

Incidence and types of canine tumours in Slovenia (2000-2020): A Retrospective study

Key words

dog;
tumour;
incidence;
age;
breed;
Slovenia

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Abstract: We conducted a large retrospective study to establish a registry of canine tumours diagnosed in Slovenia over a 20-year period and to analyse their incidence rate and some epidemiological characteristics. In the study, we analysed the results of histopathological examinations of biopsies and samples from the necropsies of dogs submitted to the Institute of Pathology, Wild Animals, Fish and Bees of the Veterinary Faculty, University of Ljubljana between 2000 and 2020. Malignant tumours predominated (58.81%), followed by benign tumours (37.17%); 4.02% of tumours were of unspecified biological behaviour. Tumours were most frequently found in the skin and subcutaneous tissue (57.83% of all tumours), the mammary gland (14.07%) and the haemolymphatic system (6.63%). The most frequently diagnosed tumours were mast cell tumour (14.17%), mammary (adeno)carcinoma (10.02%), cutaneous histiocytoma (7.34%) and cutaneous/subcutaneous lipoma (6.92%). 51.69% of dogs with tumours were female, and 48.17% were male. Tumours were most common in Golden Retrievers (4.86%), Boxers (4.72%), German Shepherds (4.66%) and Labradors (4.27%), and were the most common between age of 8 and 11 years. In 151 dogs (2.03%) multiple tumours of different types were detected at the same time. The results of our study are mostly comparable with the results of other similar studies.

Received: 6 December 2024
Accepted: 23 December 2024

Introduction

Neoplasia is one of the most common diagnoses in dogs today and is the main cause of mortality in dogs. The Veterinary Cancer Society estimates that 25% of dogs will be diagnosed with cancer during their lifespan (1-3). Cancer epidemiology is a growing field of research and emerges as a crucial and expanding area of investigation in veterinary medicine. The limited information available on the incidence, type, location, and behaviour of neoplasms in canine populations underscores the significance of advancing research in this field (1). Effective tracking of cancers in animals is an essential prerequisite for scientific evidence that demonstrates the potential of companion animals to serve as valuable models for human cancer studies and for cancer prevention and control in general (4). Analysis data on the incidence rate of animal tumours is crucial for predicting disease progression and outcome, as well as for identifying possible mechanisms involved in the development of certain tumour types. Such early discoveries can lead

to development of more appropriate therapy for patients. Companion animals and humans share the same household and living environment, exposing them to similar risk factors. This close cohabitation makes companion animals valuable indicators for the identification of environmental pollutants that may contribute to oncogenesis, making such studies beneficial for both veterinary and human medicine. Dogs have been shown to be effective sentinels for environmental hazards such as asbestos, dyes, passive smoking, and insecticides (6).

In the field of veterinary medicine, there are only a limited number of (in)active cancer registries that collect information on the incidence of tumours in animals. The California Animal Neoplasm Registry (CANR) is one of the most frequently cited veterinary cancer registries. It began collecting data in 1963 and within three years had collected records from a clearly defined study region in which more

than 30,000 cases of malignant tumours were recorded. Each of these cases was subjected to a histopathological examination (7). In Europe, for example, a study from Switzerland presented by the Swiss Canine Cancer Registry contains data on 121,963 dogs that were histopathologically examined between 1955 and 2008 (8). In a study in Italy, a tumour registry was established for dogs and cats in two provinces of the Veneto region, in which the incidence of tumours was recorded over a three-year period (9). In another study in Italy, all tumour cases in Genoa between 1985 and 2002 were reviewed (10). A study in Croatia presented data on canine tumours diagnosed between 2006 and 2009 (2).

In the past, researchers in Slovenia have conducted several retrospective studies on the occurrence of some specific tumour types in different animal species, e.g. a retrospective study on testicular tumours in dogs (11), a retrospective study on spontaneous tumours and non-neoplastic proliferative lesions in pet degus (12) and a retrospective study on the occurrence of tumours in sheep in Slovenia (13).

Storing and analysing more data over longer periods of time can have a positive impact on the scientific conclusions and estimates of the data, as well as on the reliability of the results, as shown by McAfee et al. (14).

Therefore, we conducted a large retrospective study to create a registry of canine tumours diagnosed in Slovenia over 20 years (period 2000 to 2020) and to analyse the data on the incidence of tumours and some epidemiological characteristics.

Materials and methods

The retrospective study was done at the Institute of Pathology, Wild Animals, Fish and Bees of Veterinary Faculty, University of Ljubljana. The study analysed data on canine tumours diagnosed in over 20 years (from 1st January 2000 to 31st December 2020). The samples analysed included biopsies sent in by veterinarians and samples collected at the routine necropsies performed at the institute upon the request of pet owners or veterinarians.

Samples were routinely prepared for histopathological examination, fixed in 10% buffered formalin, embedded in paraffin, sectioned at a thickness of 4 µm and stained with haematoxylin and eosin. For poorly differentiated tumours, when the owner or veterinarian has agreed, additional histochemical and immunohistochemical staining was performed according to the manufacturer's instructions and in accordance with the protocols validated by the Institute.

In order to collect the data from the archive, a data collection form was created with the following information: sex, age, breed, region of residence in Slovenia, organ system in which the tumour was diagnosed, biological behaviour of the tumour and specific type of tumour.

To evaluate the distribution of tumours by age of the dog, we divided the dogs into different age groups of two years as follows: 0-1.99 years, 2-3.99 years, 4-5.99 years, etc.

For the classification of breeds, The Fédération Cynologique Internationale (FCI) classification was used.

To determine the incidence rate of tumours in dogs, we used data from the Central Pet Animals Database of the Administration for Food Safety, Veterinary Sector, and Plant Protection. The dataset included information on registered dogs from 2008 (when the registry was established) to 2020, with the calculation of the incidence rate based on the number of active (live) dogs on June 1st of each year.

The registry provides also data on the number of registered dogs by sex, breed and municipality of residence.

To calculate the incidence rate of tumours, we used the following formula:

$$\text{Incidence rate of tumours} = \frac{\text{Number of diagnosed tumours in X year}}{\text{Population of dogs in X year}} \times 100,000$$

This formula was used to calculate the overall incidence rate of tumours in dogs as well as the incidence of tumours in males and females, the incidence of benign and malignant tumours, and the incidence of tumours in selected dog breeds.

In order to evaluate the influence of the place of residence on the occurrence of tumours, the dogs were divided into 12 statistical regions of Slovenia: Mura, Drava, Carinthia, Savinja, Central Sava, Lower Sava, Southeast Slovenia, Littoral–Inner Carniola, Central Slovenia, Upper Carniola, Gorizia and Coastal–Karst region (15).

The tumours were assigned to one of the following organ systems: 1) skin and subcutaneous tissue (including perianal glands), 2) mammary gland, 3) genital system, 4) haemolymphatic system (including thymus, lymph nodes, spleen and bone marrow), 5) endocrine and exocrine glands (including anal sacs), 6) bones and joints, 7) respiratory system, 8) alimentary system (including oral cavity), 9) sensory system (including eyes and ears), 10) urinary system, 11) hepatobiliary system, 12) cardiovascular system, 13) nervous system, and 14) muscular system.

In addition, we categorised the dogs according to the number of tumours diagnosed at the same time. The category: "solitary tumour" was applied to dogs with one tumour and "multiple tumours" to dogs with two or more tumours of different histological types. If biologically identical tumours were found at different anatomical sites in the same dog, the case was classified as a solitary tumour.

The biological behaviour of the tumours was indicated as benign, malignant, or tumour of unspecified biological behaviour (granulosa cell tumour, theca cell tumour, Leydig cell tumour, seminoma and Sertoli tumour).

The tumours were classified according to the World Health Organization's classifications of tumours of domestic animals.

The collected data were analysed using Microsoft Office Excel and Python. The Matplotlib and Plotly packages were used for visualisation, while the SciPy package was used for statistics. The Chi-square test, with $\alpha = 0.05$, was used to evaluate the relationships between tumour type and the sex of the dogs, tumour type and dog breed, and tumour type and the age group of the dogs.

Results

Detection rate and incidence of tumours

In the period from 1st January 2000 to 31st December 2020, a total of 15,584 submissions were accepted at the Institute and 7,574 tumours were diagnosed in 7,423 dogs, representing 48.60% of the samples submitted (Figure 1).

Between 2008 and 2020, the average incidence rate of tumours was 197 cases per 100,000 dogs per year. The incidence rate was relatively stable until 2014, when it began to rise sharply, peaked in 2017, and then declined slightly (Figure 2).

Biological behaviour of the tumours

Of all tumours, malignant tumours were in the majority with 4454 (58.81%) of all tumours, benign tumours were diagnosed in 2815 (37.17%) samples, and the remaining 305 tumours (4.02%) were classified as tumours of unspecified biological behaviour. The percentage of malignant tumours was statistically significantly higher than the percentage of benign tumours and tumours of unspecified biological behaviour ($p < 0.01$).

Benign tumours were reported with an incidence rate of 75 cases per 100,000 dogs per year, while malignant tumours were more common with an incidence rate of 115 cases per 100,000 dogs per year. Tumours of unspecified biological behaviour had an incidence rate of 34 cases per 100,000 dogs per year.

Tumour types

The most common tumour was the mast cell tumour (1073 cases; 14.17% of all tumours), followed by mammary (adeno)carcinoma (759 cases; 10.02%), cutaneous histiocytoma (556 cases; 7.34%), cutaneous/subcutaneous lipoma (524 cases; 6.92%), lymphoma (456 cases; 6.02%),

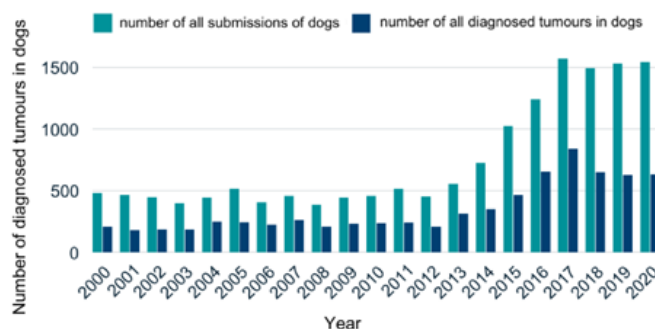


Figure 1: Data on the number of all submissions of dogs in the period 2000-2020 and the number of diagnosed tumours in dogs

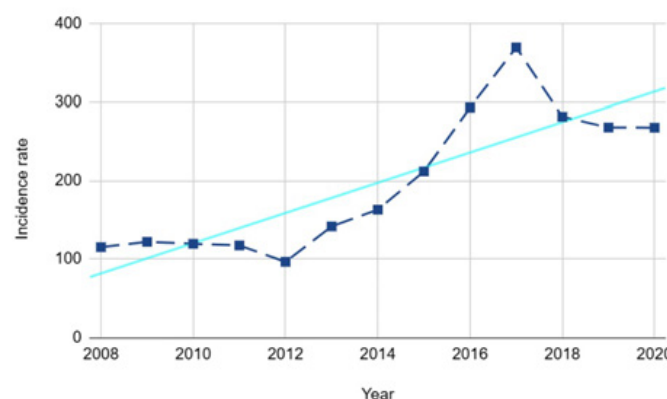


Figure 2: The incidence rate shows the number of tumours per 100,000 dogs per year for the years 2008 to 2020 (blue dashed line). The light blue line represents the linear trend for the incidence of canine tumours in Slovenia

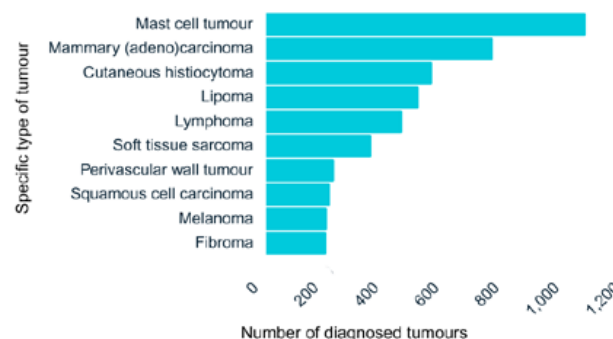


Figure 3: The most frequently diagnosed canine tumours in Slovenia in the period 2000-2020

soft tissue sarcoma (363 cases; 4.79%), perivascular wall tumour (229 cases; 3.02%), squamous cell carcinoma (213 cases; 2.81%), melanoma (208 cases; 2.75%) and fibroma (204 cases; 2.69%) (Figure 3).

Organ systems with the tumours

The three most common organ systems with tumours were the skin and subcutaneous tissue, the mammary glands and the haemolymphatic system. Tumours at these sites accounted 78.41% of all diagnosed tumour cases. The skin and subcutaneous tissue accounted for 4371 cases

(57.71%), followed by the mammary gland (1066 cases; 14.07%) and the haemolymphatic system (502 cases; 6.63%). The least frequent tumours were those of the cardiovascular system (34 cases; 0.46%), nervous system (3 cases; 0.04%) and muscular system (1 case; 0.01%).

The five most common tumour types of the skin and subcutaneous tissue were mast cell tumours (1049 cases; 24.00% of all skin and subcutaneous tumours), cutaneous histiocytomas (537 cases; 12.29%), cutaneous/subcutaneous lipomas (505 cases; 11.55%), soft tissue sarcomas (264 cases; 6.04%) and perivascular wall tumours (225 cases; 5.15%).

The five most common tumour types of the mammary gland were mammary (adeno)carcinoma (758 cases;

71.11% of all mammary tumours), mammary adenoma (151 cases; 14.17%), mammary mixed tumour (78 cases; 7.32%), fibroadenoma (16 cases; 1.50%) and squamous cell carcinoma (12 cases; 1.14%).

The most common tumour of the haemolymphatic system was lymphoma, which accounted for three quarters of all tumours of this system (371 cases; 73.90% of all haemolymphatic tumours), followed by hemangiosarcoma (80 cases; 15.94%), while the other tumour types were much rarer (Figure 4).



Figure 4: The frequency of tumour occurrence in different organ systems and the most common tumour types for each organ system

The sex of dogs with tumours

Information on sex was available for 7413 dogs (99.87%). Tumours were diagnosed in 3576 (48.17%) male dogs and 3837 (51.69%) female dogs.

In terms of sex differences, the incidence rate was 155 cases per 100,000 in male dogs and 262 cases per 100,000 in female dogs.

In female dogs mammary (adeno)carcinomas were most frequently diagnosed (745 cases; 19.42% of all female dog tumours), followed by mast cell tumours (592 cases; 15.43%), cutaneous/subcutaneous lipomas (327 cases; 8.52%), lymphomas (219 cases; 5.71%) and cutaneous histiocytomas (213 cases; 5.55%). Mammary (adeno)carcinoma, mast cell tumour, lipoma and mammary gland adenoma were statistically significantly more frequent in females than in males ($p < 0.01$) (Figure 5).

The most frequently diagnosed tumours in males were mast cell tumours (480 cases; 13.42% of all male dog tumours), cutaneous histiocytomas (340 cases; 9.51%), lymphomas (237 cases; 6.63%), cutaneous/subcutaneous lipomas (197 cases; 5.51%), and soft tissue sarcomas (195 cases; 5.45%) (Figure 6). The statistical analysis showed that cutaneous histiocytomas, adenomas and (adeno)carcinomas of the perianal gland and melanomas occurred statistically significantly more often in male dogs ($p < 0.01$).

The organ systems most frequently affected by tumours in female dogs included the skin and subcutaneous tissue (1994 cases; 51.97% of all female dog tumours), followed by the mammary gland (1049 cases; 27.34%), the alimentary system (315 cases; 8.21%), the haemolymphatic system (235 cases; 6.12%) and genital system (86 cases; 2.24%).

The organ system most frequently affected by tumours in male dogs is the skin and subcutaneous tissue (2371 cases; 66.30% of all male dog tumours), followed by the alimentary system (376 cases; 10.51%), the reproductive system (302 cases; 8.45%), the haemolymphatic system (264 cases; 7.38%) and the sensory system (105 cases; 2.94%).

Breeds of dogs

Information on the dog breed was available for 5460 (73.56%). Tumours were diagnosed in 459 different dog breeds, being most common in Golden Retrievers (361 dogs; 4.86%), Boxers (350 dogs; 4.72%), German Shepherds (346 dogs; 4.66%), Labrador Retrievers (317 dogs; 4.27%), Cocker Spaniels (293 dogs; 3.95%), Crossbreeds (234 dogs; 3.15%), Bernese Mountain Dogs (171 dogs; 2.30%), Maltese (141 dogs; 1.90%), American Staffordshire Terriers (123 dogs; 1.66%) and French Bulldogs (113 dogs; 1.52%) (Figure 7).

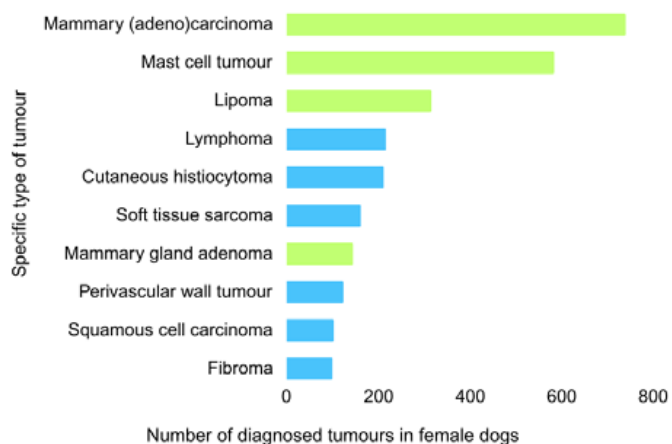


Figure 5: The most frequently diagnosed tumours in female dogs. Green coloured bars indicate a statistically significant association between the sex and the tumour type ($p < 0.01$)

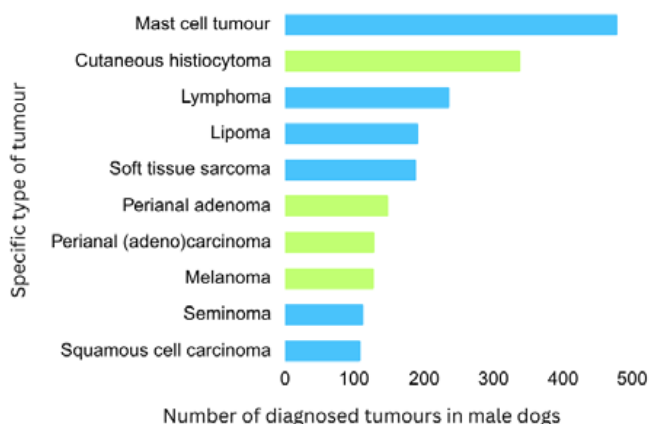


Figure 6: The most frequently diagnosed tumours in male dogs. Green coloured bars indicate a statistically significant association between the sex and the tumour type ($p < 0.01$)

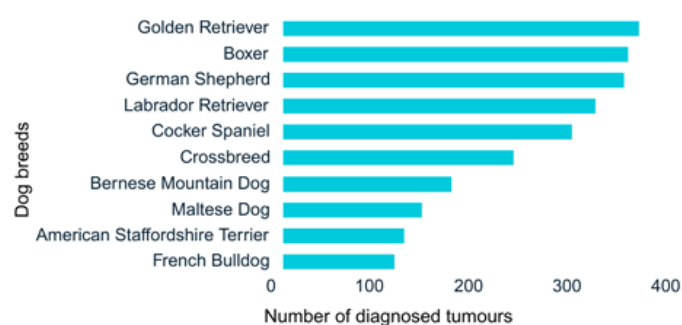


Figure 7: Number of cases of canine tumours in the dog breeds in which the tumours were most frequently diagnosed

The incidence rates of diagnosed tumours were calculated for the ten most common dog breeds. Boxers had the highest incidence rate (924 per 100,000 dogs), followed by French Bulldogs (544), English Cocker Spaniels (479), American Staffordshire Terriers (414), Golden Retrievers (303), Labrador Retrievers (281), Bernese Mountain Dogs

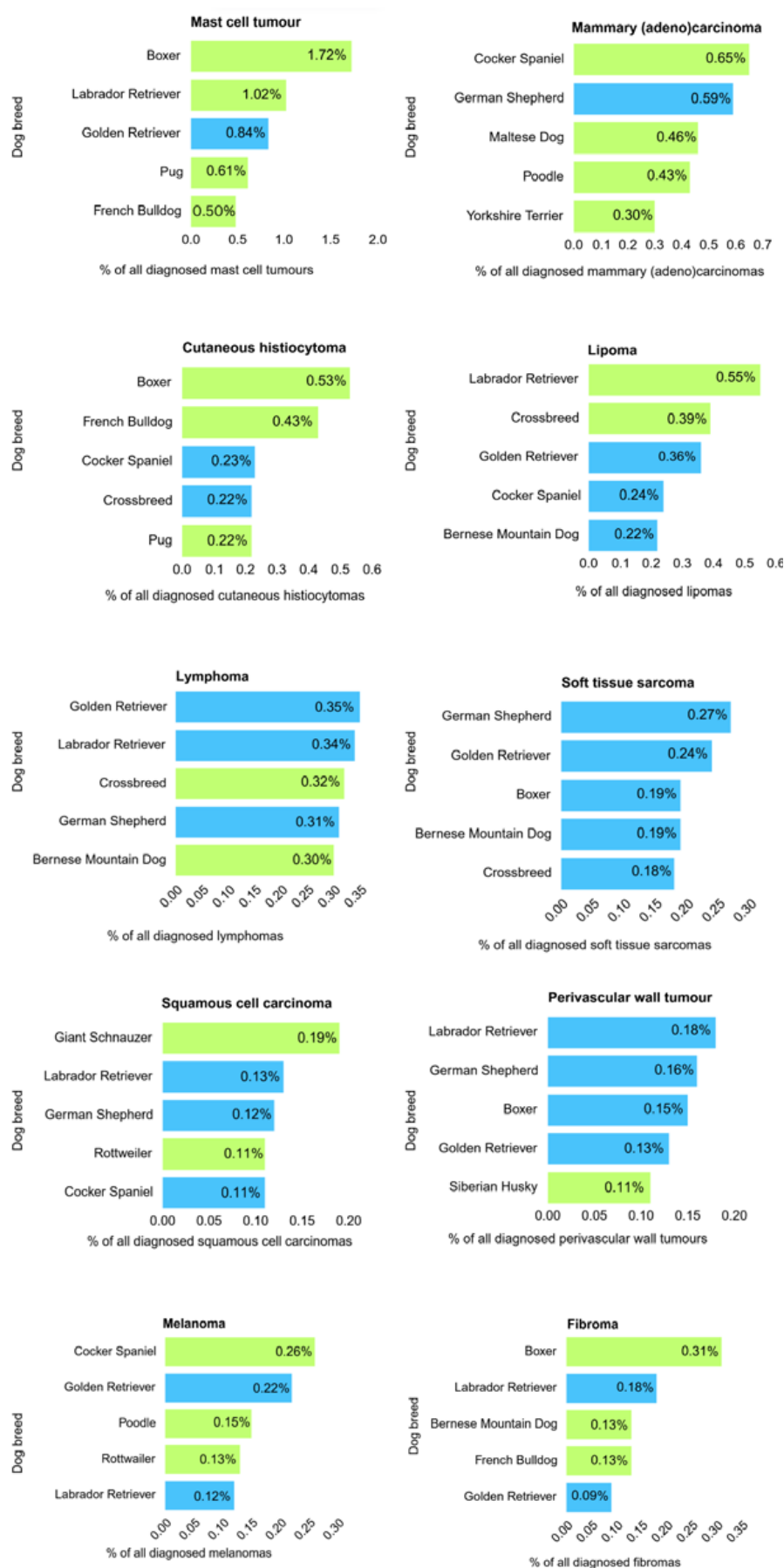


Figure 8: The most common dog breeds diagnosed with the 10 most common tumours. Green coloured bars indicate a statistically significant association between the occurrence of the tumour and the dog breed ($p=0.05$).

(269), Crossbreeds (242), Maltese Dogs (165), and German Shepherds (81).

Mast cell tumours occurred most frequently in the Boxers (128 cases; 12.04% of all mast cell tumours), followed by Labrador Retriever (76 cases; 7.15% of all mast cell tumours) and Golden Retriever (62 cases; 5.83% of all mast cell tumours).

Mammary (adeno)carcinomas occurred most frequently in Cocker Spaniels (48 cases; 6.37% of all mammary (adeno) carcinomas), German Shepherds (44 cases; 5.84%) and Maltese (34 cases; 4.51%).

Cutaneous histiocytomas were most frequently observed in Boxers (39 cases; 7.04% of all cutaneous histiocytomas), Bulldogs (30 cases; 5.42%) and Cocker Spaniels (17 cases; 3.07%). There was a significant association between some breeds and certain tumour types ($p=0.05$) (Figure 8).

The age of dogs with tumours

Information on the age of the dogs with tumours was available for 6723 dogs (90.57%). The age of the dogs with tumours ranged from 2 months to 22 years. Most tumours were diagnosed between 8 and 11 years (3118 cases; 42.00%), less frequently between 6 and 7 years (1221 cases;

16.45%) and between 12 and 13 years (789 cases; 10.63%). The average age of a dog with the tumour was 8.26 ± 3.28 years (Figure 9).

In dogs up to and including 1 year of age, cutaneous histiocytomas were by far the most common, accounting for 65.74% of all tumours, while the most common tumours in dogs aged 8 to 11 years were mammary (adeno)carcinomas and mast cell tumours, which accounted for 12.40% to 14.75% of tumours diagnosed in these age groups (Table 1).

There was a statistically significant association between the age group of the dog and certain tumour types ($p<0.01$). In dogs under 4 years old, cutaneous histiocytomas and papillomas were statistically significantly more common, mast cell tumours were common between 4 and 9.99 years, lipomas between 6 and 9.99 years of age, and lymphomas between 4 and 5.99 years. Mammary (adeno)carcinomas occurred statistically significantly more frequently in dogs aged 8 to 11.99 years ($p<0.01$) (Table 1).

The age at which the tumours occurred in males and females was similar. The average age of the male dogs with tumours was 8.17 ± 3.38 years, which was only 2.16 months lower than the average age of the female dogs (8.35 ± 3.18 years).

Table 1. The most frequently diagnosed tumours by age group and sex

Age group (years)	The sex of dogs (number of cases; %)	The most frequently diagnosed tumour types	Number of cases of all specific tumour type diagnosed (% of all tumours in the age group)
0-1.99	Male (154; 55.00%) Female (125; 44.64%)	cutaneous histiocytoma* papilloma* mast cell tumour	184 (65.74%) 20 (7.14%) 13 (4.64%)
2-3.99	Male (196; 56.81%) Female (149; 50.35 %)	cutaneous histiocytoma* mast cell tumour papilloma*	115 (33.33%) 54 (15.65%) 20 (8.41%)
4-5.99	Male (356; 49.51%) Female (362; 50.35%)	mast cell tumour* cutaneous histiocytoma lymphoma*	148 (20.58%) 85 (11.82%) 79 (10.99%)
6-7.99	Male (542; 44.39%) Female (678; 55.53%)	mast cell tumour* mammary (adeno)carcinoma lipoma*	248 (20.31%) 109 (8.93%) 104 (8.52%)
8-9.99	Male (718; 46.44%) Female (827; 53.49%)	mast cell tumour* mammary (adeno)carcinoma* lipoma*	228 (14.75%) 192 (12.42%) 149 (9.64%)
10-11.99	Male (764; 48.60%) Female (806; 51.27%)	mammary (adeno)carcinoma* mast cell tumour lipoma	203 (12.91%) 195 (12.40%) 108 (6.87%)
12-13.99	Male (366; 46.39%) Female (423; 53.61%)	mammary (adeno)carcinoma mast cell tumour melanoma	96 (12.17%) 68 (8.62%) 53 (6.72%)

* Statistically significant association between the age of the dog and tumours type

The average age of male dogs with benign tumours was 7.07 ± 3.62 years, while the average age of female dogs with tumours was 7.50 ± 3.45 years.

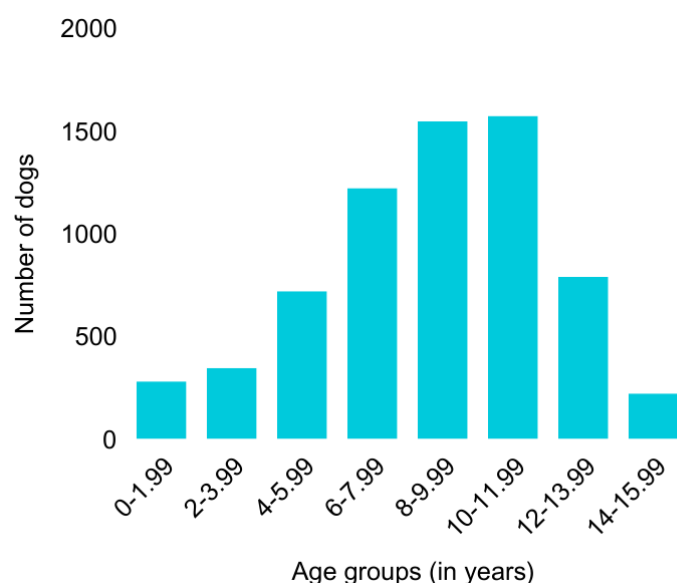


Figure 9: The number of cases of canine tumours according to age groups

The age at which malignant tumours occurred was slightly higher than the age at which benign tumours occurred. The average age of male dogs with malignant tumours was 8.68 ± 3.04 years, while the average age of female dogs was 8.84 ± 2.91 years. The tumours with unspecified biological behaviour occurred later in life in both sexes. The average age of the female dogs with tumours of unspecified biological behaviour was 10.17 ± 2.63 years, while the average age of the male dogs was 7.87 ± 3.29 years.

Region of residence of dogs with tumours

The dogs with tumours came from all 12 statistical regions of Slovenia. The data about residence were not available for 968 (13.04%) dogs. Most dogs, namely 2907 (39.16%), were from the Central Slovenia region, followed by the Drava region with 897 (12.08%) dogs. The regions of Upper Carniola (671; 9.04%), Savinja (471; 6.35%), Gorizia (376; 5.07%), Coastal-Karst region (353; 4.76%) and Southeast Slovenia (253; 3.41%) followed closely behind. Less than 200 dogs were diagnosed with tumours in the Central Sava, Lower Sava region and in the Littoral-Inner Carniola region, while less than 100 dogs with tumours were recorded in the Mura and Carinthia region (Figure 10).

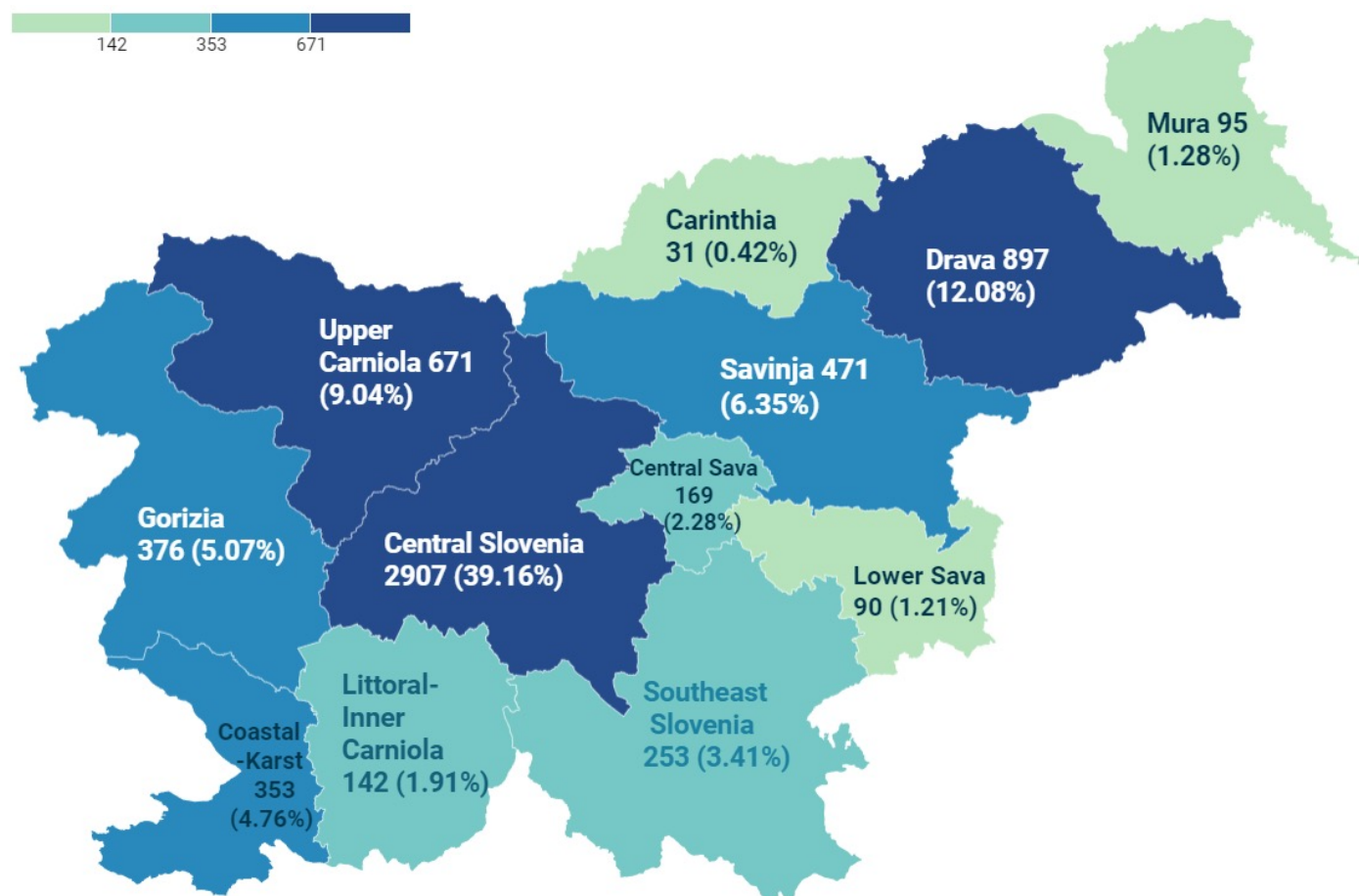


Figure 10: Distribution of tumour cases by region of residence

Temporal trend in the occurrence of the tumours

In the first five years of the observation period, mammary (adeno)carcinoma was consistently the most common tumour, accounting for around 15.00% of all cases per year. In 2005, however, there was a notable shift: the mast cell tumour showed an upward trend, while mammary (adeno)carcinoma declined. In 2008, mammary (adeno)carcinoma recorded a significant increase in cases again, while mast cell tumours continued to rise until 2016 and then reached a plateau. Cutaneous/subcutaneous lipomas and cutaneous histiocytomas also increased steadily between 2008 and 2015 (Figure 11).

Synchronous occurrence of multiple tumours

Multiple tumours within the same organ system or in different organ systems were diagnosed in 151 dogs (2.03% of all dogs). These were 76 female dogs (50.33% of dogs with multiple tumours) and 74 (49.00%) male dogs, while one dog (0.67%) had no sex information. The average age of the dogs with multiple synchronous tumours was 9.28 ± 3.64 years. The most common combinations of multiple tumours were melanoma and soft tissue sarcoma (6 dogs; 0.08% of all dogs with tumours) and seminoma and Leydig cell tumour (6 dogs; 0.08%), followed by mast cell tumour and lipoma (5 dogs; 0.07%) and seminoma and Sertoli cell tumour (5 dogs; 0.07%) (Figure 12).

Discussion

During the study period, 15,584 submissions for necropsy and histopathological examination were accepted at the Institute, and 48.60% of the submissions were diagnosed as tumours. The number of samples submitted, and tumours diagnosed was roughly the same until 2013, after which the number of samples received increased rapidly within a few years, almost doubling. We attribute this sudden increase in submissions to changes in the work of the histopathology laboratory, where we began to proactively approach veterinarians with changes in reporting, faster results, regular biennial training on the importance of histopathology, cytopathology and immunohistochemistry, a strong emphasis on teaching students, and our publications on these topics.

Merlo et al. (10) reported a stable number of samples during the 18-year study period, while Grüntzig et al. (8) described that the incidence rate increased from 13 cases per 100,000 dogs in 1955 to 695 cases in 2008. The increase was attributed to several causes - the constant growth of the dog population, the availability of diagnostic methods, longer life expectancy, the changing role of dogs in society, a higher standard of living, a greater number of veterinarians and possibly environmental factors (8) - all factors that probably also contributed to the increase in cases in Slovenia. Other authors investigated the incidence of

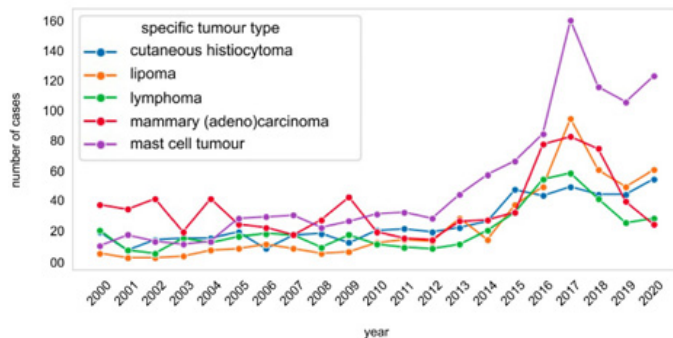


Figure 11: The temporal trends in the occurrence of the five most common canine tumours

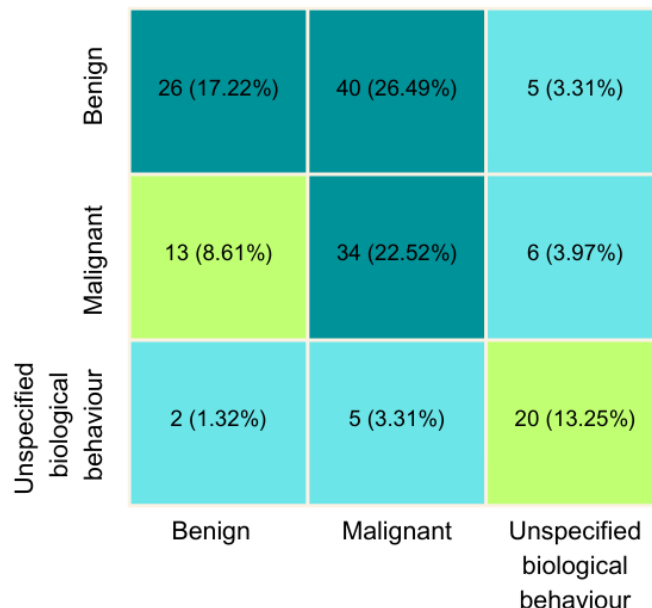


Figure 12: Number and frequency of different combinations of the biological behaviour of multiple synchronous tumours

tumours over a shorter period. However, Vascellari et al. (9) reported an increasing number of submissions during a three-year pilot project to establish a tumour registry for dogs and cats, confirming our findings.

Over a 12-year period, the average annual incidence rate of tumours in canine populations was calculated to be 197 cases per 100,000 dogs. The highest incidence rate was recorded in 2017 with 369 cases per 100,000 dogs per year, and the lowest was documented in 2008 with 115 cases per 100,000 dogs per year.

Other countries have reported different incidence rates. In northern Italy, the incidence was 282 cases per 100,000 dogs (9), similar to ours, but a much higher incidence was reported - 500 cases per 100,000 dogs per year in Sweden (17) and about 748 cases per 100,000 dogs in the UK (18). The lowest incidence rate in 2008 can be attributed to the establishment of a Central Pet Animals Database during that year. The establishment of such a registry may have

led to under-reporting, as comprehensive data collection typically requires several years (19).

In terms of biological behaviour, malignant tumours predominated in Slovenia, found in 58.81% of the samples. Similar results were also found by other authors (2,5), while in Swiss Registry (8) and Registry of Genoa (Italy) (10), the malignant tumours represented close to half of the tumours. We believe that the higher proportion of malignant tumours in our study is probably due to the individual decisions of the veterinarians to perform a histopathological examination when malignancy is suspected and not to send the excision for examination if they consider it to be benign.

The most frequently diagnosed tumours in Slovenia were mast cell tumours (14.17%), mammary (adeno)carcinoma (10.02%) and cutaneous histiocytomas (7.34%). Our results differ slightly from those of other studies in which mammary carcinoma was reported as the most common specific tumour type (2,16,20). In Germany, the most frequently diagnosed tumours were mammary tumours, mast cell tumours and histiocytomas (20), while in Poland the most common skin tumours were mast cell tumours, histiocytomas, and lipomas (5).

Mast cell tumours, the most common tumours in dogs in our study, occur with varying incidence worldwide, and account for between 7% and 27% of skin neoplasms in dogs (21). Mast cell tumours are more common in certain dog breeds, such as the Boxer, Labrador, Golden Retriever (22). In Slovenia, according to Central Pet Animals Database, the number of listed dog breeds has been increasing, so the increase in the number of cases of mast cell tumours in dogs can be partially attributed to a larger population of dogs predisposed to this tumour.

Differences in the practice of spaying bitches across Europe are associated with a higher incidence of mammary gland tumours in countries and regions where spaying is less common, such as southern Europe and Scandinavia. In contrast, a significant reduction in mammary tumours was observed in the United States due to the widespread early practice of ovariohysterectomy (23,24). Unfortunately, our research lacked data on the spaying status of bitches, so we cannot assume any correlation between the number of cases of (adeno)carcinomas and this procedure (24-27).

The organ systems with the most tumours were the skin and subcutaneous tissue (57.71%), the mammary gland (14.07%) and the haemolymphatic system (6.63%). Two of the most common locations with similar representation were also described by most authors of the retrospective studies (2,5,8,9,10,28). However, in all these cited publications the third most frequent location was the genital system (2,9,10,28), while Ciaputa et al. (5) reported the lymphatic system as the third most frequent location.

The highest number of cases of skin/subcutaneous tumours can be explained by the fact that it is a location where the changes can be easily noticed by the owner himself and that these lesions are usually more accessible for sampling than lesions in other locations, e.g. in the thoracic or cranial cavity or in internal organs.

The tumours were diagnosed with similar frequency in male dogs (48.17%) and female dogs (51.69%). The results are similar to the findings of Šoštarić-Zuckermann et al. (2) and Kimura et al. (16). In contrast to the above results, Merlo et al. (10) described an almost threefold higher incidence of all types of cancer in female dogs, which is mainly explained by the high incidence of mammary cancer in female dogs.

Tumours were found most frequently in Golden Retrievers (4.86%), Boxers (4.72%) and German Shepherds (4.66%). Considering the number of each dog breed in Slovenia, our analysis revealed that Boxers had the highest tumour incidence, with 924 tumours per 100,000 dogs per year, followed by French Bulldogs and Cocker Spaniels. These results are consistent with previous studies (2,18) reporting similar findings. A study conducted in Germany indicated an increased risk of neoplasia in certain breeds, namely Beagles, Magyar Vizslas, Boxers, Schnauzers, Spaniels, French Bulldogs and Golden Retrievers (20). Contrary, Ciaputa et al. (5) described that tumours in Poland were most common in Crossbreeds (30.64% of all tumours), followed by Labradors and German Shepherds. Vascellari et al. (9) which found the opposite, that purebred dogs have a higher risk of developing malignant tumours than crossbreeds.

In our study, mast cell tumours occurred most frequently in Boxers (12.04%), Labradors (7.15%) and Golden Retrievers (5.83%). More frequent occurrence in these three breeds was also shown by data from Croatia (2), and Brazil where the highest prevalence of mast cell tumours was described in Boxers (16).

Aupperle-Lellbach et al. (20) found a higher risk of cutaneous histiocytomas occurrence in French Bulldogs, Boxers and Pugs than in Crossbreed dogs. In our study, Boxers had the highest occurrence of cutaneous histiocytomas (7.04%), however crossbreeds with this specific tumour type were relatively common (0.22%). Yet, we must emphasise that the reported numbers of tumour cases are very low.

In one of the most recent retrospective studies on tumours in dogs, an increased risk of developing mammary tumours was described in Yorkshire Terriers, Chihuahuas, and Spaniels (20). In Slovenia, mammary (adeno)carcinoma was most common in Cocker Spaniels (6.37% of all mammary gland tumours), which is in accordance with data on breed predispositions described in other studies (29,30). We believe that the results regarding the frequency of occurrence of tumours or certain tumour types between

different authors may differ due to several factors. One of them is that the popularity of different breeds varies greatly between countries and changes over time, and there are also different proportions of crossbreeds and purebred dogs in different regions and countries.

Most tumours were diagnosed between 8 and 11 years (42.00%), 6 and 7 years (16.45%) and between 12 and 13 years (10.63%). In other studies (5,8,9,10,16), the authors used different age groups for the analysis, however, the results are similar and align with the findings on tumour occurrence in dogs in Slovenia.

In dogs up to and including one year of age, cutaneous histiocytomas were by far the most common, accounting for 65.74% of all tumours in this age group. Cutaneous histiocytomas were statistically significantly more common between 2 and 4 years of age. The most common tumours in dogs aged 8 to 11 years were mammary (adeno)carcinomas and mast cell tumours. According to data from the literature, the average age of dogs with mammary gland carcinomas is between 8 and 10 years (24), and mast cell tumours most often occur in middle-aged and older dogs, with an average age of 9 years (22).

In a small number of dogs (2.03%) we have found two or more types of tumours at the same time. The question raised by the finding of multiple tumours is whether the presence of a specific type of tumour implies a predisposition to another type of tumour. While literature suggests significant associations, contradictions also exist. It is not known for certain that the patterns of occurrence of these multiple tumours are governed by anything than coincidence (31). In our analysis, 17.22% of cases revealed two or more benign tumours, while 22.52% exhibited multiple malignant tumours, and 26.49% were combinations of malignant and benign tumours. Similarly, a study conducted in Poland (5) by Ciaputa et al., reported comparable findings, 25.71% of cases involved two or more malignant tumours, and 23.72% were all benign tumours.

In the first five years of the observation, the most common tumour was mammary (adeno)carcinoma. A notable shift occurred in 2005, when the number of mammary (adeno) carcinomas occurrences fell. We believe that spaying has been performed more frequently in the last ten years than in the past, which has influenced the occurrence of mammary gland tumours. In our research, unfortunately, we did not have available data on the spaying status of bitches, so we could not analyse the number of cases of mammary (adeno)carcinomas and the time trend of their occurrence in connection with spaying.

Most dogs with diagnosed tumours were from the Central Slovenia (39.16%). The results can be explained by the fact that this region has the largest number of inhabitants, and according to data from Central Pet Animals Database, also has the largest number of registered dogs.

This study has several potential limitations, mainly due to the retrospective nature of the study and the limited data sources. The number of tumour cases submitted and diagnosed only provides an estimate of the actual incidence of this pathology in Slovenia. Some of the tumour cases remain untreated by the veterinarians, while others are excised but not examined histopathologically. In some cases, only cytopathological analysis is performed or samples are sent to foreign laboratories, which further limits the amount of data. In addition, necropsies are only performed in a limited number of cases, mostly at the request of animal owners or veterinarians and especially when the diagnosis is unclear. Cases with a confirmed diagnosis prior to death or euthanasia are not usually submitted for necropsy. These factors limit the completeness and representativeness of the results of the study. The accompanying data on sex, age, breed, region of residence in Slovenia and organ system in which the tumour was diagnosed are often insufficient, which reduces the input data available for the analyses or made certain analyses, such as the correlation between the occurrence of certain tumours and spaying status, impossible.

Future work should focus on prospective studies with more comprehensive and standardised data collection, including detailed information on breed, breed size and potential environmental risk factors, to gain a deeper understanding of the epidemiology of canine tumours and improve prevention, diagnosis and treatment strategies.

In conclusion, we would like to emphasize the importance of establishing tumour registries for companion animals. Although rodent models are useful for preclinical studies (32), companion animals, because they share several naturally occurring tumours with humans, often allow faster translation from the laboratory to the bedside.

Acknowledgments

The authors would like to thank Dr. Urša Kos and Maja Vilfan, M. Sc. from the Administration of the Republic of Slovenia for Food Safety, Veterinary Sector and Plant Protection for data from the Central pet animals database.

This study was conducted as part of a bilateral project BI-ME/21-22-017 entitled "Incidence and tumour types of domestic, exotic and wild animals in Slovenia and Montenegro" and funded by the Slovenian Research Agency under grant number P4-0092.

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Incidenca in tipi tumorjev pri psih v Sloveniji v obdobju 2000-2020: retrospektivna raziskava

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Izvleček: Namen retrospektivne raziskave je vzpostaviti register tumorjev, diagnosticiranih pri psih v Sloveniji v obdobju 20 let, ter analizirati incidenco tumorjev in nekatere njihove epidemiološke značilnosti. V raziskavi, ki smo jo opravili na Inštitutu za patologijo, divjad, ribe in čebele Veterinarske fakultete Univerze v Ljubljani med letoma 2000 in 2020, smo analizirali rezultate histopatoloških preiskav biptov psov, ki so jih poslali kliniki, in tumorjev, odvzetih med raztelesbo psov. Malignih tumorjev je bilo več kot benignih (58,1 % vs. 37,17 %), 4,02 % tumorjev je bilo nespecificiranega biološkega obnašanja. Najpogostejši so bili tumorji kože in podkožja (57,83 % vseh tumorjev), mlečne žleze (14,07 % vseh tumorjev) ter hematopoetičnega in limfatičnega sistema (6,63 % vseh tumorjev). Najpogosteje smo diagnosticirali mastocitom (14,17 %), mamarni (adeno)karcinom (10,02 %), kožni histiocitom (7,34 %) in kožni/podkožni lipom (6,92 %). Pri 2,03 % psov smo ugotovili multiple tumorje različnih tipov. 51,69 % psov s tumorji je bilo samic in 48,17 % samcev. Tumorji so bili najpogostejši pri zlatih prinašalcih (4,86 %), bokserjih (4,72 %), nemških ovčarjih (4,66 %) in labradorcih (4,27 %), najpogosteje so bili ugotovljeni med 8. in 11. letom starosti. Rezultati naše raziskave so pretežno primerljivi z rezultati drugih podobnih raziskav.

Ključne besede: pes; tumor; incidenca; starost; pasma; Slovenija