The Journal of Veterinary Medical Science

NOTE

Internal Medicine

Identifying causes of death of companion dogs in Japan using data from pet cemeteries

Mai INOUE[1)]* and Katsuaki SUGIURA[1,2)]

[1)]Department of Global Agricultural Sciences, Graduate School of Agricultural and Life Sciences, The University of Tokyo, 1-1-1 Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan
[2)]Nippon Institute for Biological Science, 9-2221-1, Shinmachi, Ome, Tokyo 198-0024, Japan

J. Vet. Med. Sci.
83(7): 1039–1043, 2021
doi: 10.1292/jvms.21-0171

Received: 22 March 2021
Accepted: 2 May 2021
Advanced Epub:
17 May 2021

ABSTRACT. This study aimed to identify the causes of death in dogs that were buried at pet cemeteries. Using data obtained from a questionnaire completed by 5,118 dog owners from 1 April 2016 to 31 March 2017, we estimated the life expectancy and the odds ratio for principal causes of death using multiple logistic regression analysis with potential risk factors as independent variables. The life expectancy determined at birth was 13.98 years. The commonest cause of death was senility. The odds ratios of dying of senility being significantly higher in Labrador Retrievers and Shiba breeds and aged dogs, and significantly lower in Chihuahuas, dogs living indoors and neutered dogs.

KEY WORDS: cause of death, dog breed, life expectancy, pet cemetery data, senility

Many studies have been done to elucidate the life expectancy of dogs. These studies have provided useful information for the improvement of the health and welfare of dogs. The dog is also an ideal model for research in aging and longevity due to its greater than two-fold natural variation in lifespan and considerable variation among breeds in the risk of age-specific diseases [5, 9]. Therefore, identifying the causes and risk factors of death in dogs may be a useful tool to improve their health and welfare thus extending their life expectancy and, possibly and ultimately, humans [6].

We have previously reported our findings on the life expectancy of dog [11]. The aim of this study was to identify the causes of death and potential risk factors that might be associated with the death in dogs. We conducted a survey using a questionnaire which comprised nine descriptive questions about the dates of birth and death, weight, age at death, sex, spay-neuter status, cause of death and whether the dog had lived indoors or outdoors (see Supplementary Fig. 1 the questionnaire used). At the beginning of the questionnaire, information on the survey background and objective was provided. The questions were answered by those from whom consent had been obtained. To encourage honest answers, we made the responses anonymous, with a message indicating that the questionnaire was used exclusively for research purposes and that all questionnaire responses and information would remain confidential. Between April 1, 2016 and March 31, 2017, the questionnaires were distributed at the reception to owners who brought their dogs to any of the eight animal cemeteries that are members of the Tokyo Pet Cemetery Association. Responses were received from 5,118 dog owners. All eight cemeteries were located in Tokyo, and 71% of the respondents lived in Tokyo. The causes of death were freely described by the owners and were classified into one of the 18 diagnostic categories as in the previous report [10]. The weight of the dog and age at death were entered into the database as a linear variable. The sex, spay–neuter status, cause of death and the place where the dog had lived (indoor or outdoor) were entered into the database as a categorial variable. Using these data, we constructed a cohort life table to obtain the life expectancy of the dogs in the same way as in our previous report [11]. We also estimated the odds ratios for the top seven causes of death using multiple logistic regression analysis, with breed, sex, spay-neuter status, living environment (indoor/outdoor) and age as independent variables. We selected the top 16 represented breeds including Miniature Dachshund, Toy Poodle, Chihuahua, Shiba, Yorkshire Terrier, Pomeranian, Pembroke Welsh Corgi, Papillon, Shih Tzu, Miniature Schnauzer, French Bulldog, Labrador Retriever, Cavalier King Charles Spaniel, Golden Retriever, Maltese, cross breed. JMP® 15 (SAS Institute Inc., Cary, NC, USA) was used for this analysis.

The cohort life table that we constructed revealed that at birth the expectation of life was 13.98 years, a slightly longer than previously reported (13.7 years) (See Table 1 and Supplementary Table 1).

As discussed previously [11], the average life expectancy might have been underestimated in this study given the fact that the proportion of purebred dogs analyzed in this study is higher than that of the national dog population. There might have been another selection bias: the owners who were cooperative enough to respond to the questionnaire might have been more likely to be

*Correspondence to: Inoue, M.: kuro_felis_catus@me.com
(Supplementary material: refer to PMC https://www.ncbi.nlm.nih.gov/pmc/journals/2350/)

Table 1. Expectation of life at age 0

	Number	Expectation of life at age 0	95% Confidence Interval
All dogs	5,118	13.98	13.9–14.1

Table 2. Number of dogs dead by cause subjected to analysis of causes of death

	All breeds		
	Number	%	(95% Confidence Interval)
Senility	1,322	25.8	24.7–27.1
Neoplasia	1,117	21.8	20.7–23.0
Cardiovascular	495	9.7	8.9–10.5
Urinary	441	8.6	7.9–9.4
Respiratory	250	4.9	4.3–5.5
Hepatobiliary	167	3.3	2.8–3.8
Neuromuscular	148	2.9	2.5–3.4
Endocrine	79	1.5	1.2–1.9
Immunology	72	1.4	1.1–1.8
Injury	50	1.0	0.7–1.3
Digestive	41	0.8	0.6–1.1
Reproductive	20	0.4	0.3–0.6
Musculoskeletal	11	0.2	0.1–0.4
Infection	5	0.1	0.0–0.2
Otic	2	0.0	0.0–0.1
Parasitic diseases	1	0.0	0.0–0.1
Dermatology	1	0.0	0.0–0.1
Unknown	893	17.5	16.4–18.5
Total	5,115		

interested in the causes of death of dogs, and thus more likely to have detected the symptoms leading to the death of their dogs.

Table 2 shows the causes of death of the dogs analysed in this study. A notable finding was that senility was the most common cause of death. This was not consistent with the findings of previous reports using veterinary hospital data or insurance data reporting lower proportionate mortalities for senility [10, 16, 17]. This is most likely because that dog owners do not bring their dogs to a veterinary hospital or claim insurance when they are suffering from or dying of senility.

The data on the causes of death obtained from dog owers used in this study might not be as accurate as those from clinical record from veterinary hospitals or insurance claim. However, our results were consistent with those of our previous reports, in terms of the order of causes of death [10, 11]. This suggests that data from dog owners are reliable to some extent. The proportion of dogs that died from unknown causes was lower in this study than previously reported, suggesting that increasing number of dog owners are concerned about the causes of their dogs' deaths.

Figure 1 shows the odds ratio for top seven cause of death using multiple logistic regression analysis. The odds ratios by breed of dying of senility was significantly higher in Labrador Retriever and Shiba and significantly lower in Chihuahua. For other factors, the odds ratio of dying of senility was significantly higher for older dogs and significantly lower for dogs living indoors and neutered dogs. There was no clear definition used for senility in asking the dog owners about the causes of death of their dogs. The Ministry of Health, Labour and Welfare defines senility as the death at old age in the absence of a specific disease [13]. Assuming that dog owners used this definition when they chose senility as the cause of death, dogs that are less affected by apparent diseases are more likely to die of senility. With an increasing number of dogs receiving veterinary medical care and surviving cancer and other lethal diseases, in the future an increasing number of dogs are expected to die of senility. This is a reasonable assumption considering that in humans, the proportion of senility-related death increases as they age [10, 14].

Our study revealed that Shiba, a breed that had the longest life expectancy in our previous survey [11], suffers less frequently than other breeds from lethal diseases such as tumors, cardiovascular diseases and urinary diseases [10]. Our study also revealed that the proportion of Labrador Retrievers that died from tumors was not significantly higher than other breeds. This is not consistent with the result of our previous study using insurance data, which revealed that 7.4% of Labrador Retriever developed tumors, significantly higher than the proportion of dogs of other breeds which died from this cause (4.3%). This is probably because benign tumors were also taken account of when we calculated the morbidity by tumors in our previous study [10]. Benign lipomas occur more frequently in Labrador retrievers than in other breeds [15]. In addition, in the same way as Shiba, Labrador Retrievers are less prone than other breeds to lethal diseases such as cardiac and urinary diseases, which explains why they die from senility more frequently than other breeds. The lower odds ratios of death from senility in dogs that had lived indoors and

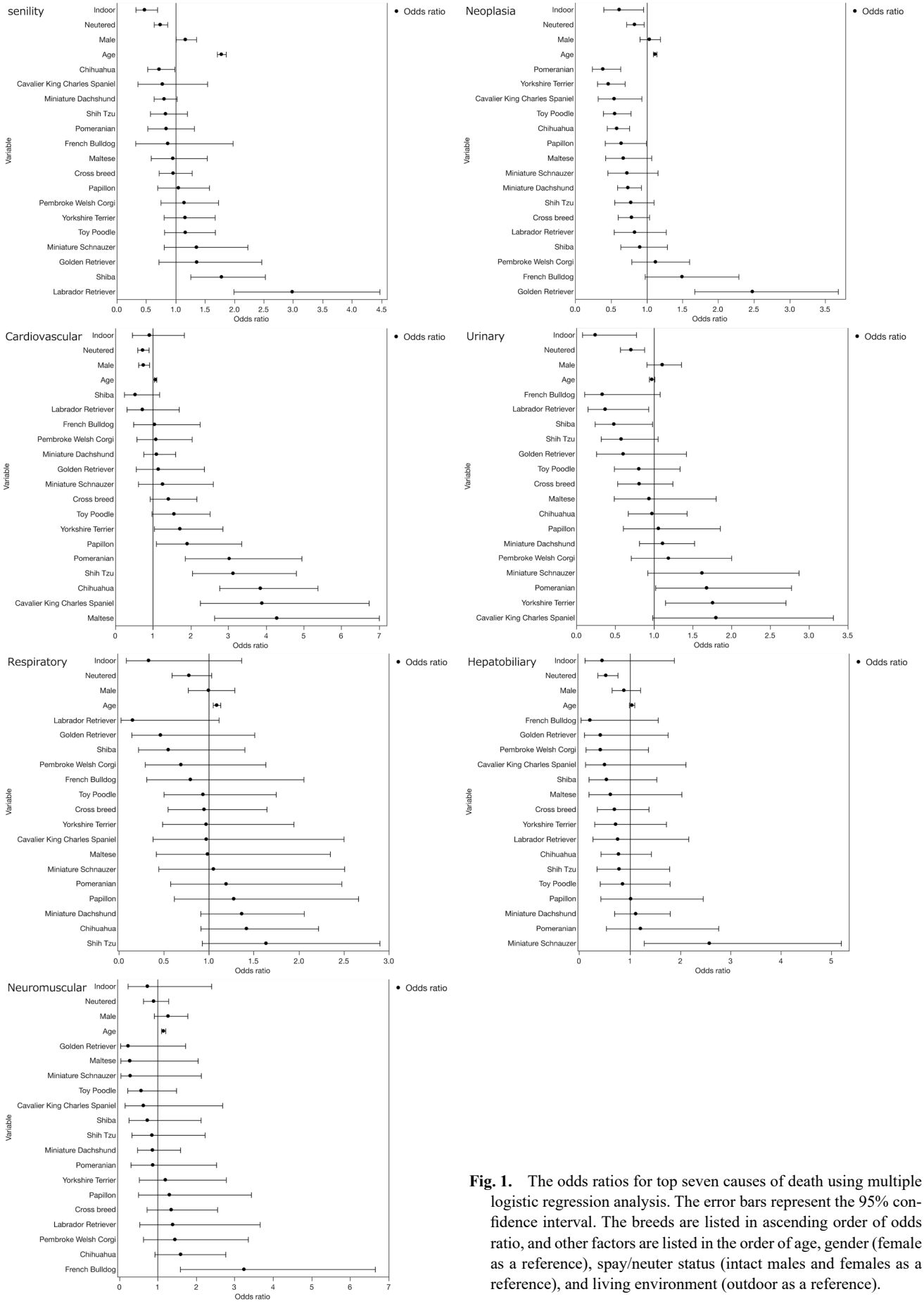

Fig. 1. The odds ratios for top seven causes of death using multiple logistic regression analysis. The error bars represent the 95% confidence interval. The breeds are listed in ascending order of odds ratio, and other factors are listed in the order of age, gender (female as a reference), spay/neuter status (intact males and females as a reference), and living environment (outdoor as a reference).

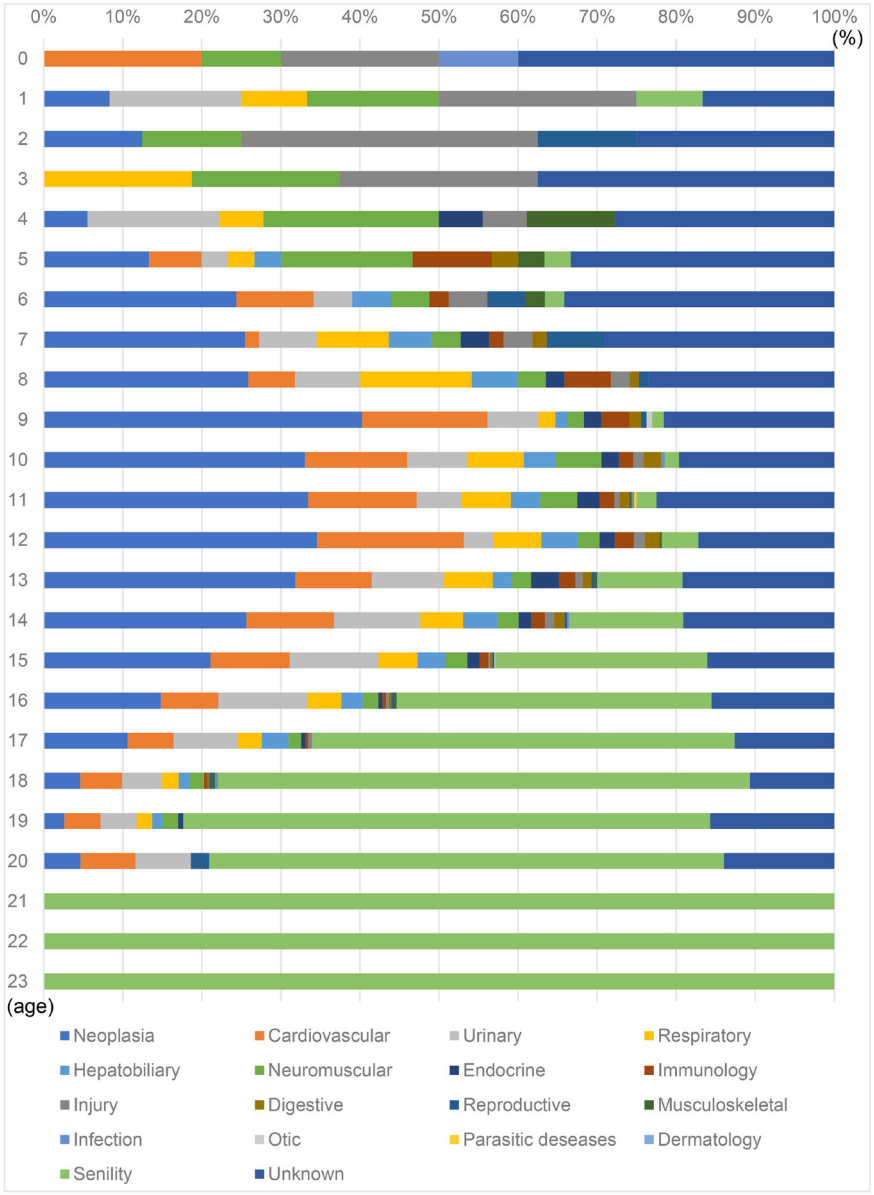

Fig. 2. Proportion of cause of death by age. The proportion of dogs dying of tumor peaked at 9–12 years and then began to decline. After the age of 15, senility became more common than tumors, and after the age of 21, senility was virtually the only cause of death.

with neuter status suggest that diseases in dogs with these conditions are more likely to be detected by their owners because they are more likely to have longer and closer contact with them.

The results of logistic regression analysis indicated that Golden Retrievers had 2.5 times higher odds of dying from neoplasia than other breeds. The analysis also revealed that the odds of death from neoplasia increased by 1.12 times for one year of aging. The odds ratio for neoplasia was significantly lower for Papillon, Chihuahua, Toy Poodle, Cavalier King Charles Spaniel, Yorkshire Terrier, Pomeranian, neutered dogs, and dogs living indoors. Our finding was consistent with previous studies reporting that the Golden Retriever has a high tumor morbidity [1, 5, 12]. Our results also revealed that the odds ratio of death from tumors is lower in spayed dogs. However, there are studies reporting increased tumor incidence in spayed dogs specifically in golden retrievers [7, 8], suggesting a possible presence of an interactive effect between breeds and spay status on proneness to tumors.

This study found that neoplasia was the leading cause of death of dogs that died from a disease. As shown in Fig. 2, the proportion of dogs dying of tumor peaked at 9–12 years and then began to decline. After the age of 15, senility became more common than tumors, and after the age of 21, senility was virtually the only cause of death. The mechanism for avoiding cancer might be explored by studying these dogs with exceptional longevity. A study using Rottweilers found that dogs with exceptional longevity have lower tumor mortality rates than dogs with normal longevity [2]. These dogs with exceptional longevity might be genetically resistant to cancer and other diseases. Even in humans, neoplastic disease, which is the most common cause of death, peaks in the 50s to early 60s and decreases in the late 60s. Senility begins to increase in humans in the late 70s, reaching close to

40% of people aged 100 years and above [14]. In humans, most centenarians die of senility. The life expectency of dogs might be extended by adopting measures to reduce the risk of cancer in dogs.

The odds ratio of dying of cardiovascular diseases was highest in Maltese, followed by Cavalier King Charles Spaniel, Chihuahua, Shih Tzu, Pomeranian, Papillon, and Yorkshire Terrier, and significantly lower in female and neutered dogs. Cardiac valvular disease, one of the most common cardiovascular diseases, is common in dogs, and differences in the incidence of this disease between different breeds have been reported [4].

Yorkshire Terrier and Pomeranian breeds had significantly higher odds ratios for urinary system diseases, while the Labrador Retriever and Shiba had lower odds ratios for these diseases. According to a report comparing blood symmetric dimethylarginine (SDMA) and creatinine concentrations for each breed, Yorkshire Terriers and Pomeranians had higher concentrations and Labrador Retrievers had lower concentrations of this substance than the average of all other breeds [3]. Assuming that SDMA and creatinine concentrations are related to the death of renal dysfunction, these findings are consistent with the results of this study.

The odds ratio of respiratory diseases increased with age, but showed no significant difference by breed.

The Miniature Schnauzer had a higher odds ratio of dying from hepatobiliary and pancreatic diseases than other breeds, while neutered dogs had a low odds ratio. This breed is reportedly prone to hyperlipidemia, which is associated with conditions such as hepatobiliary disease, pancreatitis, insulin resistance, glomerular disease, and epilepsy, and these diseases might be lethal [18].

The odds ratio for neurological disorders was higher in French Bulldogs and aged dogs. The French Bulldog is a breed that is prone to many neurological disorders as reported in a previous study using Japanese pet insurance data [10].

This study attempted to identify causes of death of companion dogs in Japan, using data obtained by questionnaire survey of dog owners who brought their dogs to pet cemeteries. This study provides useful epidemiological information on possible risk factors affecting the longevity of pet dogs in Japan. This could be used by pet owners, veterinary clinicians and breeders, to introduce measures to promote the health care of dogs in general and of certain breeds in particular.

POTENTIAL CONFLICTS OF INTEREST. The authors have nothing to disclose.

ACKNOWLEDGMENTS. We would like to thank Tokyo Society of Pet Cemeteries and the Tokyo Veterinary Medical Association for providing us with data of companion dogs for this study.

REFERENCES

1. Adams, V. J., Evans, K. M., Sampson, J. and Wood, J. L. N. 2010. Methods and mortality results of a health survey of purebred dogs in the UK. *J. Small Anim. Pract.* **51**: 512–524. [Medline] [CrossRef]
2. Cooley, D. M., Schlittler, D. L., Glickman, L. T., Hayek, M. and Waters, D. J. 2003. Exceptional longevity in pet dogs is accompanied by cancer resistance and delayed onset of major diseases. *J. Gerontol. A Biol. Sci. Med. Sci.* **58**: B1078–B1084. [Medline] [CrossRef]
3. Coyne, M., Szlosek, D., Clements, C., McCrann, D. 3rd. and Olavessen, L. 2020. Association between breed and renal biomarkers of glomerular filtration rate in dogs. *Vet. Rec.* **187**: e82–e82. [Medline] [CrossRef]
4. Egenvall, A., Bonnett, B. N. and Häggström, J. 2006. Heart disease as a cause of death in insured Swedish dogs younger than 10 years of age. *J. Vet. Intern. Med.* **20**: 894–903. [Medline] [CrossRef]
5. Fleming, J. M., Creevy, K. E. and Promislow, D. E. L. 2011. Mortality in north american dogs from 1984 to 2004: an investigation into age-, size-, and breed-related causes of death. *J. Vet. Intern. Med.* **25**: 187–198. [Medline] [CrossRef]
6. Gilmore, K. M. and Greer, K. A. 2015. Why is the dog an ideal model for aging research? *Exp. Gerontol.* **71**: 14–20. [Medline] [CrossRef]
7. Hart, B. L., Hart, L. A., Thigpen, A. P. and Willits, N. H. 2014. Long-term health effects of neutering dogs: comparison of Labrador Retrievers with Golden Retrievers. *PLoS One* **9**: e102241. [Medline] [CrossRef]
8. Hart, B. L., Hart, L. A., Thigpen, A. P. and Willits, N. H. 2020. Assisting decision-making on age of neutering for 35 breeds of dogs: associated joint disorders, cancers, and urinary incontinence. *Front. Vet. Sci.* **7**: 388. [Medline] [CrossRef]
9. Hoffman, J. M., Creevy, K. E., Franks, A., O'Neill, D. G. and Promislow, D. E. L. 2018. The companion dog as a model for human aging and mortality. *Aging Cell* **17**: e12737. [Medline] [CrossRef]
10. Inoue, M., Hasegawa, A., Hosoi, Y. and Sugiura, K. 2015. Breed, gender and age pattern of diagnosis for veterinary care in insured dogs in Japan during fiscal year 2010. *Prev. Vet. Med.* **119**: 54–60. [Medline] [CrossRef]
11. Inoue, M., Kwan, N. C. L. and Sugiura, K. 2018. Estimating the life expectancy of companion dogs in Japan using pet cemetery data. *J. Vet. Med. Sci.* **80**: 1153–1158. [Medline] [CrossRef]
12. Kent, M. S., Burton, J. H., Dank, G., Bannasch, D. L. and Rebhun, R. B. 2018. Association of cancer-related mortality, age and gonadectomy in golden retriever dogs at a veterinary academic center (1989–2016). *PLoS One* **13**: e0192578. [Medline] [CrossRef]
13. Ministry of Health Labor and Welfare. Manual to fill in a death certificate. https://www.mhlw.go.jp/toukei/manual/dl/manual_r02.pdf [accessed on April 15, 2021].
14. Ministry of Health Labor and Welfare. Overview of Vital Statistics Monthly Report (Estimation) Overview of Annual Vital Statistics. https://www.mhlw.go.jp/toukei/saikin/hw/jinkou/geppo/nengai19/dl/gaikyouR1.pdf [accessed on April 15, 2021].
15. O'Neill, D. G., Corah, C. H., Church, D. B., Brodbelt, D. C. and Rutherford, L. 2018. Lipoma in dogs under primary veterinary care in the UK: prevalence and breed associations. *Canine Genet. Epidemiol.* **5**: 9. [Medline] [CrossRef]
16. Urfer, S. R., Kaeberlein, M., Promislow, D. E. L. and Creevy, K. E. 2020. Lifespan of companion dogs seen in three independent primary care veterinary clinics in the United States. *Canine Med Genet* **7**: 7. [Medline] [CrossRef]
17. VetCompass. VetCompass, Health surveillance for UK companion animals. https://www.rvc.ac.uk/vetcompass [accessed on April 15, 2021].
18. Xenoulis, P. G., Cammarata, P. J., Walzem, R. L., Suchodolski, J. S. and Steiner, J. M. 2020. Effect of a low-fat diet on serum triglyceride and cholesterol concentrations and lipoprotein profiles in Miniature Schnauzers with hypertriglyceridemia. *J. Vet. Intern. Med.* **34**: 2605–2616. [Medline] [CrossRef]