owner took the cats to the clinic 2-4 days after anorexia or diarrhea. In 21 diseased cats with FPV infection, there were 10 cats recovering the disease,

which was 47.62%. In 10 survivors, 40% were better in a week and others recovered nearly 2 weeks. Cats having early treatment would recover this FPV disease shorter than cats with lately taken to the clinics. Most of the dead cases were kittens in same house with no vaccination and under 2 months.

THE FHV AND FCV PREVALENCE IN DISEASED CATS

In this study, 94 suspicious cats having respiratory signs were diagnosed with FHV and FCV antigen kit tests. The positive results were 64 FHV-infected cats (68.08%) and 7 FCV-infected cats (7.45%). As shown in Table 6, the main respiratory problems in cats was due to virus (56.8%) including FHV (51.2%) and FCV (5.6%), followed by other causes were 43.2%. The same as the previous study, FHV-1 and FCV were the primary etiologic agents in 80% of all upper respiratory infection in cats (Burkholder *et al.*, 2015). Other bacterial agents including Chlamydia, Mycoplasma, Bordetella might cause infection that were primary, concurrent, or secondary to the viral disease (Lopez and Martinson, 2017). Other causes might be noted including accidents, and allergies. The prevalence of FHV-1 and FCV was determined at an animal shelter in Korea, and the result revealed 49/78 (63%) cats were positive for single FHV-1 (Walter *et al.*, 2020). Meanwhile, the statistics in the UK were from 430 cats. Of these, 2.1% were positive for FHV, and 13.3% positive for FCV (Chan *et al.*, 2023). From the study of Binns *et al.* (2000), 11.0% were FHV-positive cases compared to 1.0% of healthy cats in which 30/622 (5%) samples collected, and 162/622 (26%) of cats sampled had 33.0% FCV positive compared to 21.0% of healthy cats.

Table 6: Detection of FHV and FCV infection in diseased cats with respiratory problems by using antigen test kit.

	Total	FHV		FCV	
		n ₁ =64	%	n ₂ =7	%
Infected cats/Surveyed cats		64/125	51.20	7/125	5.60
Infected cats/Suspected cats		64/94	68.08	7/94	7.45

THE DISTRIBUTION OF ASSOCIATED RISK FACTORS IN FHV AND FCV DISEASED CATS

Cats under 6 months old got 82.98% of positive FHV, and 12/77% of FCV which was higher than cats older than 6 months at 53.19% FHV and 2.13% FCV ($P<0.05$) were seen in our results (Table 7). According to Najafi *et al.* (2014), in a group of cats with viral respiratory diseases, 100% kittens under 6 months were infected with both these viruses, while FHV (46.0%) and FCV (50.0%) infected on clinically healthy cats. It was also found that FHV-1 was isolated often from cats under one year old, whereas FCV was isolated more from cats between 1 and 5 years old (Henzel *et al.*, 2012).

Table 7: The percentage of FHV and FCV-infected cats based on associated risk factors (n=71).

Factors	Group	n (n=71 cats)	Positive cases		Percentage (%)		P- value	Odds ratio	
			FHV (n ₁ =64)	FCV (n ₂ =7)	FHV	FCV		FHV	FCV
Age (months)	< 6	47	39	6	82.98	12.77	< 0.05	4.29	6.73
	≥ 6	47	25	1	53.19	2.13			
Gender	Male	59	37	4	62.71	6.78	> 0.05	0.50	0.78
	Female	35	27	3	77.14	8.57			
Breed	Exotic	61	43	5	70.49	8.20	> 0.05	1.37	1.38
	Domestic	33	21	2	63.64	6.06			
Lifestyle	Outdoor	21	16	3	76.19	14.29	> 0.05	1.67	2.88
	Indoor	73	48	4	65.75	5.48			
Household	Single-cat	60	36	2	60.00	3.33	< 0.05	0.32	0.20
	Multi- cat	34	28	5	82.35	14.71			
Vaccination Status	Non	34	30	5	88.24	14.71	< 0.05	5.74	5.00
	Vaccinated	60	34	2	56.67	3.33			

In this study, the percentage of males were 62.71% FHV, 6.78% FCV, lower than females (77.14% FHV and 8.57% FCV) ($P>0.05$). A survey in the UK among FHV and FCV 57.2% (246/430 cats) were male and the rest were female, so the result was the same with present study (Chan *et al.*, 2023). The statistics in Viet Nam showed 3 pathogens including FHV, FCV and FPV. The rate included both single infection and co-viral infection in domestic cats. In a total of 37 males in Hanoi (1998), there was 2.7% FHV and 48.6% FCV-infected cats while FHV and FCV-infected male rate were 66.6% and 70.8%, respectively, in Ho Chi Minh City (n=24). Meanwhile 28.1% female cats got FCV disease and no FHV-infected case was revealed in 1998, compared to 76.9% female FCV-infected cats and 23.1% FHV-infected females in Ho Chi Minh area (Nakamura *et al.*, 1999). Additionally, the gender distribution of upper respiratory tract infection, male cats accounted for a higher proportion than females (Gao *et al.*, 2023).

In the present study, the infected rate in diseased cats between 2 kinds of breed had no significant difference ($P>0.05$). It indicated 70.49% of FHV and 8.20% of FCV disease was found in exotic breed and 65.64% FHV, 6.06% FCV in domestic one. Purebred cats were more prone to the disease than mixed breed due to higher stress levels of genetic influence. However, the exact association still needed further investigation (Tran *et al.*, 2019). Regarding to the lifestyle, cats living inside and outside the house had slightly equal infection in our study, which were 65-76%. It indicated that there was no significant difference ($P>0.05$). According to the previous study, prevalence of FHV and FCV of outdoor access in both clinical healthy cats and cats with upper respiratory tract disease was highly correlated with other common respiratory viruses which were 76% and 83% of FHV infection, then 71% and 68% of FCV infection, respectively. However, they did not find

a significant correlation between outdoor access with 2 viruses (Najafi *et al.*, 2014). The viruses were more often isolated from cats that shared a habitat. The percentage of single cats was 60.0% FHV and 3.33% FCV in diseased cats, which was lower than a cat living with many ones (82.35% FHV and 14.71% FCV) ($P<0.05$) (Table 7). This infection was generally attribute to the method of transmission, which requires close contact between infected and susceptible animal. 52/253 cases (20.6%) was found positive in multi cat habitat, following is single habitat with 2/27 cases (7.4%) (Henzel *et al.*, 2012). The high rate of multi cat household also revealed that 83/84 cases were reported (Chan *et al.*, 2023).

The positive group of non-vaccinated cats was 88.24% FHV, 14.71% FCV, while vaccinated cats at 56.67% FHV and 3.33% FCV ($P<0.05$). Henzel *et al.* (2012) indicated that FCV and FHV-1 were isolated from both vaccinated and non-vaccinated cats in Brazil, and the results revealed that 15.7% of the total population of vaccinated cats tested positively for one or both viruses, whereas nearly 19% was found in positive non-vaccinated cats. For both virus infection, clinically recovered cats might become carriers, FCV carries shed continuously whereas FHV shed intermittently, being latent for most of the time. Vaccine had been seen available that protected reasonably well but did not prevent infection or the development of the carrier state (Gaskell *et al.*, 1982; Orr *et al.*, 1978).

DETECTION OF CLINICAL SIGNS OF DISEASED CATS INFECTED WITH FHV AND FCV

Lethargy was less common in FHV-infected cats (17.19%) than FCV-infected cats (71.42%) and the fever ($>39.5^{\circ}\text{C}$) was recorded as slightly higher than normal. Both FHV and FCV showed sneezing as early signs of disease, which were 76.56% and 42.86%, respectively (Table 8). These

percentages were likely the same as in the study in the UK, 73.3% of FHV cases and 43.5% of FCV cases. Besides, 282/740 cats with 2 types of viruses had sneezing (79.9%) as the highest clinical signs. Coughing also appeared in the disease of FHV-infected cats (37.5%) and FCV-infected cats (14.29%) compared to a previous study with 43.3% and 12.3%, respectively (Binns *et al.*, 2000).

Table 8: The percentage of clinical signs of FHV and FCV-infected cats (n=71).

Clinical signs	FHV diseased cats		FCV diseased cats	
	n ₁ =64	%	n ₂ =7	%
Lethargy	11	17.19	5	71.42
Fever (> 39.5°C)	4	6.25	2	28.57
Breathing problems	13	20.31	2	28.57
- Wheeze	7		1	
-Abdominal breathing	6		1	
Anorexia	15	23.44	4	57.14
Hypersalivation	2	3.13	1	14.29
Eye discharge	25	39.06	1	14.29
Nasal discharge	30	46.88	2	28.57
- Opaque	8		1	
- Blue	1		0	
- Clear	21		1	
Swollen mandibular node	5	7.81	3	42.86
Conjunctivitis	23	35.94	1	14.29
Coughing	24	37.5	1	14.29
Sneezing	49	76.56	3	42.86
Vomiting	6	9.38	0	0
Dehydration (> 6%)	7	10.94	3	42.86
Gingivitis leading to ulceration	0	0	2	28.57
Jaundice	0	0	1	14.29

As FHV primarily replicated in nasal mucosa, turbinate, nasopharynx, conjunctiva and upper trachea. In acute, sneezing appeared to eliminate the pathogen that leading to the discharge from the eye and nose. There was 56.25% (25/64) of ocular discharge cases in FHV-infected cats whereas 14.29% (1/7) cases in FCV infection. In the other hand, the large of nasal discharge case (30/64) was also found in cats with FHV infection, in which there was 1 case of blue discharge, and 8 opaque cases while FCV-infected cats had 2 cases (28.57%) (Table 8). Henzel *et al.* (2012) also showed that this clinical signs observed in 25 cats with evidence of both diseases were revealed ocular discharge at 64.0% and nasal discharge 28.0%. Following each disease, FHV cases got discharge with 60.0% in eyes and 50% in nose, while 30.3% and 27.7% of FCV-infected cats in the previous study (Binns *et al.*, 2000). In addition, oral replication of the virus could result hypersalivation in both viruses but it was less common in our study (Figure

3). The virus also attacked to mandibular lymph nodes and tonsil; that was why in the study of cat with FHV found 7.81% (5/64 cases) with swollen lymph node.



Figure 3: Hypersalivation in the diseased cat with FHV infection.

The discharge gradually become mucopurulent, and in severe cases, dyspnea might be accompanied by coughing. In total of 13 cases of dyspnea (20.31%) recorded in 64 cats with FHV infection, 7/13 cases were heard wheezing noise when breathing, while other cases were found abdominal breathing. Meanwhile one case each abnormality of breaths was seen in FCV-infected cats, 28.57% cases. The same with the study in UK were 20.0% and 11.1%, respectively (Binns *et al.*, 2000). While FHV had been known responsible for corneal ulcers, in the current study FHV was not detected. Conjunctivitis was recorded 35.94% and 14.29% as follow FHV and FCV infection (Table 8, Figure 4), it was the same with the study of Binns *et al.* (2000) that total percentage in present study was 33.8% and 30%. Besides, 42% FHV- and 43% FCV-infected cats were found University of Tehran (Najafi *et al.*, 2014). In addition, a cat with FHV 1 and/or FCV infection might have these clinical signs (sneezing, ocular and nasal discharge, dyspnea and coughing), while gingivitis was common in cat with FCV. However, this differentiation of disease caused by FCV or FHV 1 on the base of clinical signs was almost impossible (Najafi *et al.*, 2014). In this study, 2/7 (28.57%) FCV-in-

fect cases got gingivitis then having ulceration. As the cat came to the clinic, blood had been bleeding in their mouth, besides, the cat was exhausted and dyspnea.



Figure 4: Acute conjunctivitis in FHV-infected cat.

THE TREATMENT EFFECTIVENESS OF FHV- AND FCV-INFECTED CATS

The treatment effectiveness of FHV- and FCV-infected cats was good with 100% in FCV-infected cats and 98.44% FHV-infected cats. A non-survivor had an abnormal temperature that changed from up to down and the opposite, gingivitis and jaundice. Leptospirosis was tested but was negative. Most cases were improved in 1 week and recovered faster when taken to the clinic early. However, they became carriers. In 63 cats suffered from the FHV, 38.1% cats reactivated in 2 – 3 months and needed to get medicine.

CONCLUSIONS AND RECOMMENDATIONS

In this study, digestive and respiratory problems were the most common illness in total 528 examined cats. In particular, the most common respiratory diseases were caused by FHV and FCV with more than 50.0%, Overgeneralizes some findings, such as stating that FHV and FCV caused over 50% of respiratory diseases without acknowledging limitations in diagnostic methods. while FPV held only 14.09% in all digestive disorders. The diseased cats in groups of age, housing condition and vaccination had significant difference of all infected cases, especially in cats under 6 months old, multi cats living in a house, and non-vaccination. No difference was observed in infection rates based on gender, breed, or lifestyle, except for the lifestyle of FPV-infected cats.

The average recovery rate of these infection was 86.96%. The treatment effectiveness of FHV and FCV was about

100% while FPV disease was just nearly 50%. However, the result of treatment also depended on the characteristics of each disease, the days between clinical signs appeared and taken time to the clinics, the immunity of animals, and how the owner followed instructions of the vet. Successful prevention of 3 viruses depends on environmental hygiene and management. Cat living indoor will have a good environment and reduce the risk of infection. Besides, if the previous cat got infectious disease, the owner should clean house and prevent to bring new cats, especial kittens without vaccination to home at least 6 months to a year.

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NOVELTY STATEMENT

The digestive and respiratory problems were the most common illness in cats. This study indicated that feline herpesvirus and feline calicivirus caused more than 50.00% the respiratory diseases, and feline panleukopenia virus was 14.09% digestive disorders in cats; and evaluation of risk factors, clinical signs and treatment these viruses in diseased cats.

AUTHOR'S CONTRIBUTIONS

Conceptualization, Thuong T. Nguyen, Quynh N. Nguyen; methodology, Thuong T. Nguyen, Quynh N. Nguyen; formal analysis, Thuong T. Nguyen, Quynh N. Nguyen; writing—original draft preparation, Thuong T. Nguyen, Quynh N. Nguyen; writing—review and editing, Thuong T. Nguyen.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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