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Research article

The risk factors of having infected feline leukemia virus or feline immunodeficiency virus for feline naturally occurring chronic kidney disease

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Abstract

The infection of the feline leukemia virus (FeLV) and feline immunodeficiency virus (FIV) caused kidney problems. The proposes of this present study were to determine the prevalence and risk factors of feline naturally occurring chronic kidney disease (CKD) and to estimate the possible association between CKD and infection with either FeLV or FIV or with both FeLV and FIV in cats. The medical record of 6,287 cats visiting the Small Animal Hospital, Faculty of Veterinary Medicine, Chiang Mai University, Thailand, from January 2016 to October 2017 was presented. A case-control study was conducted to explore the risk factors for CKD by comparing 149 CKD cats and 44 clinically normal cats. Data was collected through questionnaires interviewing cats' owners and medical records. Association of risk factors and CKD were analyzed using Pearson Chi-square or Fisher's exact test as appropriate. A multivariate logistic regression model was constructed using backward elimination for CKD. The prevalence of feline naturally occurring CKD was 2.37%. The possible association between feline CKD and infection with either FeLV or FIV or with both FeLV and FIV was positive significant. The multivariate logistic regression indicated the free-roaming cat had the potential risk factor for CKD. Moreover, using a more than or an equal number of litter boxes to cats was a protective factor for CKD when compared to other factors. Further study is needed to investigate the cause of feline CKD on the mechanism of infection by FeLV and FIV.

Keywords: Chiang Mai, Feline chronic kidney disease, Feline immunodeficiency virus, Feline leukemia virus, Prevalence

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INTRODUCTION

Cats have a smaller size than dogs, and they are suitable for places with limited space such as apartments, condominium, or dorms. Up to date, cats are particularly popular in Chiang Mai (Helen, 2017), because cat raising has more advantages than the dog. Cat raising can reduce owners' stress. Moreover, the good attention of the owner makes their cats have a long life. The degenerative disease especially kidney disease is rising in geriatric cats (Elliot and Barber, 1998; Lawler et al., 2006; Piyarungsri and Pusoonthornthum, 2017).

Chronic kidney disease (CKD) is a considerable disease in aging cats (Lawler et al., 2006). The definition of CKD is kidney loss function and structure, which results in a 50% decrease in glomerular filtration rate (GFR) for more than 3 months (Polzin, 2010). According to International Renal Interest Society (IRIS), feline CKD is divided 4 stages each stages of CKD based on creatinine values including stage 1 (non-azotemic; creatinine < 1.6 mg/dL), stage 2 (mild renal azotemia; creatinine 1.6 – 2.8 mg/dL), stage 3 (moderate renal azotemia; creatinine 2.8 – 5.0 mg/dL) and stage 4 (severe renal azotemia; creatinine > 5.0 mg/dL) (Brown, 2004). Stage 4 is called chronic renal failure (CRF). CKD is subdivided into sub-stage by proteinuria and hypertension. Moreover, the update feline CKD biomarkers such as symmetric dimethylarginine (SDMA) or neutrophil gelatinase-associated lipocalin (NGAL) were considered together with creatinine for identifying kidney damage (Piyarungsri, 2017). The prevalence of CKD of the cat population in the United States was 1.9% (Lund et al., 1999). Sandi (2011) had reported that the prevalence of CKD in Banfield Small Animal Hospital, the United States was increased by 0.8% between 2006 and 2011. In Australia, the prevalence of CKD was 20% of cats visited animal hospitals (Watson, 2001). The prevalence of CRF in Bangkok, Thailand was 0.63% (Pusoonthornthum and Pusoonthornthum, 2004).

The infectious diseases such as feline immunodeficiency virus (FIV) and feline leukemia virus (FeLV) can cause CKD. There were several reports of the association between CKD and viral infection (DiBartola et al., 1987; Tozon et al., 2012; White et al., 2010). Outdoor cats had a higher risk for CKD than other lifestyles (caged or freely indoor) (Piyarungsri and Pusoonthornthum, 2017). These outdoor cats may high risk of viral infections, especially FeLV and FIV (Hoover and Mullins, 1991; Levy et al., 2006; Barros et al., 2017). Moreover, another infectious disease was associated with CKD in cats such as leptospirosis (Rodriguez et al., 2014).

Feline leukemia virus causes leukemia and lymphoid tumors in cats (Weiss et al., 2010). Overcrowded and outdoor cats were at high risk for FeLV (Hoover and Mullins, 1991; Levy et al., 2006; Barros et al., 2017). It was high morbidity but low mortality in cats (Barros et al., 2017). Hofmann-Lehmann et al. (1997) had reported that the FeLV-induced cats had an abnormal renal function with increased blood urea nitrogen (BUN) when compared with healthy cats (Hofmann-Lehmann et al., 1997). Cats with naturally occurring feline immunodeficiency virus (FIV) had an increased risk for CKD (White et al., 2010). Renal histological of cats with FIV was found glomerulonephritis, tubular changes, and interstitial lesions (Tozon et al., 2012). This histological finding is a hallmark of chronic renal diseases (Khan et al., 1999; Schelling et al., 1998). One study reported that cats with FeLV/FIV coinfection were also affected CKD (Barros et al., 2017). However, it was not mentioned the severity when compared with either FeLV or FIV infection.

However, few studies have determined the prevalence and risk factors of feline naturally occurring CKD and possible association with FIV and FeLV in Chiang Mai, Thailand. The purposes of this present study were to determine the prevalence and risk factors of feline naturally occurring CKD and to estimate the possible association between CKD and infection with either FeLV or FIV or with both FeLV and FIV in cats visiting Small Animal Hospital, Faculty of Veterinary Medicine, Chiang Mai University, Thailand.

MATERIALS and METHODS

The medical records were considered to define the prevalence and risk factors of feline naturally occurring CKD and to estimate the possible association between feline CKD and infection with either FeLV or FIV or with both FeLV and FIV in cats visiting Small Animal Hospital, Faculty of Veterinary Medicine, Chiang Mai University. Cats were divided into cats with CKD, CKD cats with either FeLV or FIV or with both FeLV and FIV, and the clinically normal cats at the same time as the study. Data were collected from January 2016 to October 2017 through questionnaires interviewing cats' owners regarding age, sex, breed, types of food, water sources, information on the frequency of feeding and drinking, lifestyle, clinical signs, hematology, and blood chemistry.

Animals

CKD cats were cats with at least 2 items of this following: (Mayer-Roenne et al., 2007; Piyarungsri and Pusoonthornthum, 2017)

1. Clinical signs including anemia, polyuria/polydipsia, dehydration or weight loss
2. BUN > 35 mg/dL
3. Creatinine > 1.6 mg/dL
4. Urine specific gravity (USG) < 1.030
5. The imaging diagnosis including the small size of the kidney, polycystic kidney or hydronephrosis

CKD cats with viral infection were cats with positive FeLV or FIV. CKD cats were tested with Feline Leukemia Virus Antigen - Feline Immunodeficiency Virus Antibody Test Kit (WITNESS® FeLV-FIV). Serum, plasma or anti-coagulated whole blood were used for testing with WITNESS® FeLV-FIV. All cats with FIV positive must be over 6 months old.

The clinically normal were age more than 5 years old and had normal results on physical exam and had normal blood tests. The control cats must have BUN < 35 mg/dL, creatinine < 1.6 mg/dL. If the clinically normal cats had previously been other systemic diseases, they would be excluded. All cats were included without gender preference.

Statistical analysis

The statistical analyses with Epi Info version 7.1.5.0 were used. Data of age, body weight, BUN, and creatinine were presented as the means ± standard deviations (SDs). The Student t-test or the Mann-Whitney U test were used to compare the age, body weight, BUN, and creatinine between groups. The prevalence of CKD cats was calculated by the ratio of CKD cats and the total number of cats. The prevalence of CKD cats with viral infection was calculated by the ratio of CKD cats with FeLV or FIV and the total number of cats. The variables that developed CKD were described by using relative frequencies. Pearson Chi-square or Fisher's exact test was used to analyzing the association of risk factors and CKD. The precision of association using univariate logistic regression was evaluated by odds ratios (OR) and 95% confidence intervals (95% CIs). A multivariate logistic regression model with backward elimination was constructed for CKD in cats. Variables associated with CKD at P values $\leq$ 0.05 were analyzed in the multivariate logistic regression analysis with backward elimination. Variables were included in the model based on the likelihood ratio $\chi 2$ statistic, at P values < 0.05.

RESULTS

The medical record of 6,287 cats visiting at Small Animal Hospital, Faculty of Veterinary Medicine, Chiang Mai University, Thailand, from January 2016 to October 2017 was presented. One hundred and forty-nine cats were diagnosed with CKD. The prevalence of feline naturally occurring CKD was 2.37%.

For these 149 CKD cats, 37 CKD cats were found positive to only FeLV (n=8, 5.37%), only FIV (n=22, 14.77%), and both FeLV and FIV (n=7, 4.70%) (Figure 1). The possible association between feline CKD and infection with either FeLV or FIV and both FeLV and FIV was positive significant (P < 0.01). The prevalence of feline CKD with FeLV and FIV infection was 0.59%. Concerning these two viral infections, most CKD cats were infected by only the FIV. These cats were age more than 8 years, intact male, domestic shorthair cats, and outdoor cats (Table 1).

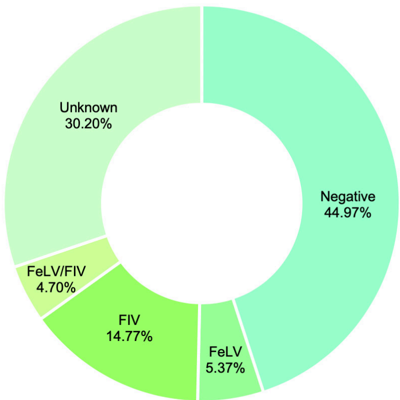

Figure 1 Chronic kidney disease cats with feline leukemia virus (FeLV) or feline immunodeficiency virus (FIV) testing (n=149) at the Small Animal Hospital, Faculty of Veterinary Medicine, Chiang Mai University between January 2016 and October 2017.

Table 1 Chronic kidney disease cats with feline leukemia virus (FeLV) or feline immunodeficiency virus (FIV) testing (n=104) at the Small Animal Hospital, Faculty of Veterinary Medicine, Chiang Mai University between January 2016 and October 2017.

	Negative (n=67)	FeLV (n=8)	FIV (n=22)	FeLV and FIV (n=7)
Age				
1 – 2 years	1	0	0	0
2 – 3 years	6	0	3	0
3 – 4 years	3	2	0	0
4 – 5 years	2	0	0	0
5 – 6 years	7	1	0	1
6 – 7 years	1	0	3	0
7 – 8 years	8	1	4	1
> 8 years	39	4	12	5
Sex				
Female intact	29	2	3	1
Female spayed	8	0	0	0
Male intact	26	6	18	6
Male castrated	4	0	1	0
Breeds				
Domestic shorthair	57	5	20	7
Persian	6	2	0	0
Purebred shorthair	4	1	2	0
Life style				
Indoor	30	2	1	0
Indoor- and outdoor	6	0	1	1
Outdoor	28	4	18	6
Unknown	3	2	2	0
IRIS stage				
Stage 2 (mild renal azotemia)	35	6	10	4
Stage 3 (moderate renal azotemia)	22	0	5	1
Stage 4 (severe renal azotemia)	10	2	7	2

IRIS, International Renal Interest Society; FeLV, Feline leukemia virus; FIV, feline immunodeficiency virus

For a case-control study, the study population included 44 clinically normal cats and 149 CKD cats. The mean age of CKD cats (9.92 ± 4.69 years old) was significantly higher than clinically normal cats (7.37 ± 2.60 years old). The mean body weight of CKD cats (3.68 ± 1.17 kg) was significantly lower than the clinically normal cats (4.40 ± 1.02 kg). The mean serum BUN and creatinine of CKD cats (72.06 ± 53.57 and 3.94 ± 3.15 mg/dL, respectively) had significantly higher than the clinically normal cats (22.34 ± 4.44 and 1.51 ± 0.23, respectively) (Table 2). The common clinical signs of CKD cats included dehydration (71.95%) and anemia (51.22%) (Figure 2).

Table 2 Mean ± standard deviations (SDs) of age, body weight, serum blood urea nitrogen, and serum creatinine between clinically normal and chronic kidney disease cats.

Parameter	Units	Clinically normal cats (n=44)	CKD cats (n=149)	P value
Age	years	7.37 ± 2.60	9.92 ± 4.69*	< 0.01
Bodyweight	kg	4.40 ± 1.02	3.68 ± 1.17*	< 0.01
BUN	mg/dL	22.34 ± 4.44	72.06 ± 53.57*	< 0.01
Creatinine	mg/dL	1.51 ± 0.23	3.94 ± 3.15*	< 0.01

CKD, Chronic Kidney Disease; BUN, blood urea nitrogen
* P < 0.01 when compared between the clinically normal cats and the CKD cats by student t-test

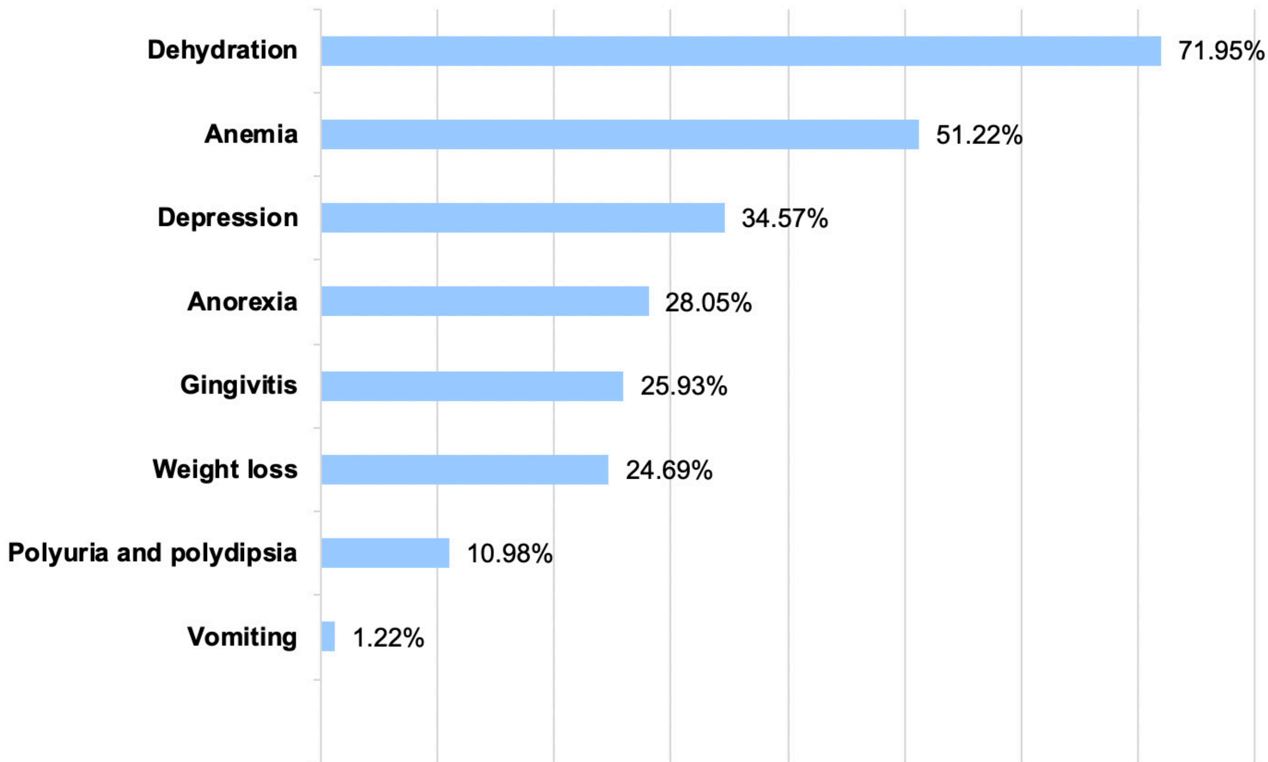

Figure 2 The clinical signs of chronic kidney disease cats at the Small Animal Hospital, Faculty of Veterinary Medicine, Chiang Mai University between January 2016 and October 2017.

Using Chi-square or Fisher's exact, sex, type of diets, lifestyle, and number of litter boxes had significantly associated with CKD (Table 3). From univariable logistic regression analysis (Table 3), female intact and male intact had increased risk for CKD when compared with male castrated (OR = 6.44, 95% CI: 2.10 – 19.81; OR = 8.11, 95% CI: 2.65 – 24.78, respectively). The outdoor lifestyle was higher odds ratio for CKD than indoor lifestyle (OR = 8.00, 95% CI: 3.26 – 19.65). Cats using litter boxes including a more than or an equal number and a less than the number of litter boxes to cats had decreased odds ratio for CKD compared with cats not using the litter box (OR = 0.02, 95% CI: 0.01 – 0.19; OR = 0.09, 95% CI: 0.01 – 0.77, respectively) (Table 3).

Table 3 Univariate logistic regression analysis of variables associated with chronic kidney disease and control cats that visited the Small Animal Hospital, Faculty of Veterinary Medicine, Chiang Mai University between January 2016 and October 2017.

Variables	Clinically normal cats	CKD cats	Odds ratio	95% CI	P value
Sex[a]					**<0.001**
Female intact[a]	10/44 (22.73%)	58/149 (38.93%)	6.44	2.10 – 19.81	**0.001**
Female spayed	14/44 (31.82%)	9/149 (6.04%)	0.71	0.20 – 2.44	0.592
Male intact[a]	10/44 (22.73%)	73/149 (48.99%)	8.11	2.65 – 24.78	**<0.001**
Male castrated	10/44 (22.73%)	9/149 (6.04%)	Reference		
Breeds					**0.002**
Domestic shorthair	33/44 (75.00%)	128/149 (85.91%)	3.88	1.55 – 9.72	**0.004**
Long-hair	11/44 (25.00%)	11/149 (7.38%)	Reference		
Purebred shorthair	0/44 (0.00%)	10/149 (6.71%)	N/A		
Type of diets[a]					**0.002**
Dried and can	15/32 (46.88%)	22/82 (26.83%)	Reference		
Homemade & can	0/32 (0.00%)	6/82 (7.32%)	N/A		
Can food	0/32 (0.00%)	3/82 (3.66%)	N/A		
Dried, can, and homemade	7/32 (21.88%)	8/82 (9.76%)	0.39	0.13 – 1.17	0.121
Homemade & dried food	0/32 (0.00%)	23/82 (28.05%)	N/A		
Dried food	9/32 (28.13%)	12/82 (14.63%)	0.44	0.16 – 1.17	0.111
Homemade	1/32 (3.13%)	8/82 (9.76%)	3.35	0.40 – 27.94	0.440
Frequency of meals					0.334
1	1/44 (2.27%)	0/57 (0.00%)	N/A		
2	31/44 (70.45%)	36/57 (63.16%)	0.66	0.28 – 1.56	0.348
Ad libitum	12/44 (27.27%)	21/57 (36.84%)	Reference		
Drinking water source					0.460
Filtered water	15/44 (34.09%)	10/45 (22.22%)	Reference		
Bottled water	9/44 (20.45%)	11/45 (24.44%)	1.83	0.56 – 6.03	0.318
Tap water	20/44 (45.45%)	24/45 (53.33%)	1.80	0.66 – 4.87	0.248
Frequency of drinking water					≅ 1.000
Ad libitum	44/44 (100%)	45/45 (100%)			
Life style[a]					**<0.001**
Indoor	33/44 (75.00%)	43/149 (28.86%)	Reference		
Indoor- and outdoor	4/44 (9.09%)	12/149 (8.05%)	2.30	0.68 – 7.79	0.180
Outdoora	7/44 (15.91%)	73/149 (48.99%)	8.00	3.26 – 19.65	**<0.001**
Unknown	0/44 (0.00%)	21/149 (14.09%)	N/A		
Number of cats in a household					0.315
1 cat	5/31(16.13%)	12/38 (31.58%)	Reference		
2 cats	6/31(19.35%)	5/38 (13.16%)	0.35	0.07 – 1.69	0.190
≥ 3 cats	20/31(64.52%)	21/38 (55.26%)	0.44	0.13 – 1.47	0.180
Number of litter boxes[a]					**<0.001**
≥ number of catsa	15/31 (48.39%)	4/37 (10.81%)	0.02	0.01 – 0.19	**0.001**
< number of catsa	15/31 (48.39%)	19/37 (51.35%)	0.09	0.01 – 0.77	**0.030**
No litter box	1/31 (3.23%)	14/37 (37.84%)	Reference		

CKD, Chronic Kidney Disease; 95% CI, 95% confidence interval; N/A, not available
[a] $P < 0.05$

Multivariable logistic regression using backward elimination (Table 4) demonstrated that the outdoor lifestyle had a higher risk for CKD than other variables (OR = 4.59, 95% CI: 1.03 – 20.42). Moreover, a more than or an equal number of litter boxes to cats decreased risk for CKD when compared to other factors (OR = 0.07, 95% CI: 0.01 – 0.79).

Table 4 Multivariable logistic regression analysis (backward) of variables including female intact, male intact, the outdoor lifestyle, number of litter boxes ≥ cat number and number of litter boxes < cat number in chronic kidney disease cats at Small Animal Hospital, Faculty of Veterinary Medicine, Chiang Mai University between January 2016 and October 2017.

Variables	Odds ratio	95% CI	P value
Female intact	1.88	0.41 – 8.70	0.420
Male intact	2.21	0.53 – 9.31	0.279
Outdoor lifestyle*	4.59	1.03 – 20.42	0.046
Number of litter boxes < cat number	0.17	0.02 – 1.64	0.125
Number of litter boxes ≥ cat number*	0.07	0.01 – 0.79	0.031

CKD, Chronic Kidney Disease; 95% CI, 95% confidence interval
* P < 0.05

DISCUSSSION

The prevalence of feline naturally occurring CKD in this study was higher than previous studies in the United States (1.9%) (Lund et al., 1999) and Bangkok, Thailand (0.63%) (Pusoonthornthum and Pusoonthornthum, 2004). The different findings may be explained that CKD cats in previous studies were included from all cat populations in the United States (Lund et al., 1999) and only CKD stage 4 in Bangkok, Thailand (Pusoonthornthum and Pusoonthornthum, 2004). However, the prevalence of cats with CKD in this study was lower than the study in Australia (20%) (Watson, 2001). These different results may due to geographic area, duration of sample collection and study designs.

The prevalence of CKD cats with either FeLV or FIV or with both FeLV and FIV infection was 0.59%. These CKD cats mostly occurred positive only FIV. Most CKD cats infected only FIV were cats age more than 8 years old, male intact, domestic shorthair cats, and outdoor cats. It was similar to one study that male cats with age more than 6 years old were higher positive FIV (Ravi et al., 2010). Moreover, FeLV and FIV infection can cause immune-complex glomerulonephritis (Rossi et al., 2019) that can progress to CKD (Minkus et al., 1994).

This study demonstrated that FeLV or FIV infection was significantly associated with feline CKD. In agreement with several studies, cats with kidney problems were associated with FIV infection (Poli et al., 1993; Thomas et al., 1993; Poli et al., 1995; Poli et al., 2012). Cats with FIV infection in Australia were associated with azotemia and small size of kidneys (Thomas et al., 1993). The cats with naturally occurring FIV infection had kidney abnormalities from histopathology and ultrastructure (Poli et al., 1993; Poli et al., 1995; Poli et al., 2012). Histopathological changes of kidney abnormalities including bowman's space dilatation, mesangial widening, and glomerular amyloidosis were found in cats with naturally occurring FIV infection (Tozon et al., 2012). In contrast with one study, cats with renal disease were not significantly associated with FIV (Ravi et al., 2010). Proteinuria was associated with naturally FIV-infected cats, while the association between FIV infection and renal azotemia was not detected (Baxter et al., 2012). The difference between the present and previous studies may due to the study design. The present study selected CKD cats to be the main population, whereas the previous studies selected cats with FIV to be the main population. One previous study reported CKD cats with age < 11 years old were significantly related to FIV infection, but no significant association between FIV infection and CKD in cats was observed (White et al., 2010). The small number of CKD cats in the previous study may affect the difference in the association of FIV and CKD between the present and previous studies.

Although western blot assay is recommended to confirm FIV enzyme-linked immunosorbent assay (ELISA) results, the reported sensitivity and specificity for the WITNESS ELISA kit are high. The WITNESS® FeLV-FIV test kit is an accurate in-clinic test that detects the presence of FeLV antigen and FIV antibodies. In FeLV, WITNESS tests yielded sensitivity and specificity of 92.9% and 96.5%, respectively (Zoetis service and support). In FIV, WITNESS® tests yielded sensitivity and specificity of 93.8% and 93.4%, respectively (Zoetis service and support). However, false-positive and false negative results could occur when using this test kit. A false-positive and false-negative of FeLV is 3.5% and 7.1%, respectively. A false-positive and false-negative of FIV is 6.6% and 6.2%, respectively. The false-positive and false-negative of this test kit are also low. One study supported the accuracy of this test kit (Krecic et al., 2018). WITNESS tests for FeLV yielded sensitivities and specificities of 100% and 97.8, respectively, in comparison to immunofluorescence assay (IFA) and 91.5% and 100% in comparison to a polymerase chain reaction (PCR) as the reference method (Krecic et al., 2018). FeLV positive was low detected in CKD cats in this study. This result may explain that FeLV latent form is not detected by the ELISA test kit. PCR should be used for confirming FeLV infection in further study. However, confirmatory analyses were not performed given the retrospective nature of the study.

Although the mean age of clinically normal cats was over 7 years old. The mean age of CKD cats was also significantly higher than clinically normal cats. This study found that 3.33% of CKD cats were age over 20 years old. These cats with age over 20 years old may cause the difference of the mean age between CKD cats and the clinically normal cats. The geriatric cats were commonly affected by CKD (DiBartola et al., 1987; Lawler et al., 2006; White et al., 2010). Our study found that the mean body weight of CKD cats was significantly lower than clinically normal cats. It's related to the medical record of clinical signs that these CKD cats affected 24.69% of weight loss. In contrast to one previous study, there was no significant difference in the mean body weight of CKD and the clinically normal cats (Piyarungsri and Pusoonthornthum, 2017). Overweight was a high incidence of neutered cats (Kienzle and Moik, 2011). Therefore, the difference in the mean body weight between the present and previous studies may explain that the large proportion of neutered cats in the control group of the present study may affect the mean body weight. While the proportion of neutered cats of two groups in the previous study is the same.

From the univariable logistic regression analysis, female intact and male intact had increased risk for CKD when compared with male castrated. Neutering results in reduced territory behavior such as fighting (Hart and Cooper, 1984). The bite wound from the fighting behavior is an important way for the infectious disease especially FIV (Shelton et al., 1989). Earlier the infected FIV causes renal dysfunction; hence, cats with a high risk of infected FIV were also a high risk of developing CKD. In agreement with several previous studies indicated that FIV was associated with CKD (DiBartola et al., 1987; White et al., 2010; Poli et al., 2012). This reason may explain that neutering may decrease the risk of feline CKD by decreasing infectious disease especially FIV.

The freely outdoor lifestyle was associated with an increased odds ratio for CKD compared with an indoor lifestyle. In agreement with the previous study in Bangkok, Thailand, the freely outdoor cats had a higher risk for CKD than cats living in other environments (Piyarungsri and Pusoonthornthum, 2017). In the same way as the study in the United States, CKD in cats were associated with roaming freely outdoors from hunting behavior (Bartlett et al., 2010). The free-roaming cats have more chance to expose to the infectious pathogens or toxic substances which cause kidney disease.

Cats using litter boxes had a decreased odds ratio for CKD compared with cats not using a litter box. This result may relate to the lifestyle of cats. Most free-roaming cats in this study didn't use a litter box. Inadequate litter boxes for cats increased the risk for feline lower urinary tract disease (FLUTD) (Buffington et al., 2006; Piyarungsri et al., 2020) which lead to kidney problems. Although obstructive FLUTD trends to be acute kidney injury (Elkhiat et al., 2019), cats with irreversible renal damage may progress to chronic kidney disease with decreased quality of life (Reynolds and Lefebvre, 2013).

The multivariable logistic regression using backward elimination, in the present study, demonstrated that the outdoor lifestyle had a higher risk for CKD than other variables. Moreover, a more than or an equal number of litter boxes to cats was decreased risk for CKD when compared to other factors. These important factors may relate to infectious diseases such as FIV and FeLV infection because our study indicated a significant positive association between feline CKD and infection of FeLV or FIV.

CONCLUSION

The prevalence of feline naturally occurring CKD was 2.37% in cats visiting Small Animal Hospital, Faculty of Veterinary Medicine, Chiang Mai University, Thailand. The possible association between feline CKD and infection with either FeLV or FIV or with both FeLV and FIV was positive significant. The free-roaming cat had the potential risk factor for CKD. Moreover, using a more than or an equal number of litter boxes to cats was a protective factor for CKD when compared to other factors. Further study is needed to investigate the cause of feline CKD on the mechanism of infection by FeLV and FIV.

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CONFLICT of INTEREST

The authors declare that they have no conflict of interest.

AUTHOR CONTRIBUTION

K.P. wrote the manuscript and conducted the case and control selection. K.P., S.T. and A.T. designed the study. K.P. and S.T. analyzed the data. K.P., S.T., C.S., A.T. and K.B. performed case collection.

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