Feline Cancer Prevalence in South Africa (1998 – 2005): Contrasts with the Rest of the World

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Abstract: A paucity of information exists on the relative proportions, incidences or outcomes of diagnosis and treatment of feline cancer in South Africa. Standard texts of veterinary oncology quote data from the Northern hemisphere, and geographic differences are apparent. In this retrospective analysis, the electronic medical database of the Onderstepoort Veterinary Academic Hospital was analysed for feline cancer felines admissions for the period 1998 – 2005 (n = 100 out of N = 12,893 feline admissions, or 0.78% of total feline admissions). The average and median age of feline cancer felines was 7 and 9.5 years respectively. In contrast to published reports of US, Australian and European data where lymphosarcoma is the most common cancer affecting cats, squamous cell carcinoma (SCC) forms the predominant neoplasm (48% of all tumours). White or part-white cats were overrepresented in this group, which is consistent with greater ultraviolet light exposure. Lymphoma was the second most common diagnosis, followed by various carcinomas and adenocarcinomas. A large proportion (54%) of felines received some form of treatment.

Keywords: Feline, cancer, prevalence, South Africa, squamous cell carcinoma, lymphosarcoma.

INTRODUCTION

The geographic influence on cancer incidence is well described in the medical and veterinary literature. There are various postulated or proven causes of these spatial differences, such as environmental factors (ultraviolet radiation, pollutants) and genetic heterogeneities and inbreeding within subpopulations. Several surveys have been conducted in the field of veterinary cancer epidemiology using a variety of techniques and sources including records from insurance companies [1, 2], veterinary hospital [3-15], veterinary histopathology records [16], national cancer registers [2, 17-20] and telephonic and personal interviews [2, 13, 20, 21].

Patterns of incidence soon become apparent once any database is constructed from this information, allowing clinicians and researchers to highlight the most frequent and therefore important animal neoplasms. In some cases, researchers have attempted to use animal species as sentinels for human disease [22-24] or *vice versa*, [21] by overlapping animal and human patterns of disease using geographic information systems (GIS). Nonetheless, one study found little evidence of the interspecific concurrence or temporal clustering between canine and human cancers [24].

There is a lack of current data on the relative proportions, incidences or outcomes of diagnosis and treatment of feline cancer in South Africa, barring one survey of histopathology reports [16] and a canine cutaneous neoplasia study from neighbouring Zimbabwe [25]. Standard texts of veterinary oncology quote data from the Northern hemisphere [26], and geographic differences are evident. The objective of this study was to understand the pattern of clinically relevant feline neoplasias seen at a veterinary teaching hospital.

MATERIALS AND METHODS

The electronic medical database of the Onderstepoort Veterinary Academic Hospital (OVAH) was retrospectively analysed for data of feline neoplasiaadmissions for 1998 – 2005.Records were analysed for signalment and were categorised according to neoplasm type or diagnosis (histopathology, cytology or presumed); tumour location and metastasis; survival (where known); whether or not any medical or surgical treatments were performed; and colouration (white/not white) in cats with squamous cell carcinoma. The total and subtotal numbers, ages and breed distribution of these animals was compared with the hospital population data for the same period. Where necessary, owners or referring veterinarians were contacted to ascertain outcomes and survival times. When a tissue diagnosis was not recorded in the hospital database, histopathology records were retrieved. If an animal was diagnosed with more than one tumour type, these were recorded as separate occurrences. Data was entered into a spreadsheet database (Microsoft Excel 2000, Microsoft Corp) and assigned into the aforementioned

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categories. A breed analysis was performed by comparing breeds diagnosed with neoplasia, against the breed distribution in the entire hospital population, and then analysed to determine abnormal clustering of disease in certain breeds and signalments (StatistiXL v1.5, StatistiXL Inc).

For this, a series of hypotheses were used to construct 2 x 2 contingency tables evaluating differences between observed and expected frequencies (χ^2 analysis). Where frequencies of observations were low, Yates's correction was applied, and significance sought using the Fisher's 2-tail method at $p \leq 0.05$. Both the χ^2 and Fisher's exact test were used to determine whether a particular breed, characteristic or signalment varied as a function of the disease. Gender distributions were compared in a similar manner. Breeds diagnosed with neoplastic disease were compared to their overall proportion in the OVAH feline population *via* two-way contingency tables and χ^2 analysis performed to discover unexpected increases in any breed's likelihood of being diagnosed with neoplasia. For breeds with small numbers, the Fisher's correction was used. Siamese and Oriental breeds were also grouped together and the statistical test repeated. Hypotheses tested in relation to these data were (1) were Siamese, or Siamese+Orientals, more likely to be diagnosed with lymphoma, than other breeds; (2) was any breed more likely to be diagnosed with squamous cell carcinoma; and (3) were white/part-white cats more likely to be diagnosed with squamous cell carcinoma than other breeds? In the OVAH feline population, LSA (lymphosarcoma) was not a frequent diagnosis, and FeLV/FIV testing was not routinely performed during this period. Thus statistical analysis over retroviral-LSA status was not performed. LSA data was evaluated to determine whether Siamese and Siamese/Oriental cats were significantly over-represented amongst LSA felines in this population.

The distribution of cytological or histopathological diagnoses, sub-classified to anatomical presentation, was tabulated. A comparison of percentages with each diagnosis and within each group was made with Bastianello and various authors from other countries (see Table **5** for references). Bastianello combined the urogenital and mammary neoplasia groups, hence this subcategory on Table **5**. Comparisons with other authors was sometimes quite difficult, based on different classifications, inclusions and exclusions from groupings such as "head and neck", "skin" and "nasal". Table **6** represents the classification system as used by Louwerens *et al*. [27] to aid comparisons.

RESULTS

The number of feline neoplasia cases identified was 100 including 1 duplicate record for 2 different neoplasms on 1 feline out of N = 12,893 feline admissions, or 0.78% of total feline admissions.

Signalment Distribution

The OVAH population was skewed 72:28 for entire:neutered. Male:Female ratio was 54:46, and entire felines outnumbered neutered ones (Table **1**). All observed gender frequencies were significantly different from hospital gender distributions ($p<0.05$) and similar to those described for alimentary neoplasia in another study [10]. Entire males and females were under-represented amongst cats diagnosed with neoplasia, while neutered males and females were over-represented to a significant degree.

Eight breeds encompassed all felines diagnosed with neoplasia (Table **2**). These breeds accounted for 96% of all hospital registrations. Of 100 feline records (n=99 felines), 71 were classified as DSH (domestic shorthair), 9 each were DLH (domestic longhair) or Siamese, the three most common breeds seen in the study population. No breed approached significance barring the Devon Rex ($\chi^2 = 5.816$, $p = 0.016$) and the Havana. Seeing as only two individuals of the latter breed were registered at the OVAH, the significance of this observation was deemed dubious. Siamese cats, and the Siamese+Oriental group, were more frequently

Table 1: Gender Distributions of the Felines in the Hospital and Neoplasia Populations

Group	Male:Female	Male (Entire)	Male (neutered)	Female (entire)	Female (spayed)
Neoplasia group (*n*)	49:51	20%	29%	15%	36%
Hospital population (*N*)	54:46	37%	17%	35%	11%
χ^2 Statistic		13.640	12.471	18.109	58.483
p-value		<0.001	<0.001	<0.001	<0.001

Table 2: Breed Propensity to be Diagnosed with a Neoplastic Disease: 2-Way Contingency Table (χ^2 Results; Y = Yates Correction Applied; 1 Degree of Freedom for all Results; * = Significance at *P*<0.05)

Breed (Hospital N_0 = *12,460)*	*n*	Breed *N*	χ^2 value*	P (<0.05 significant)	Fisher's 2-tail *p* (where applicable)
Domestic Shorthair (DSH)	71	8464	0.355	0.563	
Domestic Longhair (DLH)	9	863	0.608	0.436	
Siamese	9	888	0.486	0.486	
Oriental	2	59	2.124 ^{Y}	0.145	0.086
Siamese + Oriental	11	947	1.429	0.232	
Devon Rex	3	39	13.882 ^{Y}	<0.001 *	0.005 *
Persian	4	1063	2.240	0.134	
Havana	1	2	9.571 ^{Y}	0.002 *	0.024 *
Sphynx	1	45	0.051 ^{Y}	0.822	0.307

Table 3: Breed and Signalment Propensity to be Diagnosed with a Specific Neoplastic Disease: 2-way Contingency Table of Main Results (χ^2 Results; ^{Y} = Yates Correction Applied; 1 Degree of Freedom for all Results)

	Section/ Breed/ Signalment	*n*	Cancer *N*	%	χ^2 value*	P (<0.05 significant)	Fisher's 2-tail (where applicable)
1.	Siamese & LSA**	6	19	31.6	14.388	0.0001 ^{Y}	0.001 *
	Siamese +Oriental & LSA**	8	19	42.1	9.023	0.003 ^{Y}	0.006
2.	DSH	41	48	85.4	9.318	0.002 *	
	DLH	4	48	8.3	0.016	0.900 ^{Y}	0.715
	Devon Rex	1	48	2.1	0.005	0.944 ^{Y}	0.863 ***
	Siamese	1	48	2.1	3.890	0.049 ^{Y}	0.021 ***
	Sphynx	1	48	2.1	0.002	0.968 ^{Y}	0.480 ***
3.	White/Part-white cats & SCC**	36	48	75	16.388	0.00005 *	

* = Significant at *P*<0.05; ** LSA = lymphoma, SCC = squamous cell carcinoma; *** = only 1 feline.

diagnosed with LSA than other breeds (Table **3**, Section 1).

With regard to SCC (squamous cell carcinoma), DSH cats were diagnosed significantly more often than other breeds, and part white or white cats were very significantly over-represented amongst SCC sufferers. 48/56 (86%) of all skin tumours were SCC. The number of white/part-white cats admitted during each year of the study period, as a proportion of the total number of admissions for that year, was charted and was not significant (P>0.05; Figure **1**). 36/48 cases (75%) of SCC were diagnosed in White or Part-White cats, which was significant (Tables **3** & **4**). This is significantly greater (P = 0.00003) than the remainder of the white/part-white cats in the study group (54/99, or 54.5%), or the hospital population (31.1%). The proportion of white/part-white cats registered for all reasons did not vary a great deal from year to year (Figure **2**), but was always statistically smaller than the proportion of cats suffering from SCC, who had the same colouration. When cats with SCC were divided by breed, only DSH (Domestic Shorthair cats) demonstrated a significantly higher than expected tendency to be diagnosed with SCC (χ^2 = 13.374, df = 1, *p* = 0.00021; Table **3**, Sections 2 & 3).

Cats with SCC were also older than other cancer felines (average of 10.9 $\pm$ 3.4 years old *versus* non-SCC cancer felines 9.4 $\pm$ 5.0 years and the hospital population average age 7.39 $\pm$ 2.2 years. Differences were statistically significant (*p* = 0.031 and *p*<0.001, respectively). In contrast, in the SCC group, the average age of white/part white cats was not significantly different from that of non-white cats (2-sample t-test, *p*=0.113). In general, cats diagnosed with a neoplastic disease were older than the general hospital population (*p*< 0.001).

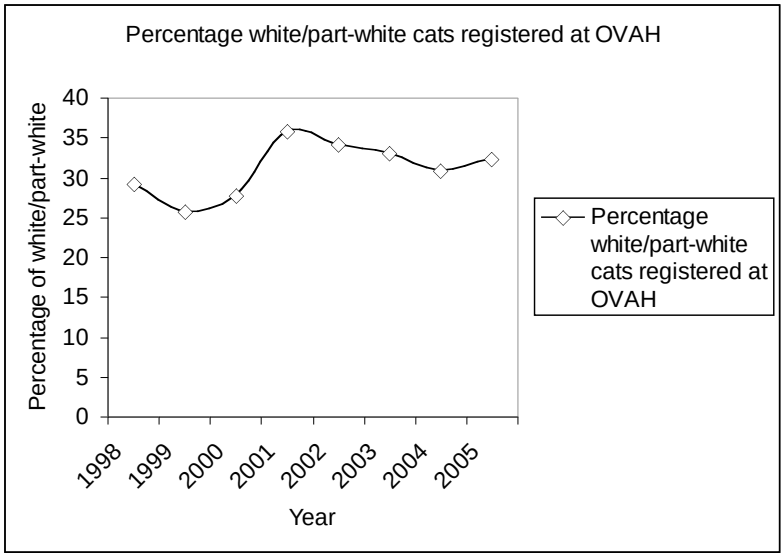

Figure 1: Graph showing the percentage of cats registered each year, which were white/part-white. This was significantly different from the proportion of white/part-white cats amongst those diagnosed with SCC, which had the same colouration (75% vs 31.1%) but not different from year to year.

Table 4: Proportions of White/Part-White Cats and Squamous Cell Carcinoma

Group	White/Part-White	Not White	TOTALS
Squamous cell carcinoma	36	12	48
Other neoplasias	18	34	52
TOTALS	54	46	100

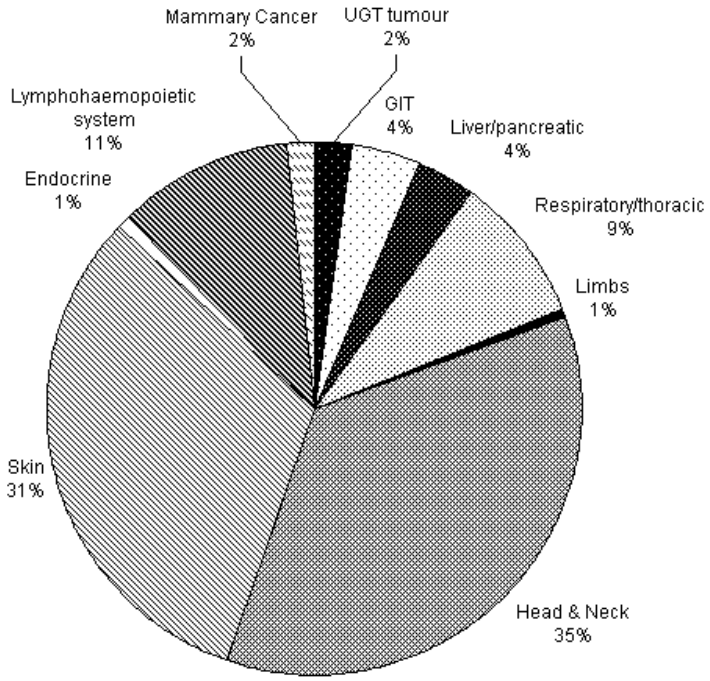

Figure 2: Pictogram demonstrating anatomic distributions of feline neoplasia diagnosed at the OVAH.

Table 5: Feline Tumours 1998 – 2005, Arranged by Primary Tissue

Tissue/Organ	Neoplasm	n	Total in tissue	Bastianello, 1983 (%)	US, UK/EU, Australian, Japanese authors (%)
Lymphohaemo-poetic system	Lymphoma[a]	18	20	21.4	22 [44] 3.3 [20] 18 [11] 50.5 [40] 0.84 [38]
	Leukaemia, lymphoid	1			
	Thymoma	1			
Skin & adnexa	Squamous cell carcinoma	48	56	35	55.1 [20] 0.6 – 1.7 [65][m] 35/7 [44] 28 [11] SCC 10.9 [66] All: 47.7 [66] HSA: 1.8 [67] MCT 21 [68]
	Sweat gland adenocarcinoma[b]	3			
	Fibrosarcoma, injection site	1			
	Haemangiosarcoma of nasal planum	1			
	Mast cell tumour	1			
	Apocrine adenoma	1			
	Unknown nature (undiagnosed)	1			
Urogenital	Transitional cell carcinoma	1	2		1.4 [20][j] 2 [11]
	Bladder lymphoma[c]	1			
Mammary	Carcinoma	3	3	9.9	16.3 [20, 54] 20 [11] 20.6 [66]
Urogenital & Mammary combined[d]	All types	4	5	9.9	22 [11]
Digestive system[e]	Adenocarcinoma	2	5	10.3	5.4 [20][k] 0 - 7.8 [4][n] 19.7 – 37.2 [10]
	Lingual Haemangiosarcoma	1			
	Maxillary melanoma	1			
	Undiagnosed oral tumours	1			
Musculoskeletal system	Sarcoma, cranium	1	3	4.9	16 [44]
	Sarcoma, thoracic wall	1			
	Osteosarcoma	1			
Respiratory tract[f]	Spindle cell sarcoma, intrathoracic	1	5	3.3	2.5 [20] 0.01 – 0.38 [69] 1 – 8.4 [70]
	Intranasal sarcoma	2			
	Mast cell tumour	1			
	Undiagnosed facial-nasal tumour	1			
Liver/pancreas[g]	Bile Duct Carcinoma	2	4	2.9	0.6 – 10.1 [71] 2.5 [20] 6.9 [72] 0.01 [73][p]
	Hepatic Carcinoma	1			
	Pancreatic adenocarcinoma	1			
Nervous system	Any type	0	0	0.8	2.2 [74, 75]
Endocrine	Adrenal gland tumour[h]	1	1	0.4	
Other	Records incomplete, “cancer”	1	1	0	
	Eye, blood vessels, adipose, miscellaneous	0	0	11.1	
TOTAL			N = 100	100%	

[a]One of which also had renal metastases (therefore not included in urogenital category).
[b]One of these two felines also had a nasal squamous cell carcinoma.
[c]Also counted under lymphoma elsewhere, but not in this table.
[d]This is to aid comparison with Bastianello [16] who combined these groups.
[e]Not including 4 intestinal or mesenteric lymphomas.
[f]excluding thymoma, mediastinal lymphoma and lymphoma metastasising to the lungs.
[g]Not including 1 each of intestinal lymphoma and adenocarcinoma metastasising to liver.
[h]With spread to ipselateral kidney (therefore not included in urogenital category).
[i,j,k]Vascellari *et al.* lump soft tissue and skin together as a category and separate genital tract and urinary tract tumours; and oral cavity and intestinal tumours.
[m]Follicular tumours only.
[n]Epulides as a proportion of oral tumours.
[p]Exocrine pancreatic neoplasia 12.6/100,000 cases.
[q]Malignant + benign epithelial 19+16 / SCC only [44].

Distribution of Types of Neoplasia

Tumours were tabulated in the same format and categories as used by Bastianello. Diagnoses were categorised according to anatomical location (Figure **2**). One feline was diagnosed with two simultaneous, different neoplasms (nasal squamous cell carcinoma and sweat gland adenocarcinoma of the skin over the parotid region). The single most common neoplasm seen was the squamous cell carcinoma (48% of all neoplasms and 85.7% of all skin and adnexal tumours). Lymphohaemopoetic neoplasms comprised 20/99 of neoplasia diagnoses (Table **5**). LSA cases were tabulated in the format used by Louwerens and coworkers to aid comparisons with the anatomical-diagnosis forms of LSA described in that work [27].

Sarcomas

Eight varied sarcomas were seen in the study population; three were not identified more precisely than "sarcoma", and only on the basis of cytology. Only one putative case of post-vaccination sarcoma was diagnosed, in a juvenile cat (6 months old), on the basis of cytology. The client could not be contacted and records were sparse. The accuracy of this diagnosis was questioned, as cytology has a high false-positive level for this neoplasm, and histopathology is necessary for the diagnosis [26].

Other Carcinomas

Sixteen cases of non-SCC neoplasia were classified in the heterogenous group of "Other Carcinomas". Of these three cases each of mammary, sweat gland and hepatic carcinoma or adenocarcinoma were diagnosed (9/16 total). Average (10.1 years) and median (9.5 years) age did not differ significantly from that of the other 84 neoplasia cases. Carcinomas, including mammary carcinoma and excluding SCC, formed the third most common neoplasm in cats.

Treatment and Euthanasia

Only 74/99 of felines had their cancers confirmed by a tissue sample either cytology or histopathology. This may account for most of the discrepancies between this clinical-based study and Bastianello's histopathology-only-based report [16]. Almost half (54%) of all feline cancer felines received some form of treatment, although the majority of these were formed by squamous cell carcinoma and some lymphoma felines. The remainder were euthanased without recourse to any treatment. This is similar to the treatment levels reported in one study (48%) [28].

DISCUSSION

The single most prevalent form of feline neoplasia seen in the 8-year period. The preponderance of cases in white/part-white cats was striking. Squamous cell carcinoma is a common post-actinic neoplasm in humans and animals that has a high expression of 5-lipoxygenase [29]. In the past, human oncologists and dermatologists used the Burn Index as a guide for skin cancer prevention schemes. For a variety of reasons, this has fallen into disrepute. A unitless quantity, the Global Solar UV index (UVI), has been developed as a guide in skin cancer prevention schemes [30]. The UVI is derived from a simple formula which multiplies a constant by the summation of energy delivery over the target spectrum (Figure **3**). The integrand is the product of the solar spectral irradiance at a particular wavelength, multiplied by an "erythema reference" action spectrum, integrated over a wavelength interval dλ. This gives a unitless figure from 1 to over 12, which is then reported daily or even several times daily, by national and regional weather services around the world. In medical dermato-oncology, skin cancer prophylactic measures are influenced by the effects of feline pigmentation. Skins are arbitrarily divided into three groups – Melano-compromised, melano-competent, and melano-protected (types I, II & III, respectively) [31]. In this study, 81% of the cats developing SCC could fall into the Skin Type I, meaning that, when compared alongside human exposure levels, South Africa, they had 139 days per year when they were exposed to enough UVB to develop erythema [32, 33]. In humans, SCC is the second most common form of skin cancer, and UV radiation is clearly linked to its development and the concurrent immune suppression that occurs with chronic, high-dose UV irradiation [34]. Cats and people in South Africa with Skin Type II and III categories would have experienced the same signs for only 97 and 32 days per year, respectively (Figure **4**) [32]. Therefore the link between white hair coat (and thus melano-compromise) seen in this population is validated by the significantly higher risk for development of SCC due to higher erythemal irradiance. A similar theory was described by Pirie and Dubielzig for feline conjunctival haemangiosarcoma in the United States [35]. Newkirk and Rohrbach noted a higher age in SCC-affected eyelids, and a predominance of this tumour type in unpigmented

tissues [36]. A final piece of evidence for this line on reasoning is that only 15% of cutaneous neoplasms in a US study were SCC, *versus* 86.7% in this South African study [8].

$$I_{\mathrm{UV}} = \mathrm{k}_{er} \int_{250nm}^{400nm} E_{\lambda}\, s_{er}(\lambda)\mathrm{d}\lambda$$

Figure 3: The formula from which Global Solar UV Index is derived. E_λ is the solar spectral irradiance in $W\cdot/(m^2\cdot nm^1)$ at wavelength λ and dλ is the wavelength interval (250 – 400 nm) used in the summation; s_{er} is the erythema reference action spectrum, and k_{er} is a constant of 40 m^2/W applied to the formula [30].

LSA receives much attention in the US and European veterinary literature as the most common neoplasm of cats [10, 15, 20, 27, 37-46]. By contrast, only 18 cases of LSA and one of leukaemia were seen over an8-year period at the OVAH. Contrast this and some Australian data [38] with the facts presented by Meichner and co-workers, from Germany, showing a time-related decrease in the prevalence of LSA and the mediastinal form in particular, as FeLV testing and vaccination became more prevalent [42]. This is in contrast to these South African data, with 61% of all LSA being mediastinal, almost certainly reflecting the low level of testing and vaccination. The study by Vascellari and co-workers, from Italy, also reports skin and soft tissue tumours as the most common form, with lymphoid neoplasia only comprising 3.3% of all cases in their registry [20]. It is impossible to make more detailed comparisons of the Italian data and that presented here, from the article cited whereas that of Rostami and co-workers is more comparable in approach, if not results [11]. The distribution of anatomical subtypes of LSA has received a fair amount of attention in the past, particularly with reference to the effects of changing FeLV epidemiology [11, 15, 27, 39, 47-49]. The preponderance of young cats (mainly Siamese or Orientals) led to a remarkable skewness in the anatomical presentation of the lymphomas at the OVAH and is consistent with the predisposition for this form of LSA reported elsewhere [10, 27, 38, 39, 45, 50]. Siamese cats are also described as being four times more likely than other cats, to develop anal sac gland carcinoma, [13] other intestinal carcinomas [10, 51, 52] and mammary carcinoma [53]. The predisposition to neoplasia in sterilised animals, noted by Rissetto *et al.* for alimentary neoplasia, was mirrored in the South African population [10]; numbers in this study prevented a similar breakdown comparison. It is entirely possible that pet owners who sterilise their cats pay more attention to the overall welfare of their animals than “non-sterilising” owners, creating bias in this result.

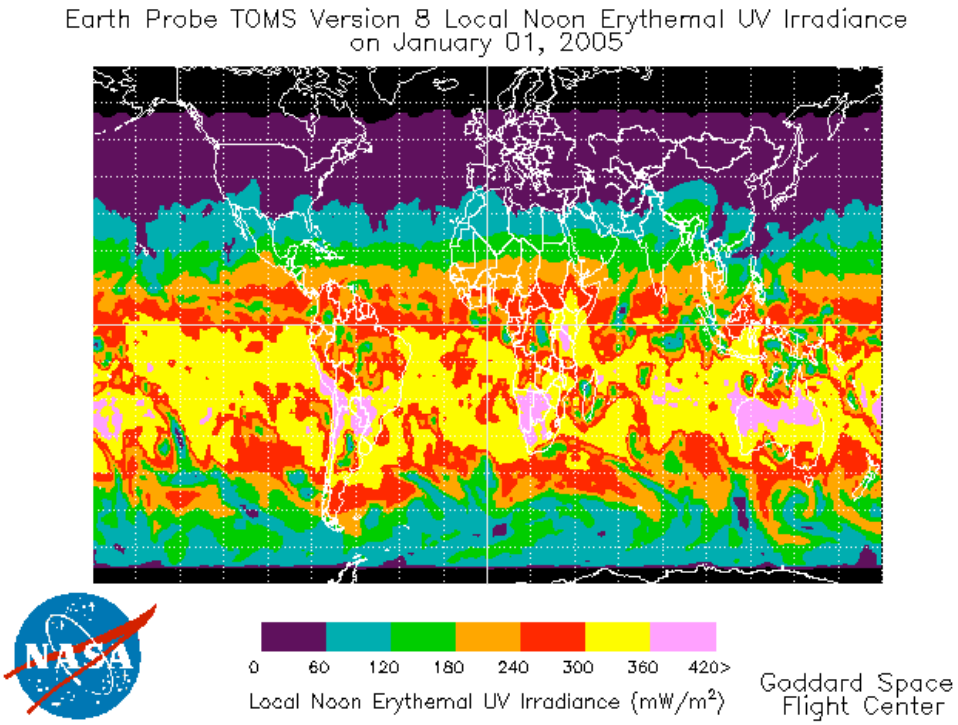

Figure 4: Satellite data showing that the UV Irradiance in the US, Canada and most of Europe in the 0 – 120 band, while South Africa (and Australia) are in the 180+ band for erythemal UV irradiance. © Goddard Space Flight Center, NASA, courtesy Dr. Jay R. Herman. ftp://toms.gsfc.nasa.gov/pub/eptoms/images/erythemal/Y2005/IM_eryln_ept_20050101.png

Table 6: Age Distribution of Primary Anatomic Presentation for Cats with Lymphoma in the Format of Louwerens *et al.* (2005) to Aid Comparison

Age (years)	Abdominal	Atypical	Mediastinal	Mixed	Nodal
Median Age (years)	2	n/a	1	6	5
1	0	0	3	0	0
2	2	0	4	0	0
3	0	0	0	0	0
4	0	0	2	1	0
5	0	0	0	0	1
6	0	0	0	1	0
7	0	0	0	1	0
8	0	0	0	0	0
9	0	0	2	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	1	0	0	1	0
Total cats	3 (16.7%)	0 (0%)	11 (61.1%)	4 (22.2%)	1 (5.5%)
Louwerens [27] (USA)	53.9%	21%	5.7%	16.4%	4.8%
Haga *et al.* [40] (Japan)	5.1%	2.5%	5.1%	Not stated	64%
Gabor and Malik (Australia) [15, 39]	30.3%	33.5%*	12.9%	Not stated	23.3%
Court *et al.* (Australia) [38]	20%	26.7%	23.3%	Not stated	30%

*atypical+leukaemic + renal.

Table 7: Comparison of Ranking of the Three Most Common Groups of Neoplasias According to Different Publications (some Amalgamated)

Neoplasm	This study (1997-2005)	Bastianello (1983)	Various authors cited in text	Zappulli (2005) citations [56]
Squamous cell carcinoma	1st	1st	4th – 6th	2nd
Lymphoma	2nd	2nd	1st	1st
Carcinomas (others)	3rd	3rd	3rd	3rd (mammary)

Mammary carcinoma was diagnosed in several cats, albeit less frequently than by Bastianello [16, 54, 55]. Ovariohysterectomy has a seven-fold sparing effect on the prevalence of this cancer in cats, and as the general level of ovariohysterectomy was low in the study population, an opportunity exists to reduce the incidence of this tumour in cats in South Africa. Mammary carcinoma has been reported as the third most common tumour of cats by some authors [56].

Lastly, a comparison of this data with the histopathology-based report of Bastianello and various American, Australian and European data dating as far back as the 1950s demonstrated the marked geographic environmental influence of actinic radiation on producing SCC [32, 57]. The various carcinomas, excluding the SCC, form the next most important group of cancers, relegating lymphoma to second place. The congruency with Bastianello's histopathology articles in 1983 is much better in cats than in dogs (unpublished data).

In conclusion, this report agrees quite closely with the histopathology study of Bastianello. In a positive

light it has been shown that squamous cell carcinoma, which has a good long-term prognosis [36, 58-63] and not lymphoma, is the most common cancer in South Africa. This also validates the 13.4-fold increase in SCC risk suffered by white cats, described over 40 years ago by Dorn and co-workers [64]. Geographic influences on epidemiological patterns are ubiquitous, and may be the result of access to healthcare, population genetics, environmental factors (such as UV levels) or FeLV vaccination levels [18]; or peculiarities of the modelling technique employed. Nonetheless, basic epidemiological knowledge is essential in order to target research, therapeutic and teaching resources.

Shortcomings of the study include its retrospective nature and the small numbers of certain breeds and tumours in certain categories; the difficulty making like-for-like comparisons with previous reports, especially across disciplines (medicine, pathology); and the relatively low number of felines (99). Lastly, the medical records during the study period were not always complete or computerised.

Data from histopathology-based studies is helpful, but may not accurately reflect clinical caseloads, only biopsy caseloads. Since, in certain circumstances and by individual clinicians, some neoplasms are diagnosed on clinical appearance, cytology or by means of diagnostic imaging, histopathology surveys alone may fail to reflect population epidemiology of neoplastic diseases within a population. Even so, the study by Bastianello and more recent ones by Mukaratirwa *et al*. [25] in canines fill important gaps in our knowledge of regional differences in cancer epidemiology, and enable corroboration of clinical data.

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CONFLICT OF INTEREST

The Author(s) declare(s) that there is no conflict of interest.

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