Annals of Research in Oncology
Vol. 3(1), 14-23, 2023

REVIEW

ANIMAL SENTINELS AND CANCER REGISTRIES: STATE OF THE ART AND NEW PERSPECTIVES

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ABSTRACT: The concept that animals may serve as sentinels of environmental hazards is not new. Nowadays, it has been widely recognized the important role that pets have in the field of comparative oncology. Cancer epidemiologic data are the foundation for prevention and control; therefore, Cancer Registries represent a fundamental tool that systematically collects, and stores validated and comprehensive data. In Veterinary Medicine, cancer registries have unfortunately been sporadic, short-lived, and lacked communication and collaboration. Therefore, there is little up-to-date information available on the incidence of different types of cancer in companion animals anywhere in the world. The purpose of this review is to provide a brief overview of the currently and globally active veterinary cancer registries. Moreover, a special focus will be dedicated to a novel web-based cancer registration system implemented in the Department of Veterinary Medicine in Naples, Italy. This platform was designed and conceived for the implementation of the regional Animal Cancer Registry, for a constant evaluation of the frequency, the incidence and/or the prevalence of cancer cases in pets and for advancement in the field of veterinary comparative oncology.

Doi: 10.48286/aro.2023.61

Impact statement: Animal Cancer Registries are a fundamental instrument for advancement in the field of veterinary comparative oncology. Epidemiologic data on cancer in companion animals can help to identify new environmental hazards.

Key words: *Animal Cancer Registry; comparative oncology; sentinel animals, web-based cancer database*

Received: Jul 16, 2022/**Accepted**: February 1, 2023/
Published: March 15, 2023

INTRODUCTION

The presence of environmental contaminants in air, water and food may represent significant health risks for human population. Several environmental toxicants have been proven by scientific studies as important risk factor for chronic diseases and cancer. In some cases, solid scientific evidence has determined that the exposure to a specific environmental compound is the cause of a specific disease (*i.e.*, asbestos exposure and mesothelioma) (1). However, the causality between environmental hazards and diseases is often difficult to be proved. Several authors suggest that human epidemiologic studies may be usefully complemented by similar studies conducted on sentinel animal species in order to prevent and overcome confounding factors such as chronic low-dose exposure, multiple exposure routes, long latency periods and non-specific health outcomes (2, 3). In 1960, the publication of the book Silent Spring by Rose Carson firmly introduced the concept that the exposure to environmental hazards may determine adverse effects on the health of animal population as well as humans (4). Since both humans and ani-

mals may develop disease through exposure to environmental hazards, it has been suggested that animals, like the "canary in the coal mine" could serve as natural sentinels for human health providing crucial information about the relationship between environmental hazards and human health risk (2, 5-8). Due to differences in body weight and metabolism from humans, animals may be more susceptible than humans to particular hazards (2, 5-8). Animals also tend to be less mobile and to be exposed to higher levels of a given environmental hazard, compared to humans living nearby who may be actively modifying exposures through clothing, buildings, and dietary choices. Furthermore, animals usually have shorter life spans than humans and therefore may exhibit a shorter latency for development of an environmentally induced condition (2, 5-8). Significantly, cancer develops naturally in dogs within the environment they share with their human owners, therefore cancer initiation and progression in dogs are influenced by similar risk factors including age, diet, sex, household conditions and pollution (2, 3). Moreover, cancer in animals shares several traits with its human counterpart such as histological features, genetic alteration, biological behavior and, most importantly, cancer biology (2, 3). This concept is the foundation of comparative oncology, an emerging and quickly expanding field of research that has the purpose of studying cancer risk and tumor development across different species and to provide a suitable model for advancing of the understanding, diagnosis, and management of cancer in humans (6, 9). Alas, the application of Sentinel Animal Systems in obtaining data about environmental monitoring and human health risk is not free from uncertainties and ambiguity. One of the main limitations includes the results interpretation, which can be difficult and controversial if not compared objectively and reasonably to human health hazard risks (10). Moreover, the use of Sentinel Animal Systems is usually limited by the lack of standardized methods in researching programs, thus, on large scale, misleading and inadequate collection of data in well-structured and efficient database (10). Cancer data are the foundation for prevention and control; therefore, Cancer Registries (CR) represent a fundamental tool that systematically collect, and stores validated and comprehensive data that include patient personal information (sex, age, date and place of birth, residence) and cancer-related data such as the characteristics of the individual tumor (location, morphology, grading, stage and behavior) and eventually the availability of the screening status (11). This information is extremely useful for both clinicians and epidemiologists because they allow the analysis and the interpretation of data providing information that may be successfully used for health care planning and monitoring, for carrying out evaluations of the effectiveness of cancer screenings (11) and even more for the implementation of prevention measures. The sources from which the information about cancer patients is collected define three different types of Cancer Registries, each one with proper advantages and drawbacks. Hospital-based Cancer Registry (HCR) and Pathology-based Cancer Registry (PCR) collect all medical records from patients from a given hospital or diagnostic laboratory, respectively (12, 13). The information held by HCR and PCR are extremely important for improving the clinical management and human resources needed to support patient care and also to better understand the diagnostic capacity of the institution and country where they are located (12, 13). However, neither HCR or PCR are reflective of the area and/or the overall population from which the cases arise, thus several cancer cases may be missed affecting epidemiological studies and the estimation of tumor incidence rates (12, 13). Population-based Cancer Registry (PBCR) records all new cancer cases generated by hospital and pathology-based cancer registries in a well-defined and enumerated population (generally the population in a specific geographical area in which these cancers are occurring) (14). Population-based Cancer Registries are considered the gold standard in human cancer epidemiology (14), moreover they are extremely important in accessing to mortality information needed for the calculation of survival rates screening and the assessment of treatment programs efficacy in reducing cancer deaths. Currently, human cancer registries are regulated by law and their establishment and maintenance have been (and still are) complex and time-consuming (14). In Veterinary Medicine, cancer registries have unfortunately been sporadic, short-lived, and lacked communication and collaboration (9, 14-16). Therefore, there is little up-to-date information available on the incidence of different types of cancer in companion animals anywhere in the world (9). Several initiatives to set up veterinary cancer registries have been developed since the early 1960s (16), but numerous veterinary cancer registries have been discontinued for limited funding, for the non-mandatory nature of animal cancer case reporting, and for the serious issues in enumerating the background population (15). In recent years, we

are witnessing to a rising revived interest in veterinary cancer registries and several initiatives have been taken for the activation and/or implementation of regional, national and international databases for animal cancer registration (9).

The purpose of this review is to provide a brief overview of the current and active veterinary cancer registries, with a special focus on a novel web-based cancer registration system implemented in the Department of Veterinary Medicine and animal production of Federico II University of Naples to support the Campania Animal Cancer Regional Registry in Italy and that was designed and conceived as an integrated part of the regional Animal Cancer Registry.

ANIMAL CANCER REGISTRIES: INTERNATIONAL STATE OF THE ART

The Vet Cancer Registry is an international, free, and web-based data collection point for confirmed veterinary cancer cases that was initiated in 1994 with the development of the International Veterinary Brain Tumor Registry (VIBTR). This service is still active and cases with confirmed diagnoses have been registered from all over the world (16). In the United States, the Veterinary Oncology Market Committee from the Veterinary Cancer Society (VCS) has recently started a collaboration with large national laboratories to establish incidence data for a variety of neoplasms in pet animals (17). In 2013, the first Animal Cancer Registry in Latin America was created in Brazil with the Sao Paulo Animal Cancer Registry (RCA-SP) (18). The RCA-SP is a hospital- and web-based registry that provides clinicians with an electronic medical record system to collect and store pertinent cancer data connected to a central database (18).

In 2020, the Latin American Society of Veterinary Oncology (SLOVET) intends to launch, with Portuguese platform Vet-OncoNet, the first Latin American Veterinary Cancer Registry (17).

In November 2019, The University of Queensland established the ACARCinom network, the first Australia-wide registry of animal cancers that will generate accessible datasets for identifying patterns and trends of cancers in animal using retrospective data from the Veterinary Laboratory Services (17). In Kenya, a collaborative work is ongoing with the human Kenya National Cancer Registry investigating cancers affecting humans and dogs in Nairobi (19).

In the United Kingdom, a pathology-based animal tumor registry was set up within the Small Animal Veterinary Surveillance Network (SAVSNET) run by the University of Liverpool. The collected data derive from anonymous general practice, electronic health records or diagnostic pathology reports and comprise both the tumor description (type and location) and the animal (breed, neutering status and veterinary practice postcode) (15).

ANIMAL CANCER REGISTRIES: STATE OF THE ART IN EUROPE

In Norway, a cancer registration project was initiated for canine cancer in a defined geographical region in 1990 (16). This registry collects, stores and reports information about the geographical distribution, reproduction status, nutritional status, prior hormonal treatment, and concurrent diseases and includes both malignant and benign neoplasms. In the past, the Registry originally provided free histopathological evaluation to practitioners in the area when submitting cases for the registry, but in 1998 the register became a national register and free histopathology is no longer available for the practitioners (16).

In 2005, a new veterinary cancer registry was established at the Royal Veterinary and Agricultural University in Denmark (Danish Veterinary Cancer Registry). Veterinarians voluntarily submit data to this web-based data compilation. It is an incidence registry, and inclusion of a case is based on clinical information, cytology, diagnostic imaging and histopathology when available (16). In Portugal, a platform named Vet-OncoNet has been created in order to share information on companion animal tumors and, accordingly to One Health concept, to contribute to the research in prevention and therapy in animal and human oncology (20). This platform involves researchers from the departments of Population Studies, Veterinary Clinics, Pathology and Molecular Immunology at the Instituto de Ciências Biomédicas Abel Salazar (ICBAS) and the Department of Veterinary Public Health of the Instituto de Saúde Pública da Universidade do Porto (ISPUP). Vet-OncoNet is a replicable tripartite animal cancer database that uses business intelligence tools to optimize the process of capturing, treating, and reporting animal cancer data to a national level in three interfaces: ACR (animal cancer registry, pathology-based), COR (clinical oncology registry, vet practice-based) and RFR (risk

factor registry, owner-based) (20). Furthermore, being aware of the role of animals within the family and as possible sentinels of environmental risks to cancer in humans, the network built an interface (Pet-OncoNet) dedicated to owners and a database (RFR) that receives information regarding pets and owners' daily habits (20).

In Spain, the first national pet cancer registry project is currently being constructed at the School of Veterinary Sciences of the University of Las Palmas de Gran Canaria (17).

The Swiss Canine Cancer Registry comprises diagnostic records of dogs provided by 3 veterinary diagnostic laboratories in Switzerland (the Vetsuisse Faculty Institute for Veterinary Pathology Zürich, the Vetsuisse Faculty Institute for Animal Pathology Bern, and the Zyto/Histo Diagnostik private veterinary diagnostic laboratory) (16). The canine population data originated from the Swiss animal registration database Animal Identity Service ANIS; the registration of resident dogs and the deregistration in case of death or permanently leaving Switzerland has been mandatory since 2007 (17, 21).

ANIMAL CANCER REGISTRIES: STATE OF THE ART IN ITALY

In Italy, the Animal Tumor Registry (ATR) has been an increasing reality throughout the national territory (22). The first Registry was established in the province of Genoa in 2008 (23), but twelve active ATRs are now officially identified, distributed between northern and southern Italy and operating in limited territorial areas and coordinated by the Veterinary and Comparative Oncology Reference Center (CE.R.O.VE.C.) of the Genoa section of the Experimental Zooprophylactic Institute of Piedmont, Liguria, Valle d'Aosta and Genoa. Animal Cancer Registry of the provinces of Venice and Vicenza of the Veneto Region started in 2005 (24). In 2017, incidence data were obtained in Piedmont, a well-delimited geographical area in northwest Italy (25). The RTA of Rome has been active since 2009, through current research projects of the IZS Lazio and Tuscany (IZSLT) in the field of oncology and environmental epidemiology, carried out on pilot areas in the province of Rome. From 2018, all Lazio Region was involved (26). In 2014, the Umbria Region activated the Animal Cancer Registry that involve veterinarians, the Department of Veterinary Medicine of the University of Perugia and the Experimental Zooprophylactic Institute of Umbria and Marche (IZSUM) for diagnosis by double-blind reading and for data processing (22, 27). The same approach and methodology were implemented by Marche Region in 2015 (28). In 2013, Animal Cancer Registry started in both Sardinia and Sicily Regions (22).

ANIMAL CANCER REGISTRY IN CAMPANIA REGION, ITALY

The area of Naples in Campania region, in Italy, is experiencing the dramatic consequences of more than two decades of extensive illegal dumping and burning of mixed waste of urban as well as industrial origin. The illegal and criminal practice of waste burning caused an international toxic-waste scandal that sadly renamed the agricultural landscape of Italy's Campania region as "Land of Fires". In this scenario, the potential risks for environmental, human and animal health prompted the Italian authorities to establish, in 2010, the Regional Centre for Veterinary Urban Hygiene (CRIUV) as the first example in Italy of integration and synergy among the veterinary public health system (ASL), Zooprophylactic Institute and Federico II University of Naples. The mission of the Centre is articulated in several activities aiming to develop strategies for the assessment of risk exposure to environmental pollution in animals and, subsequently, in human population. The CRIUV is the principal site of the Animal Cancer Registry in Campania region (29-31) and regulated its cooperation with the National Center for Veterinary and Comparative Oncology (CEROVEC).

The ACR of Campania region, in southern Italy, was established in 2011 by a regional law as a surveillance and research unit within the CRIUV. The principal aims of Campania ACR are: 1) to collect data and estimate companion animals' cancer incidence on the whole regional territory, 2) understand the natural history of cancer occurrence in pet animals, and 3) eventually compare animal and human cancer incidence data.

Campania ACR aims to be a Population-based Cancer Registry at least for canine tumors; since registration of dog is mandatory and official demographic registry of the canine population established in the Campania region is used as primary source to estimate the amount of the canine population. To date, the total number of dogs registered in Campania is 1.287.747 (32) which represent 1/4 of the human population that an estimated

5.624.420 people in Campania (33). The strategies to prevent possible biases related to failure to comply with the registration obligation and failure to notify deaths are not yet put in place, therefore the accuracy of the registration remains uncertain. Campania ACR recognizes two reference veterinary anatomic pathology laboratories for data collection, namely the anatomic pathology laboratory of the Department of Veterinary Medicine and Animal Production of Federico II University of Naples and the laboratory of the Istituto Zooprofilattico Sperimentale del Mezzogiorno based in Campania Region.

Campania ACR is supported by public funds that allow to provide discount for cytological and histopathological evaluation to veterinary practitioners and veterinary laboratories working in the registry's interest areas. Moreover, all veterinary practitioners in Campania region are constantly informed about the ACR activities by informative campaigns and continuing education courses promoted by veterinary public health services and veterinary professional associations. All veterinary practitioners are invited to submit any suspected neoplasm from animals living in Campania region. A standardized sample submission form is specifically designed for the registration of tumor cases and is available on the website of the two reference laboratories. The sample submission form has blank fields to fill with animal specific information including species, age, sex, breed, neutered/spayed status, and identification number. Residence address of the owner is also included. Tumor data include the tissue, organ and anatomical site, number of samples (number of slides in case of cytology) and the type of biopsy, date of excision, clinical stadiation of the tumor and any related and relevant historical and clinical information. Formalin fixed samples are routinely processed, paraffin embedded and stained with Haematoxylin and Eosin (HE) for histological examination. Immunohistochemistry is also performed in case of poorly differentiated neoplasm. Tumors are classified according to the most recent available classification systems of tumors of domestic animals and coded according to the World Health Organization's International Classification of Disease for Oncology (ICD-O) (9) to eventually facilitate comparisons with existing human and animal cancer registries. This kind of classification and coding is used by Campania ACR and other regional ACR and it is the same used in human medicine according to WHO rules.

In 2020, a web-based database system (Piattaforma myClinical) was set up for the Diagnostic Service of Pathology and Animal Health (DIPSA) of the Department of Veterinary Medicine in Naples, Italy and implemented with specific features that permit the communication among veterinary practitioners and pathologists. The database was designed for the collection and management of information regarding animal cancer patients in Campania; the database was also integrated with a quality-control based data recording that assigns each new case its own code (ID number), thus avoiding duplicating case registrations. Information including species, breed, age, topographic localization of the tumor, clinical and histological characteristics of cancer can be systematically recorded, collected and consequently used for epidemiological analysis. Importantly, the pathologists that analyze the samples have the possibility to insert a morphological diagnosis and to categorize the neoplasms using the last recognized classification system easily and directly for canine tumors associated to the last edition of the International Classification of disease for Oncology (ICD-O) (9). Furthermore, the database is connected to a geographic information system (GIS) that permits the creation of maps providing a spatial distribution of neoplastic diseases. The same web-based database is currently used to collect and store information of cancer animal patients from Molise (since 2020) (34) providing and sharing data to its respective regional animal cancer registry. In our opinion, the herein described platform has multiple applications and can be potentially used to compare animal cancer data and human cancer data laying the fundamentals for a substantial advance in the study of veterinary comparative oncology. Recorded information can be used for the implementation of the Regional Cancer Registry, for a constant evaluation of the frequency, the incidence and/or the prevalence of cancer cases in pets and to compare data with human cancer registries.

PIATTAFORMA myClinical: DATA COLLECTED IN TWO YEARS ACTIVITY (2020-2022)

Based on data collected so far and only using those case reports for which at least some essential information (species, breed, age, sex and neutered/spayed status, topography, and morphological diagnosis) are available, frequencies of tumor topographies and main morphological diagnosis

are described, considering age, breed and sex. Seven age classes are defined (0-3 years, 4-5 years, 6-7 years, 8-9 years, 10-11 years, 12-13 years, and 14 years and more) while breeds are distinct in purebred and not purebred. A declaration of one breed was accepted as reported, while a declaration comprising two breeds (*i.e.*, shepherd-cross, or shepherd-boxer-cross) was categorized as not purebred. To investigate malignancy, each tumor group was divided into benign (behavior code 0-2) and malignant (behavior code 3-9) according to the ICD-O classification (9). When one animal is diagnosed with more than one tumor type or location, these are collected as separate events. This descriptive analysis of data takes into consideration age at diagnosis, sex, neutered/spayed status, tumor location and morphological diagnosis. In the absence of suitable denominators, the proportion of cases for a specific category of the tumor over the total number of the tumors (*e.g.*, the number of malignant mammary tumors over the total number of malignant tumors) is evaluated and expressed as a percentage of all tumors. Also, some comparisons between groups are made. From January 2020 to October 2022 DIPSA database collected 5740 histologic and cytologic diagnosis of which 3318 resulted to be neoplastic diagnosis; specifically, 2937 (89%) are histological diagnosis and 381 (11%) are cytological diagnosis. Regarding the species, 2941(89 %) neoplasms are from dogs, 345 neoplasms (10%) are from cats and 32 (1%) neoplasms are from other species (hamster, horse, and rabbit). Most of the dogs are female (55%) and most of males (90%) and females (67%) are not neutered/spayed (**Figure 1a**). 1264 dogs (43%) are mixed breed, and the most frequent breeds are Labrador retriever (4.8%, n. 141), German shepherd (4.2%, n. 123) and Boxer (2.6%, n. 76) (**Figure 1b**). The most represented age range are between 8 and 11 years for female dogs and 10-13 y for male dogs (**Figure 1c** and **d**). The mean age at first diagnosis is similar in both sexes, with small differences in neutering status and cancer behavior: neutered/spayed dogs were slightly older at first diagnosis than entire ones, and malignant tumors were firstly diagnosed in slightly older dogs (**Table 1**).

Malignant tumors represent 78% of the total cases collected in cat (N = 269) and 54% of the total cases collected in dog (n = 1588) (**Figure 2a**). Epithelial (56%), and mesenchymal (30%) tumors are the most represented tumors in dogs, whereas epithelial tumors (65%) and hematopoietic tumors (20%) are the most frequent in cat (**Figure 2b**). Malignant tumors represent 78% of the total cases collected in cat (N = 269) and 54% of the total cases collect-

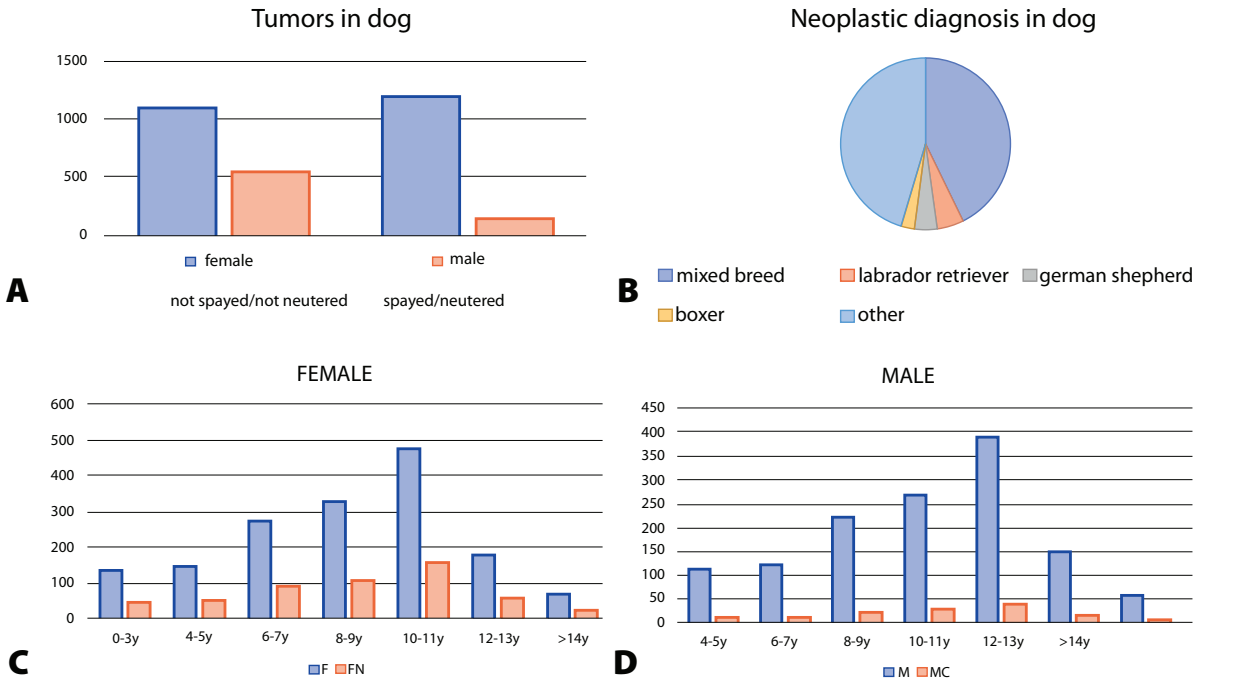

Figure 1. *Distribution of tumor diagnosis according to data collected by Piattaforma myClinical in the years 2020-2022. (**a**) Distribution of tumor diagnosis in dogs based on sex and spayed/neutered status; (**b**) distribution of tumor diagnosis in dog based on breed; (**c**) and (**d**) distribution of tumor diagnosis tumor diagnosis in dogs based on sex and age range.*

Table I. *Mean age at first diagnosis by sex, neutering status, and tumour behaviour.*

SEX AND NEUTERING STATUS	MEAN AGE AT DIAGNOSIS (YEARS) - BENIGN	MEAN AGE AT DIAGNOSIS (YEARS) - MALIGNANT
Female, spayed	8.2	9.5
Female, not spayed	8.3	9.2
Male, neutered	8.8	9.8
Male, not neutered	9	9.5

ed in dog (n = 1588). In dogs most of the malignant tumors occur in female (58%). Related to the total canine population, female dogs develop a malignant tumor in 31% of cases compared with 23% of male dogs. Spayed female dog develop a malignant tumor in 20% of cases compared with not spayed female dog that develop malignant tumors in 39% of cases. The same is observed in male dogs where neutered animals develop malignant tumors in 13% of cases compared with not neutered male dogs that develop malignant tumors in 38% of cases. Skin and soft tissue (40%) and mammary gland (30%) are the most frequent location of malignant tumors in the canine population followed by alimentary tract (12%) and hemopoietic system (7%) in male dog, whereas mammary gland (30%) and skin (36%) are the most frequent location of malignant tumors in female dogs (**Figure 2c**). Considering both malignant and benign neoplasms the most involved organ system is represented by skin and soft tissue, followed by mammary gland, genital tract, alimentary and hemopoietic systems (**Figure 2d**).

CONCLUSIONS

Cancer is one of the leading causes of death and illness in human population and it is considered as the most significant global public health issue of the 21st century. In recent years, it has been documented a concerning increase of cancer patients also in companion animals with over 4.2 million dogs diagnosed with cancer annually in USA, 15 to 30% of which die (35). A better quality of veterinary medical care and the improvement of diagnostic tools in veterinary medicine may have partially in-

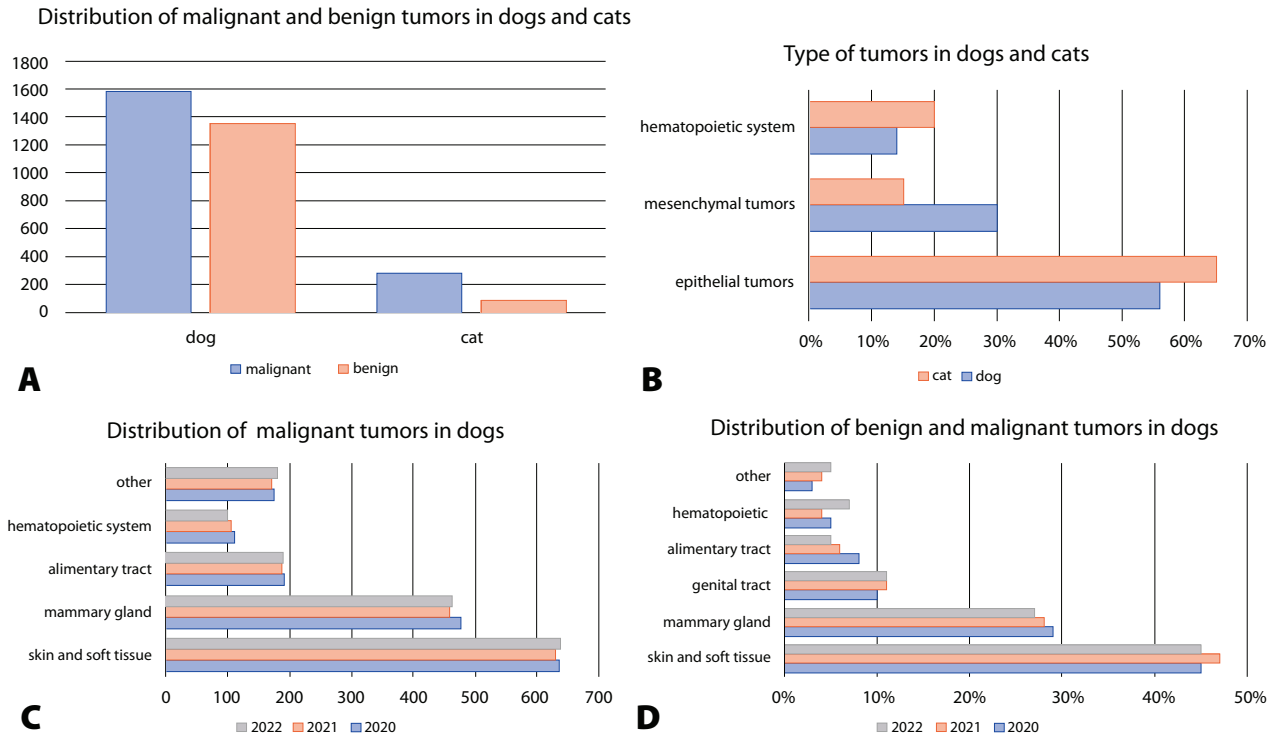

Figure 2. *Distribution of benign and malignant tumor according to data collected by Piattaforma myClinical in the years 2020-2022. (**a**) Number of benign and malignant tumor diagnosis in dogs and cats; (**b**) distribution of tumors in dogs and cats according to histological type; (**c**) distribution of malignant tumors in dogs according to topography; (**d**) distribution of benign and malignant tumors in dogs according to topography.*

fluenced these increasing numbers, but the role of environmental conditions to animal health is not to be underestimated. It is nowadays widely recognized that animals can play an important role of sentinel towards environmental risk factors both for the shorter biological cycle and for the lower "dose" required; moreover, veterinary epidemiologic studies have several advantages such as lower costs and greater ease of obtaining tissue and necropsy data (2, 7).

The data presented in this work represent a preliminary description of data collected in a short time but in a period of revamped interest for cancer registry and data collection, as evidenced by an increased number of publications in this field. Incompleteness or inaccuracy of some data compromise a correct interpretation and attempts of speculation about possible correlations. Among the measures of validity, there is the proportion of missing values for significant variables such as age at diagnosis, sex, or site of the tumors (36). In our institution the most frequently missing data are those related to municipality of residence of the animals that hampers any possible consideration about geographical distribution of tumors. Other data that are often incomplete are those related to sexual condition and age. Samples with missing data are most often those from private laboratories while when samples are sent by practitioners, data are usually complete. It is understandable that some information is lost during the intermediate step especially if it is carried out by a structure that has no direct relationship with animals and owners. Moreover, until two years ago the sample registration procedure has always been manual with samples accompanied by paper case-report format. Since this makes easy to lose information, in 2020 a web-based system has been developed and introduced. In this system the presence of mandatory fields facilitates a more complete data collection. Currently sample registration process is based on a hybrid system where some laboratories or veterinary practitioners have access to the web-based tumor registration system while others still use the paper format, and this explains why many data are often lacking. Another limitation of this system is that topographical code is assigned at the time of registration, based on information provided in case history. This introduces a bias in collecting data from involved anatomical sites increasing the number of topography codes related to ill-defined sites. This happens because morphological diagnosis accurately defines the site of origin of the neoplasm in most cases; hence, topography code should be assigned based on what pathologist states in morphological diagnosis as indicated for human cancer registries. Despite these limitations this system has many resources. The constant education and the well-coordinated work among practitioners, pathologists and computer scientists will improve data collection and uniformity to allow feasible data sharing and will actively contribute to build a true animal PBCR. As already mentioned above, validity, completeness, and comparability of data collected in cancer registry are a pivotal issue. Therefore, initiatives aimed to create a consensus and to promote establishment of standardized methods for animal cancer reporting and registration should be supported worldwide. However, data obtained for veterinary epidemiological studies must be wisely and accurately collected and standardized to create an integrated system of permanent epidemiological cancer surveillance in animals and subsequently in humans. Based on these premises, Animal Cancer Registries are a fundamental and necessary instrument for the detection of neoplastic incidence in an animal population, to evaluate neoplasm trend assessments, to plan interventions and to compare data with those obtained from human studies in a One Health approach.

COMPLIANCE WITH ETHICAL STANDARDS

Fundings

There were no institutional or private fundings for this article.

Conflict of interests

The Authors have declared no conflict of interests.

Availability of data and materials

All relevant data is listed in the manuscript.

Authors' contributions

All the Authors contributed equally to conception, data collection, analysis and writing of this paper.

Ethical approval

Human studies and subjects

N/A.

Animal studies

N/A.

Publication ethics

Plagiarism

N/A.

Data falsification and fabrication

The contents of the article are original and any overlaps with other articles are by the Authors themselves and appropriately cited.

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