Prevalence and Risk Factors for Obesity in Adult Cats from Private US Veterinary Practices

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ABSTRACT

Using a cross-sectional study design, the prevalence of overweight and obesity in adult cats seen by US veterinarians during 1995 was determined. Risk factors for overweight and obesity were also determined from the following variables: age, breed, gender, body condition score, food type, reported concurrent disease, and geographic region. Thirty-five percent of adult cats (n = 8,159) were overweight or obese. From multivariate analyses, overweight cats were more likely to be neutered, male, eating a premium or therapeutic food, and to be concurrently diagnosed with disease of the oral cavity or urinary tract. Obese cats were more likely to be of the Domestic Shorthair, Domestic Longhair, Domestic Mediumhair, Mixed, or Manx breeds, being fed a premium or therapeutic food, and concurrently diagnosed with diabetes mellitus, neoplasia, oral disease, or dermatopathy. Practitioners can use these data to strongly advocate for the maintenance of feline patients at ideal body condition.

INTRODUCTION

The prevalence of obesity in domestic feline populations has been estimated from a limited number of studies. Results from these studies range from a combined overweight and obesity prevalence of 40% in a population of cats from a Danish veterinary hospital[1] to 25% in a population of adult cats from a northeastern United States veterinary hospitals population.[2] The relationship of obesity to the development of disease in cats is of much clinical interest, but has been the subject of limited research. A cohort study of disease risk in obese and overweight cats revealed associations with diabetes mellitus, lameness, and skin disease.[3] More numerous studies in canine populations have found relationships between canine obesity and musculoskeletal disorders,[4-6] cardiovascular problems,[6] glucose intolerance and diabetes mellitus,[7,8] hypertension,[9] immune dysfunc-

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tion,[10] and bladder[11] and mammary cancer.[12] Because of the known relationship of human obesity to certain diseases, such as hypertension, cardiovascular disease, diabetes mellitus, stroke, osteoarthritis, some cancers, and premature mortality, it is speculated that similar relationships may hold true for cats.[13,14] Knowledge of obesity/overweight as a risk factor for disease can heighten awareness and target health screening of cats. With evidence from feline research studies as a tool, practitioners may be able to advocate more strongly for obesity prevention and weight reduction plans for their clients' pets.

The major objectives of this study were to determine the prevalence of overweight and obesity in adult feline populations seen by private veterinary practitioners in the United States and to elucidate basic risk factors for overweight and obesity, that is, age, breed, gender and neuter status, food type, concurrent disease, and geographic region of residence. Such associations or risk factors are very important for identifying cats at risk for obesity and for identifying which diseases are more likely to afflict overweight and obese cats.

MATERIALS AND METHODS

The general study methods and population from the National Companion Animal Study (NCAS) have been previously described in detail.[15] Using a proprietary practice management system (Advanced Veterinary Systems [AVS], VetConnect Systems, Eau Claire, WI, USA), data collected included: date of birth, diagnoses (new and existing), breed, gender, neuter status, body condition score (BCS),[16] major and minor food type and form, and geographic region.

Body condition score. Body condition scores were assigned as a whole number value from 1 to 5 by the veterinarian examining the cat. A BCS of 1 indicated the animal was excessively thin, 3 was ideal, and 5 was obese. The amount of fat cover over the cats' ribs and the abdominal contour were used in assessing body condition. (Criteria for assessing the abdomen were not considered in assigning a BCS in cats less than 6 months of age because kittens often have pendulous abdomens.)

All participating clinics were provided with a training videotape on the use of the BCS scale. Multiple body condition scores over the year of data collection were averaged to obtain a single BCS per animal. Average BCS was used to place cats in either the overweight or obese category for this analysis. Obese animals were defined as having an average BCS greater than 4.5 and less than or equal to 5.0. Overweight animals were defined as having an average BCS greater than 3.5 and less than or equal to 4.5.

Food type and form. Food categories were Popular Dry, Premium Dry, Therapeutic Dry, Popular Canned, Premium Canned, Therapeutic Canned, Homemade, Semi-moist, and Other. "Popular" described brands typically purchased in a grocery store, farm store, or large-format pet retailer. "Premium" was used to define brands typically purchased in a veterinary practice, pet store, or large-format pet retailer. "Therapeutic" referred to brands prescribed and sold by veterinarians for the treatment or prevention of disease. "Homemade" referred to a complete diet prepared at home from individual food ingredients. "Other" included meat or other food products, commercial treats, or table scraps.

The cat owner chose one major food component (greater or equal to 60% of food by volume) and a minor food component (remainder of food, if applicable). Additional food codes were added at subsequent patient visits only if changes in feeding had occurred. Only major diet (greater than or equal to 60% of food fed by volume) was included in this analysis; semi-moist food was combined with food in the "Other" category due to the low frequency of feeding semi-moist as a major food.

Geographic region. West and East South Central were combined to form South Central; New England and Middle Atlantic were combined to Northeast; Pacific included Alaska and Hawaii.

Diagnoses. New and existing diagnoses for a specific cat at each clinic visit were recorded using a system for standardized nomenclature.[17] Individual diseases and disease categories were included in the analysis based on hypotheses informed by literature review. Subjects were counted once in a category for one or more diagnoses reported during the study that fell into that category.

Statistical Methods

The adult cat population was defined as animals over 1 year of age; analyses were conducted on cats that had at least one diagnosis (including "Healthy") of any kind recorded over the study period (i.e., these cats constituted the population denominator for the study) and had at least one recorded BCS. The SAS statistical program, 6th edition[18] (SAS Institute, Cary, NC, USA), was used to generate frequencies, prevalence estimates, univariate distributions, and multivariate analyses.

Disease and disease category prevalence was estimated for obese and overweight cats by BCS for all diseases included in the multivariate analysis. Overall adult population prevalence estimates for obesity and overweight were generated using 2 methods: average BCS and reported diagnoses for obesity and overweight (that is, when either "obesity" or "overweight" was entered as a diagnosis for that visit by the veterinarian).

Univariate distributions were generated to describe the prevalence of overweight and obesity by age, breed, gender, and neuter status of the population. To control for confounding of the relationship between risk factors and overweight or obesity, a multivariate analysis was conducted using full logistic regression models.[19] Confounders are factors—for example, age or breed—that are related to both the exposure being examined and the outcome (overweight or obesity). Confounders can distort assessment of the relationship between the exposure of interest and the outcome. For example, when comparing state-specific cancer rates between people living in Colorado versus Florida, lower cancer rates might be observed in Colorado. Since age is a predictor of cancer risk, the rates may reflect the older population in Florida compared with a younger population in Colorado. Age, therefore, is confounding the potential difference between rates. Because the multivariate model controls for confounding by age, breed, and so on, the risk factors generated are therefore independent predictors of obesity. Variables in the multivariate models for this study included age in years; 10 most prevalent breeds; gender; neuter status; major food type consumed (greater than or equal to 60% of food volume fed); concurrent disease; and geographic region of United States.

Concurrent diseases and disease categories included in the feline model included: arthritis, dermatopathy, diabetes mellitus, gastrointestinal disease, heart disease, hepatic lipidosis, lameness, musculoskeletal disease, neoplasia, oral disease, and urinary disease (see Appendix). An interaction term for gender and neuter status was also included in all logistic models to account for the potential of differential risk for obesity for males versus females by neuter status. The referent category for food type was popular/dry; the West North Central region was the referent category for geographic region. For all statistical tests, $\alpha = .05$.

In the multivariate analysis, the prevalence odds ratio (OR) was used as an approximation of relative risk. Relative risk is a measure of the strength of the association between a disease and potential risk factors like age and breed. When the OR is greater than one, the factor is found to be associated with an increased risk of that disease. For example, the OR for obesity and a concurrent diagnosis of diabetes mellitus is 2.2; an obese cat is more than twice as likely to be diagnosed with diabetes compared with an adult cat of normal/underweight body condition (all other factors being equal) (Table 1). A relative risk estimate does not necessarily reflect a causal relationship (for example, that obesity causes diabetes melli-

Table 1. Multivariate Disease Models: Risk Factors for Overweight and Obese Adult Cats (N = 8,159)

	Risk Factors (*P*-value)	Odds Ratio (CI*)	β†
Overweight Cats	Male (.05)	1.4 (1.0,1.8)	.31
(n = 2,342)	Neuter (.006)	1.4 (1.1,1.7)	.30
	Premium foods (< .0001)	1.4 (1.2,1.5)	.31
	Therapeutic foods (.002)	1.3 (1.1,1.6)	.24
	Oral disease (< .0001)	1.8 (1.6,2.0)	.57
	Urinary disease (.0002)	1.6 (1.3,1.9)	.46
Obese Cats	Domestic Shorthair (.02)	10.5 (1.5,76.1)	2.4
(n = 522)	Domestic Mediumhair (.03)	10.3 (1.3,78.7)	2.3
	Domestic Longhair (.04)	8.0 (1.1,58.5)	2.1
	Manx (.04)	13.0 (1.1,151.1)	2.6
	Mixed breed (.05)	8.1 (1.0,63.3)	2.1
	Premium foods (<. 0001)	1.8 (1.5,2.2)	.60
	Therapeutic foods (< .0001)	2.4 (1.8,3.3)	.86
	Dermatopathy (.006)	1.5 (1.1,2.0)	.39
	Diabetes mellitus (.01)	2.2 (1.1, 4.4)	.88
	Neoplasm (.04)	2.0 (1.0, 3.8)	.67
	Oral disease (.002)	1.4 (1.1,1.7)	.31

*95% confidence interval (CI).
†Parameter estimate/coefficient from logistic model.

tus), but rather an association between the disease and the predictive factor.

A Hosmer-Lemeshow goodness-of-fit test[19] was estimated for each disease model to determine how well the model explained the variability in the observed data. The higher the *P* value, the better the "fit" of the model to explain the relationship of the independent variables (risk factors) to the dependent variable (overweight or obesity). The null hypothesis for this statistic is that the model fits; a *P* value greater than .05 leads one to fail to reject the null hypothesis.

RESULTS

A total of 8,159 adult cats with a reported BCS were included in this analysis of a National Companion Animal Study population of 11,102 adult cats. Prevalence of obesity in this adult private practice population based on body condition assigned by veterinarians was 6.4% for adult cats; 28.7% were overweight. A total of 35.1% of cats older than 1 year of age, therefore, were either overweight or obese.

Prevalence of obesity for adult cats based on reported diagnoses (that is, when obesity was entered as a diagnostic code) was 2.2%; the prevalence of overweight based on reported diagnosis was 1.4%. Only 3.2% of the adult cats identified as overweight based on BCS were also coded by the veterinarian as "overweight." Among cats identified as obese by BCS, 21.5% had a diagnostic code of "obesity" entered by the veterinarian.

Prevalence of individual disease and disease categories included by hypothesis in the analysis are detailed in Table 2. Oral disease, dermatopathy, and urinary disease were the most common diseases included in this analysis. Over 40% of obese and overweight adult cats were diagnosed with at least 1 disease in the oral disease category.

The prevalence of obesity and overweight (Figure 1) is greatest for cats in their middle-aged years (between 5 and 11 years). Neutered males (Figure 2) had the highest prevalence of overweight (33.3%) and obesity (7.7%); intact females had the lowest

Table 2. Disease and Disease Category* Prevalence by Body Condition Category for Adult Cats

Disease/Disease Category	Obese (4.5 <BCS† ≤ 5.0) n = 639	Overweight (3.5 < BCS ≤ 4.5) n = 2,792	Normal and Underweight (1.0 < BCS < 3.5) n = 6,434
Arthritis	0.3%	0.4%	0.3%
Dermatopathy	12.8%	9.3%	9.3%
Diabetes mellitus	1.9%	0.6%	0.8%
Gastrointestinal disease	4.2%	2.7%	2.8%
Heart disease	1.7%	2.1%	3.1%
Hepatic lipidosis	0.2%	.04%	.09%
Lameness	0.9%	1.1%	1.2%
Musculoskeletal disease	0.8%	0.7%	0.7%
Neoplasia	1.7%	1.0%	1.4%
Oral disease	42.3%	44.3%	31.5%
Urinary disease	7.4%	7.1%	4.8%

*Cat was reported to have at least 1 disease in category.
†BCS indicates body condition score.

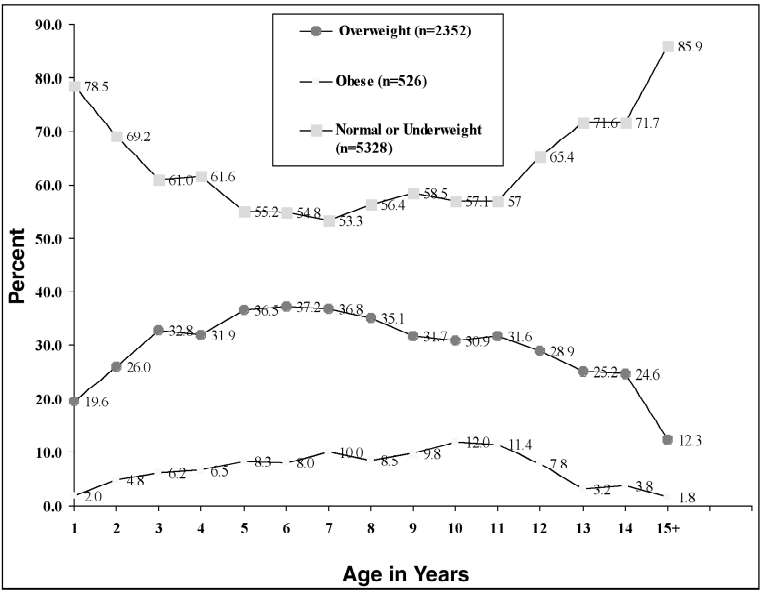

Figure 1. Prevalence of obesity and overweight by year of age for adult cats.

prevalence of overweight (20.4%) and obesity (4.8%). Overweight prevalence of 30% or more (Figure 3) was found in the Domestic Shorthair (DSH), Domestic Mediumhair (DMH), unknown, and Manx breeds. Breed prevalence for obesity ranged from 1.8% (Persian, Himalayan) to 9.4% (Manx).

In the multivariate analysis (Table 1), overweight cats were more likely to be neutered, male, eating a premium or therapeutic food, and were more likely to be concurrently diagnosed with oral or urinary tract disease. Obese cats were likely to be of the Domestic Shorthair (DSH), Domestic Mediumhair (DMH), Domestic Longhair (DLH), Mixed or Manx breeds; fed a premium or therapeutic food, and more likely to be concurrently diagnosed with diabetes mellitus, oral disease, dermatopathy, or neoplasia.

No association was found between overweight or obesity and geographic region of residence or age. Interaction between gender and neuter status did not emerge as a significant predictor in the multivariate models. Probabilities calculated for the Goodness of Fit statistics were: $P = 0.3$ (overweight model) and $P = 0.9$ (obesity model).

DISCUSSION

This study documents a combined overall prevalence of overweight and obesity of 35% in the adult cat population in the United States. Obesity alone had a prevalence of

6.4%. The NCAS is the first nationwide study to provide these important percentages. Of particular note is that more than a third (41.0%) of all castrated male cats in this study were overweight or obese. Between the ages of 5 and 11 years, over 40% of all cats were overweight or obese. As expected, based on previous research on the effects of neutering on energy requirements, intact cats were underrepresented in the overweight and obese categories.[20,21] The data suggest that the primary target of overweight and obesity prevention should be young and middle-aged, neutered cats, especially males. Recent canine data suggest that the ideal body condition range for health maintenance for dogs is lower than previously thought.[22] In this study, euthanasia (end-of-life decisions) due to incapacitating osteoarthritis occurred earlier in dogs when body condition was not maintained within an ideal range. Although cats are not prone to developing clinically apparent osteoarthritis as they age, arthritis is evident radiographically.[23] Because of this and other disease risks, similar recommendations may need to be extended to cats.

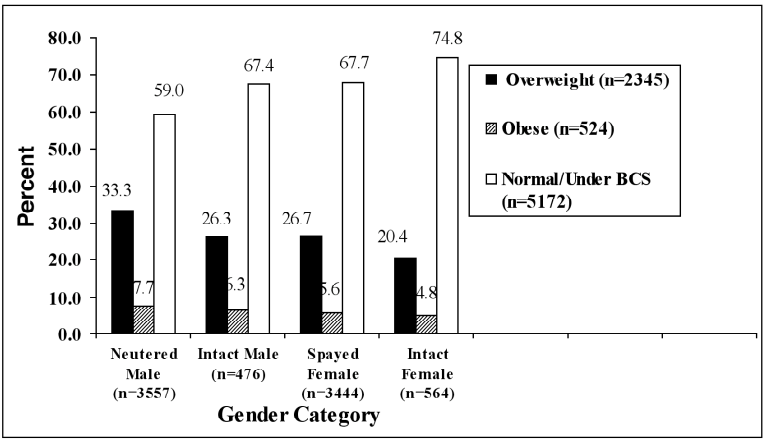

Figure 2. Prevalence of obesity and overweight by gender for adult cats.

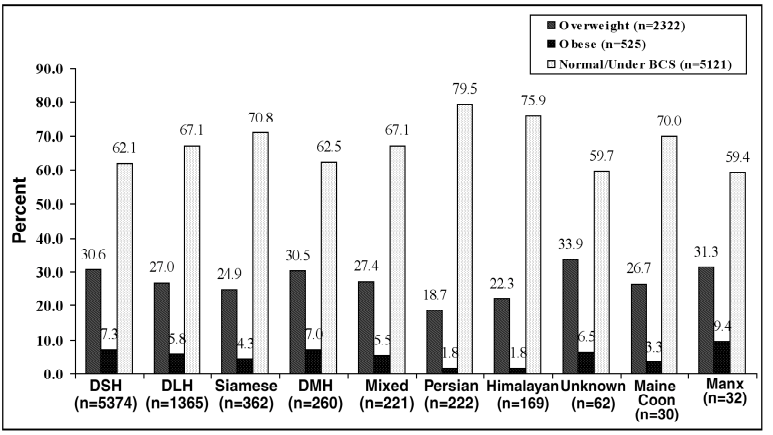

Figure 3. Prevalence of obesity and overweight by breed* for adult cats. *In order of decreasing overall breed frequency. DSH indicates domestic shorthair; DLH, domestic longhair; DMH, domestic mediumhair.

Data from this study also demonstrate that the prevalence of overweight or obesity diminishes in very old cats. A cross-sectional study cannot determine whether this was due to weight loss in cats as they age or the death of overweight and obese cats at an earlier age than their lighter-weight counterparts. A recent report on weight distribution in a large colony of cats suggests that this observation is likely due to weight loss with age.[24] Our results suggest that it may be prudent to take steps to encourage maintenance of adequate body weight in geriatric cats before significant weight loss is noted. This may require a change to a higher-caloric-density food in aging cats even while their BCS is still optimal.

Breed documentation is less certain in cats than in dogs, with the majority of cats being designated DSH, DMH, DLH or Mixed types without pedigree information

to make such categorization. Regardless, some useful breed-specific data emerged from this study. Based on the multivariate analysis, Manx cats were at risk for obesity. Conversely, Siamese cats, often anecdotally said to be prone to obesity, were not found to be at risk for overweight or obesity.

The disease associations documented here are of particular interest as they provide additional evidence of the links between overweight or obesity and specific diseases in cats. Both overweight and obese cats are at greater risk of oral disease than the rest of the adult cat population. Overweight cats are at increased risk for urinary tract disease; however, a relationship between obesity and urinary tract disease as a category was not found, possibly due to a lack of statistical power because there were fewer obese cats and/or effects of grouping many diseases into one category. Obese cats are at increased risk for diabetes mellitus, corroborating previous feline studies suggesting this association.[3,25] Obesity therefore joins gender (male-neutered) as a risk factor for diabetes mellitus.[25] Obesity also increased risk for dermatopathy and neoplasia in our study. The relationship between obesity and skin disease supports the finding in an earlier cohort study of cats.[3] An association of obesity with neoplasia is interesting; however, risk for specific types of cancer would require study designs more suited for the study of rare disease. Despite the greater prevalence of gastrointestinal disease in obese cats (Table 2), the multivariate analysis did not reveal a significant association of obesity or overweight with this group of diseases.

Feeding premium and therapeutic foods was associated with increased risk of overweight and obesity in this study. Premium foods, defined for this study as nontherapeutic brands typically purchased from a veterinary clinic, pet store, or large-format pet product retailer, are typically higher in caloric density than "popular" dry foods. Our results may indicate that the caloric density of premium foods as they are fed (in quantity or frequency), may exceed the needs of many cats. Therapeutic foods were defined as brands prescribed and sold by a veterinarian for the treatment or prevention of disease. This study did not collect data on the indication for being fed a therapeutic food (for example, weight management). Presumably, some percentage of overweight or obese cats was being fed therapeutic foods for this reason.

Region did not emerge as a risk factor for adult cat obesity or overweight and could reflect the fact that the lifestyle of cats across the geographic regions of the United States is fairly uniform and does not influence the risk for obesity/overweight. However, it is also possible that we were unable to discern any differences based on lifestyle since data on whether cats lived predominately indoors or outdoors were not collected. Previous studies have identified inactivity,[3,26] indoor living,[27] and apartment dwelling[3] as risk factors for feline obesity.

We observed dramatic underreporting of overweight and obesity when comparing prevalence from BCS results to reported diagnoses, especially for overweight cats. For example, the prevalence of obesity defined by BCS for cats was 6.4% compared with 2.2% when defined by reported diagnostic code. The difference between overweight prevalence in cats defined by BCS (28.7%) and reported diagnosis (1.4%) was even greater. Underreporting of the diagnosis of obesity and overweight may reflect the perception of practitioners that obesity/overweight does not constitute a disease state, especially for animals in the overweight category. Alternatively, the knowledge that BCS was being collected for this study may have reduced the frequency with which overweight or obesity was recorded as a diagnosis.

Major strengths of the study reported here include the size and geographic distribution of the population studied as well as the ability to generalize the results to private practice populations in the United States.

Although the data for this study were collected during 1995, the scope and the results of the study remain relevant to the contemporary description and assessment of the obesity problem of cats seen in private companion animal practice. Surveillance and monitoring of the health of US cats is especially relevant in light of the current epidemic of human obesity. Despite the "age" of the data, the NCAS provides knowledge that will enhance the health care of feline populations today.

Limitations of the study include the use of a cross-sectional study design, a lack of standardized case definitions, and the potential for underreporting of cases.[15] A cross-sectional study is of limited use for discerning disease causality as well as risk for rare diseases.[28] For the results reported in this study, the lack of case definitions and the potential for disease misclassification must be considered. Grouping of individual diagnoses into system categories was necessary to increase the efficiency of the statistical analysis and to minimize error from disease misclassification. The failure of this study to document a risk relationship between overweight or obesity and an uncommon disease, such as hepatic lipidosis, does not prove or disprove such a relationship. Misclassification of the outcome (overweight or obesity) by BCS must also be considered as a source of differences between our study results and others as the assessment of body condition has not been standardized across research studies.

In addition to providing important descriptive data on the problem of obesity in cats seen by practitioners in the United States, the factors reported in this study can help practitioners anticipate predisposition to obesity/overweight. Feeding practices of neutered pets may need to be more closely guided by veterinarians, especially in regard to feeding calorie-dense premium foods. Future studies should ideally include additional lifestyle factors such as indoor/outdoor status as variables to help fully model and predict obesity. A cohort design would allow cats to be followed over their lifetime, enabling determination of which cats transition from overweight to obesity as well as to elucidate whether obese cats are dying at younger ages than their normal-weight cohorts. Finally, with these study results, the ability of practitioners to communicate the importance of maintaining feline patients at ideal body condition will be strengthened.

APPENDIX. Diseases Diagnosed by Veterinarians in Study Cats

Dermatopathy (prevalent diagnoses > .05%): acne, alopecia (general, psychogenic, pustular), dandruff, dermatitis (allergic, flea bite, food allergy, foxtail, fly bite, general, miliary, moist, paronychial, pruritic, seborrheic), dermatophytosis, folliculitis, ingrown toenail, pyoderma (deep, general).

Gastrointestinal Disease (prevalent diagnoses > .05%): anal sac disease, chronic diarrhea, colitis (acute, general), constipation, enteritis, gastritis, gastritis (acute, general), gastroenteritis (bacterial, eosinophilic, general), inflammatory bowel disease (eosinophilic, lymphoplasmacytic, mixed), megacolon.

Heart Disease (prevalent diagnoses > .05%): congestive heart failure, cardiomyopathy (congestive, dilated, general, hypertrophic, taurine deficiency), heart disease, heart murmur (acquired, general), hypertension.

Musculoskeletal Disease (prevalent diagnoses > .05%): arthritis, cruciate ligament rupture, patellar luxation, soft tissue injury, osteomyelitis.

Neoplasia *(prevalent diagnoses ≥ .05%)*: adenocarcinoma, basal cell carcinoma, fibrosarcoma, lipoma, lymphosarcoma, mammary tumor, mast cell tumor, squamous cell carcinoma, tumor-unspecified.

Oral Disease (prevalent diagnoses > .05%): cervical lesion, dental caries, dental calculus, dental calculus/gingivitis, fractured tooth, gingivitis, periodontal disease, ptyalism, stomatitis.

Urinary Tract Disease (prevalent diagnoses > .05%): acute cystitis (acute, bacterial, chronic, general), bladder stone(s), feline urologic syndrome, obstruction, urinary tract infection, urolithiasis (calcium oxalate, struvite, unspecified).

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