

# **Epidemiological studies on diagnostic patterns and life expectancy of insured dogs and cats in Japan**

(保険金支払いデータを活用した家庭飼育犬および猫の  
寿命並びに疾患に関する疫学研究)

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## ABBREVIATIONS

AIC	Akaike information criterion
CI	Confidence interval
CYAR	Cat year at risk
FLUTD	Feline lower urinary tract disease
ICD-10	International Classification of Diseases and Related Health Problems 10 <sup>th</sup> revision
IGF-1	Insulin-like growth factor 1
IR	Incidence rate
JKC	Japan Kennel Club
JPFA	Japan Pet Food Association
TJRK	Tama Jui Rinsho Kenkyukai
WHO	World Health Organization



## General Introduction

### **Changes in the diseases in dogs and cats**

The domestic dog and cat have become integral to modern human family life. The Japanese dog and cat populations are estimated to be 10.35 and 9.96 million, with 15.1% and 10.1% of Japanese households being estimated to own at least one dog or cat respectively (JPFA, 2014). Humans benefit from dog and cat ownership both physically (Ownby et al., 2002; Friedmann et al., 2009) and mentally (Virues-Ortega et al., 2006; Walsh, 2009). An increasing number of dogs and cats in Japan, with their integration into human life, enjoy improved health than hitherto partly due to the use of commercial pet food and partly to veterinary medical care. As a result, their life expectancy is expected to have been extended in recent years. With the extension of life expectancy, they have diseases in recent years that are similar to those of human beings, e.g. cardiovascular system disorders, endocrine disorders, cancer, while until the mid-1980s, accidents and infectious and parasitic diseases are the major causes of death.

### **History of pet insurance**

With the integration of companion animals into human life, the number of owners who want to have their pets to receive proper veterinary medical care increased. The first pet insurance policy was written for a dog in Sweden. Today, about 80% of dogs and horses and 20% of cats are insured in Sweden. In 1947, the first pet insurance policy was sold in Britain, and pet insurance took off rapidly there. Today, about 25% of pets in the UK are covered. In 1982, the first pet insurance policy is sold in the US to protect TV's heroic dog Lassie (Filofetch, 2015). Pet owners are estimated to spend about \$13 billion on veterinary care in 2010. Pet insurance continues to grow in popularity as owners seek help managing the costs of veterinary care. In Japan, pet insurance gained a foothold in 2000, when a pet insurance company, Anicom

started its operation, and is gaining more popularity in recent years. Since 2000, an increasing number of dogs are insured for veterinary care in Japan. At the end of 2014, 828,040 dogs and 119,011 cats, representing approximately 8% and 1% of the total dog and cat populations in Japan, were insured for veterinary care, more than half of them being covered by Anicom.

### **Epidemiological studies of companion animal diseases**

Knowing the pattern of disease occurrence of a defined animal population and the risk factors that may affect it, is important to maintain the health and prevent diseases in companion animals. It provides useful information that can be utilized by veterinary practitioners to guide diagnostic decision making, by breeders when planning breeding programs and by owner when acquiring a new pet. Despite substantial medical advances at the clinical level on diagnosis and treatment of diseases in individual animals, there is a shortage of epidemiological information in companion animals at population level (O'Neil et al., 2014a).

A lot of literature supports the existence of disease predispositions affecting dog breeds, sexes and ages, but they rarely provide quantitative information on relative or increased risk of disease between breeds, sex and age (Asher et al., 2009; Summers et al., 2010; Gough and Thomas, 2010).

Some kennel clubs provide information on disease predisposition of different dog breeds (American Kennel Club, 2014; The Kennel Club, 2004), but their information is mostly based on a limited number of pedigree dogs, and consequently is not representative of the general population.

A few large population-based studies were undertaken, mostly during the 1960s and 1970s (Mills and Nielsen, 1967; Robinson, 1967; Fennell, 1975; Schneider and Vaida, 1975; Tedor and Reif, 1978; Nassar et al., 1984). However, these types of studies tend to be costly in terms of financial and

personal resources. There has been a trend in human and veterinary medicine to utilize existing data sources (Thrusfield, 1986; Wennberg et al., 1987; Bright et al., 1989; Bonnett, 1991; Lauderdale et al., 1993).

In recent years, epidemiological analysis of dog diseases have been conducted using data from referral hospitals (Fleming et al., 2011), and data from veterinary primary-care practices and veterinary practices (O'Neill et al., 2014b; Edney, 1997).

The data from referral hospitals are accurate in regard to diagnosis but they have no information about the total population at risk and the possible selection bias when only cases are referred to them. The data from primary-care practices and veterinary practices are more representative of the national dog population than those from referral hospitals, but they have a selection bias when a large proportion of dogs are not registered with practices or when the practices participating in the study are not representative of the overall veterinary practice structure.

### **Use of pet insurance data**

Pet insurance data have been used for research purposes since the 1970's (Bergsten, 1978; Greenhall, 1979) with increasing frequency during the last 15 years. Researchers have shown interest in pet insurance data because, although diagnostic information on insured animals may be inaccurate, they contain sound information relating to breed, sex and age of both diseased and healthy animals in the background population with less selection bias compared with data from referral hospitals and veterinary primary-care practices (Egenvall et al., 1998; 2009), and the insured population can be followed from enrolment to termination of coverage. Recently, epidemiological analysis by breed sex, age, and habitat has been conducted using data of insured dogs on mortality (Bonnett et al., 1997; Egenvall et al., 2000b);

mammary tumors (Egenvall et al., 2005), atopic dermatitis (Nodtvedt et al., 2006a; 2006b; 2007), lymphoma (Edwards et al., 2003) and bone tumors (Egenvall et al., 2007). Published studies based on data of insured dogs and cats are shown in Table 1.

### **Description of the insurance procedures**

Individual companion animals can have veterinary care and/or life insurance; however, insurance terms vary quite widely between companies and even more among countries. In general, veterinary care insurance covers the costs of veterinary consultation, treatments and life-insurance refunds the value of the animal in case of death.

Data used in the studies in this thesis were downloaded from the database owned by Anicom. Dogs and cats younger than 11 years old are eligible to enter the Anicom insurance program, which provides insurance for veterinary medical care (and not for life insurance). The insurance policy term is one year from the enrolment and the owner can choose to renew the policy at the end of each policy year until the dog dies. The Anicom pet insurance program covers veterinary care costs. If a dog receives veterinary care, the owner gets between 50 and 70% of the cost reimbursed, depending on the type of insurance program that the dog is covered by. There is a maximum amount of reimbursement set for veterinary care without hospitalization, veterinary care with hospitalization and veterinary care with surgical operation. The insurance claim is usually made electronically or by paper forms by the owner or by the attending veterinarian. Basic data about the dog, such as the date of birth, breed, and sex are submitted at the time of enrolment into the insurance program. Date of visit to the veterinarian, the amount paid for the veterinary care and reason for the claim, including diagnostic categories and diagnosis, are submitted with the claim (Figure 1).

In **Chapter I**, I evaluated the life expectancy and causes of death in insured dogs. I constructed a life table for all breeds combined and for five groups of breeds grouped according to their ideal body weights. I categorized the cause of death of insured dogs into one of the 18 diagnostic categories, and calculated the probability of death of dog breed group.

In **Chapter II**, I calculated the annual prevalence of diseases of 18 diagnostic categories. I also calculated the annual prevalence standardized for ages for 17 major breeds, using population of all breeds combined as a standard population.

In **Chapter III**, I calculated the annual incidence rates of having at least one insurance claim using the data of five years of insured cats. I also calculated the annual incidence rates standardized for ages for breeds, using population of crossbreed as a standard population.

In **Chapter IV**, I investigated the association between breed, sex and age and cardiovascular disorders in insured dogs, using multiple logistic regression analysis, and estimated the effects of sex, age and breed on the risk of cardiovascular disorders.

## Chapter I

# A current life table and causes of death for insured dogs in Japan

This chapter represents a revised version of the paper published in Preventive Veterinary Medicine Volume 2015, 120, 210–218 with the following co-authors:

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## **Abstract**

The life expectancy and causes of death were evaluated in 299,555 dogs insured in Japan between 1 April 2010 and 31 March 2011, of which 4,169 dogs died during this period. The overall life expectancy of dogs was 13.7 years. The probability of death was high in the first year of life, the lowest in the second and third years, and increased exponentially after three years of age. The life expectancy was 13.8 years in the  $\leq 5$  kg body weight group, 14.2 years in the 5-10kg body weight group, 13.6 years in the 10-20kg body weight group, 12.5 years in the 20-40kg body weight group and 10.6 years in the  $\geq 40$ kg body weight group. As body weight increases, the life expectancy tended to decrease except for the  $\leq 5$  kg body weight group. The probability of death increased as dogs get older for most potential causes of death. Neoplasia was the cause of death with the highest probability of death, causing death in the large and giant breed groups with a higher probability than in the other three breed groups. Cardiovascular system disorders were the second major cause of death and the toy group had a probability of death significantly higher than the other breed groups at age 12+.



### **1.1. Introduction**

Knowing the life expectancy of a defined animal population and the risk factors that may affect it, can provide information required to assist in the prevention and control of disease and the education of owners. There have been studies on canine longevity and causes of death using data from veterinary hospitals (Patronek et al., 1997; Bronson, 1982; Fleming et al., 2011), pet insurance data (Bonnett et al., 1997; Egenvall et al., 2000a and 2000b) and data based on questionnaire surveys of pet owners (Michell, 1999; Reid and Peterson, 2000; Proschowsky et al., 2003). Despite the fact that studies using pet insurance data have inherent sampling biases, they provide useful information about the potential risk factors that affect the longevity of dogs. For example, Bonnett et al. (1997) and Egenvall et al. (2000a) reported mortality risks and causes of death for over 200,000 dogs using records from a Swedish pet insurance company. Egenvall et al. (2000b) reported the age patterns for risk of death in selected breeds of insured dogs.

An increasing number of dogs in Japan enjoy improved health than hitherto partly due to the use of commercial pet food and partly to veterinary medical care. As a result, their life expectancy is expected to have been extended in recent years. However, as there is no official system requiring owners to report the birth and death of dogs and there has been no study conducted to estimate the life expectancy of dogs in Japan, except for a study conducted by Hayashidani et al. (1988). They used pet cemetery data, constructed a cohort life table and estimated the life expectancy of dogs to be 8.3 years at

birth (age zero) and 8.6 years at one year old (age one).

There are two principal forms of the life table: the cohort (or generation) life table and the current life table. The cohort life table records the actual mortality experience of a particular group of individuals (the cohort) over its entire lifetime. The current life table gives a cross-sectional view of the mortality and survival experience of a population during a current year and is dependent on the age-specific death rates prevailing in the year for which it is constructed (Chiang, 1984).

The purpose of the study in this chapter was to construct a current life table of dogs in Japan using data from a Japanese company operating veterinary care insurance programs in the fiscal year 2010 and to determine the common causes of death.

## **1.2. Materials and Methods**

### **1.2.1. Data management**

Data on all dogs that entered an insurance program or renewed the insurance policy any time during fiscal year 2010 (1 April 2010-31 March 2011) were entered into a database for this study. Each of these dogs was observed for one year from the entrance into the insurance program or renewal of it. As a result, the observation period of each dog varied depending on what date the dog entered or renewed the insurance program. For example, if a dog entered or renewed the insurance program on 1 April 2010, the dog was observed from 1 April 2010 until 31 March 2011. If a dog entered or renewed the program on 2 April 2010, the dog was observed from

2 April 2010 until 1 April 2011, and so on (Figure 2). The variables included in the database were breed, sex, the date of birth and date of entrance into or renewal of the insurance program. Whether the dog renewed the insurance policy at the end of the one year observation period was also entered into the database. For dogs that died during the observation period, the date and cause of death and age at death were entered into the database. Anicom provides insurance only for veterinary care and not life insurance for dogs, therefore the dates of death and causes of death are not stated in the claim forms. When the insurance was cancelled due to death of the insured dog, the date of death was confirmed with the owner. The reason for the claim stated on the form submitted in the month before the date of death was assumed to be the cause of death. To validate the data on the causes of death, I randomly selected 106 dogs that left the insurance program in November 2014 with submission of insurance cancelation due to death and asked the owners about the actual cause of death, and examined if the diagnostic information on the veterinary care claim was in agreement with the actual causes of death. This telephone survey revealed that of the 106 dogs that died, 89 had a veterinary care claim within one month of death. Of these, 71 dogs (80%) had a diagnostic category in agreement with the actual causes of death, and 18 dogs (20%) had a diagnostic category inconsistent with the actual causes of death or had only symptomatic diagnosis. Thus, the telephone survey supported my assumptions in the majority of cases.

The age at death for each dog was calculated based on the date of birth and

the date of death. Those dogs that had the insurance policy renewed at the end of the observation period were considered to have survived the one year observation period. Those dogs that left the insurance program without submission of cancellation due to death or did not renew the program were excluded from this study. The number of dogs subjected to the construction of life table and analysis of cause of death is shown in Table 2.

### **1.2.2. Construction of life table**

In constructing the life table, I used an age interval of one year. I calculated the probability of a dog dying in age interval  $(x, x+1)$ ,  $q_x$  as a proportion of dogs that died during this age interval over the dogs alive at age  $x$ . I calculated the fraction of last year of life for age  $x$ ,  $a'_x$  as the average of the fraction of last year of life for dogs that had died during the interval  $(x, x+1)$ . I constructed a life table from  $q_x$  and  $a'_x$ , in accordance with the method described by Chiang (1984). The life expectancy at age  $x$  was calculated, as the number of years, on the average, yet to be lived by a dog of age  $x$ . I constructed a life table for all breeds combined and for five groups of breeds grouped according to their ideal body weights: toy ( $<5\text{kg}$ ), small ( $5\text{--}10\text{ kg}$ ), medium ( $10\text{--}20\text{kg}$ ), large ( $20\text{--}40\text{kg}$ ) and giant ( $>40\text{kg}$ ). Data on the ideal weight of each breed were obtained from the Japan Kennel Club (2013). I summed up the dogs aged 17 and over to one age interval (17+) in constructing a life table for all breeds combined, and toy, small and medium breeds. I summed up the dogs aged 16 and over to one age interval (16+) for large breed, and the dogs age 13 and over to one age interval (13+) for giant breed group. The number of dogs by age insured in fiscal year 2010 grouped

into these five groups is shown in Table 3.

I calculated the variance of life expectancy at each age using the method described by Chiang (1984). The significance of difference of life expectancy between different breed groups was also tested using the method by Chiang (1984), i.e. I first obtained the ratio of the difference of estimated life expectancy between different groups to the standard error of the difference at each age interval and then checked if the value of this ratio exceeded the critical value of  $Z_{.99}=2.33$  corresponding to  $\alpha=.01$  level of significance.

### **1.2.3. Analysis of causes of death**

The 4,169 dogs that left the insurance program due to death were subjected to the analysis of causes of death. I categorized the causes of death of these dogs into one of the 18 diagnostic categories by body system or type of disease: disorders of cardiovascular, respiratory, digestive, urinary, reproductive, neuromuscular and musculoskeletal systems; hepatobiliary and exocrine pancreatic disorders; diseases of eye, ear, teeth and skin; immunological and endocrine disorders; infectious diseases, parasitic diseases, injuries, neoplasia and unknown. These diagnostic categories are used by veterinarians when they complete the insurance claim form for the owners. The cause was classified as 'unknown' for 548 dogs, where the cause stated on the claim form was only a symptomatic diagnosis, such as loss of appetite, diarrhoea, etc. and unclassifiable into any of these categories. There were 940 dogs that died with no claim for veterinary care within one month before the date of death. These dogs were also classified as died of 'unknown' causes. The breakdown of these dogs by cause of death is shown

in Table 4. I calculated the probability of death of for a dog breed group  $b$  from a diagnostic category  $d$  at age group  $a$ ,  $P_{b,a,d}$  by:

$$P_{b,a,d} = n_{b,a,d} / N_{b,a}$$

where  $N_{b,a}$  is the total number of dogs of breed group  $b$  that entered into or renewed the insurance policy at age group  $a$ , and  $n_{b,a,d}$  is the number of dogs of breed group  $b$  that entered into or renewed the insurance policy at age group  $a$  and died of diagnostic category  $d$  during the one year observation period. I used age groups of two years each up to age 11 ( $a=0-1, 2-3, 4-5, 5-7, 8-9, 10-11$ ) to get sufficient numbers of dogs in the denominator to improve the statistical power for comparisons between age groups. I summed up the dogs aged 12 and over to one age group (12+) for toy, small, medium and large breed groups, and the dogs aged 10 and over to one age group (10+) for giant breed group.

In constructing the life tables and analyzing the causes of death, I used spreadsheet software Excel 14.0 (Microsoft Corporation).

### **1.3. Results**

#### **1.3.1. Life expectancy of insured dogs in Japan**

Table 5 presents the current life table of insured dogs of all breeds combined in Japan. The probability of death was high in the first year of life, lowest in the second and third years of life and increased exponentially after three years old. The life expectancy at age zero, or the average lifespan was 13.7 years.

Tables 6, 7, 8, 9 and 10 present life table for toy, small, medium, large and

giant breed groups respectively. The life expectancy at age zero was 13.8 (95%CI: 13.6-14.1) years for the toy group; 14.2 (95%CI: 14.0-14.4) years for the small group; 13.6 (95%CI: 13.4-13.8) years for the medium group; 12.5 (95%CI: 12.3-12.8) for the large group; and 10.6 (95%CI: 9.7-11.5) years for the giant breed group.

Figure 3 indicates the life expectancy of the five breed groups up to 10 years of age. There was a significant difference in the life expectancy at age zero up to age six between the breed groups with p value <0.01 except for between toy and small groups and between toy and medium groups. The difference in the life expectancy between breed groups became less significant as the age increased and the number of dogs (n) decreased.

### **1.3.2. Causes of death of insured dogs in Japan**

Figure 4 shows the probability of death of insured dogs in Japan at different ages by six major causes. The probability of death increased as dogs get older for most causes. Neoplasia was the cause of death with the highest probability of death. The probability of death from neoplasia in the large and giant breed groups appeared to be higher than the other groups at both young and old ages. There was no significant difference detected between breed groups except for between large and giant groups and other breed groups at age groups 6-7, 8-9, 10-11 and 12+.

Cardiovascular system disorders were the second major cause of death. The toy group had the probability of death of 4.7% at age 12+, significantly higher than the medium and large breed groups at the same age group.

The probability of death from musculoskeletal system disorders in the large

and giant breed groups at age 12+ and at age 10+ was 1.8% and 2.5% respectively, and appeared to be higher than the other breed groups, but there was no significant difference between breed groups at any age groups (graph not shown).

The probability of death from urinary tract disorders, digestive and respiratory system disorders and neuromuscular disorders also increased with age and reached 2-3 % at age 12+, with no significant difference between breed groups.

The probability of death from hematological/immunological disorders, endocrine disorders, infectious diseases, parasitosis or injury was below 1% for most age groups in all breed groups. The probability of death from infectious diseases was 0.05% in the first two years of life, but remained lower than 0.01% at older age groups. The probability of death from ophthalmological disorders, otic diseases, dentistry, parasitosis, and dermatological disorders was below 0.1% at all age groups in all breed groups.

#### **1.4. Discussion**

To examine how much I can generalize from my data, I compared the dog population insured by Anicom with the general dog population in Japan. The number of insured dogs used in this study represents only two percent of the total dog population in Japan, and therefore the dog population used in this study might not be representative of the general dog population in terms of breed and age distributions. According to the result of a survey



conducted by the Japan Pet Food Association in 2011, Miniature Dachshund, Toy Poodle, Shiba, Chihuahua and mongrels represent 15.7%, 7.9%, 6.9%, 6.6% and 18.9% respectively of the dog population in Japan (JPFA, 2013), while these breeds represent 16.8%, 15.1%, 4.9%, 15.5% and 5.0% respectively of the insured dog population used in this study. This indicates that the purebred dogs might be over-represented in this study. Also, considering the fact that most insured dogs are enrolled into an insurance program at in their first year of life when they are sold from pet shops and breeders to owners and that the number of insured dogs is on the increase in Japan, young dogs are over-represented in this study. Given the fact that the proportion of insured dogs is higher in urban areas than in rural areas, dogs living in urban areas are over-represented in the insured dog population.

I then considered if there was any potential bias in calculating the life expectancy from my data. Firstly, I can well assume that the insured dogs receive better veterinary care than non-insured dogs, indicating that the life expectancy might have been overestimated in this study. Secondly, I did not consider the puppy mortality in calculating the probability of death in the first year of life, because there were no data on the mortality of the dogs between birth and purchase from pet shops and breeders when insurance would start. This might have resulted in underestimation of the probability of death in the first year of life and consequently overestimation of the life expectancy.

In this study those dogs that left the insurance program without the owners

either renewing the policy or, notifying that their dog had died were excluded from analysis. Some owners left the program probably because they thought that it was not worthwhile continuing because they had no veterinary treatment for their pet for an extended period. As a result of this censoring not due to death, with healthy dogs being removed from the study population, the probability of death might have been overestimated and consequently life expectancy might have been underestimated.

In this study, I constructed a current life table and estimated an overall life expectancy of 13.7 at age zero, while a previous study by Hayashidani et al. (1988) constructed a cohort life table by estimating the target population from data of only dead dogs brought to a cemetery in Tokyo from June 1981 through May 1982 and estimated an overall life expectancy of 8.3 and 8.6 years at ages zero and one respectively. Data collected in this way are generally subject to bias because not all dead dogs are brought to cemeteries. The proportion brought to the cemeteries might vary with age (e.g., the proportion of young dead dogs brought to cemeteries might be smaller than that of old dead dogs), and those still alive were not included in the data. Thus, the data used in their study might not have represented the general dog population. Moreover, the cemetery records they used may not be accurate because they were based on the memory of dog owners, who might have forgotten the exact age of their dogs as the dogs got older (Hayashidani et al., 1988).

Because of these methodological differences and presence of biases in this and their studies, one cannot make a direct comparison between the results

of the two studies. Nevertheless, one can assume an extension of life expectancy of dogs in Japan in the past three decades to some extent due to the increased provision of veterinary care and the assumed improved nutrition as a result of increasing use of well-balanced commercial pet food as well as promotion of animal welfare among Japanese people in recent years.

The results of this study showed that small breeds have the longest longevity, followed by toy breeds, medium breeds, large breeds and giant breeds. Many previous studies that reported longevity difference between breeds of dogs of different body weights showed that the breeds with smaller body weights have longer longevity (Li et al., 1996; Patronek et al., 1997; Kraus et al., 2013) . These studies suggested that the breeds of smaller body weights live longer, without comparing the longevity between toy and small breeds (Li et al., 1996; Patronek et al., 1997; Kraus et al., 2013; Adams et al., 2010; O'Neill et al., 2013). Adams et al. (2010) compared the longevity of dogs between five breed groups (toy, small, medium, large and giant), and concluded that the breeds of smaller body weights live longer, although small breeds were dominant in the 14 breeds with the highest median age at death. O'Neill et al. (2013) reported the median age at death of 36 dog breeds, of which the 10 breeds with the highest median age at death were six small breeds, one medium breed and three large breeds. In Japan, the toy breeds are represented by a small number of popular breeds such as Chihuahua and Toy poodle.

Further research is needed to identify factors affecting the difference in

longevity between breed groups, although some genetic basis for dog size variation and lifespan has been reported previously: Sutter et al. (2007) examined genetic variation in small and giant breeds of dogs and found evidence that a single gene (IGF-1), encoding insulin-like growth factor 1 (IGF-1) single-nucleotide polymorphism haplotype is common to all small breed and is almost absent from giant breeds, suggesting that the same causal sequence variant is major contributor to body size in all small dogs. Holzenberger et al. (2003), using heterozygous knockout mice, reported that the IGF-1 receptor may be a central regulator of mammalian lifespan.

The results of this study showed that the probability of death from major diseases such as neoplasia, cardiovascular, musculoskeletal, digestive and respiratory system disorders, hepatobiliary and exocrine pancreatic disorders and neuromuscular and urinary tract disorders increased as dogs aged, while that from infectious and parasitic diseases is highest in the first year of life. This finding is consistent with most previous studies (Bonnett et al., 1997; Ekenvall et al., 2000a and 2000b; Adams et al., 2010; O'Neill et al., 2013). Fleming et al. (2011) reported that the relative frequency of death in young dogs in North America was high not only from infectious diseases but also from cardiovascular, gastrointestinal, musculoskeletal, respiratory disorders and traumatic diseases. This difference might be caused by the different environment in which dogs are kept between Japan and North America but should be subjected to further studies.

In analyzing the causes of death in this study, I assumed that the diagnosis stated on the claim form for veterinary care submitted within one month

before the date of death was the cause of death, because Anicom provides insurance for only veterinary care and not life insurance for dogs and causes of death are not stated in the claim forms. Therefore some of the causes of death in this database might have differed from the actual causes of death. Also, in this study those dogs that died with no claim for veterinary care within one month before the date of death were classified as died from 'unknown' causes. The telephone survey that I conducted in November 2014 to validate the data on the causes of death revealed that of the 106 randomly selected dogs that died, 17 dogs (16%) did not submit a veterinary care claim within one month before the date of death. Of these, 7 dogs died from accident, 7 suddenly from an unidentified cause, and 3 from senile decay. The result of my telephone survey showed that those dogs which died without submission of claim mostly died suddenly or by accident with no chance to receive veterinary care. This might have resulted in the underestimation of the probability of death from injuries and other diseases that cause sudden death. While several studies have been conducted to validate the insurance data mostly for agreement between diagnostic information in insurance claims and practice records (Egenvall et al., 1998; Penell et al., 2007; Egenvall et al., 2009; Heske et al., 2014), no study has been made to validate the insurance data for the agreement between reasons for veterinary care submitted before death and the causes of death. Further studies are needed to address this issue.

There was no significant difference detected between different breed groups of dogs at most old age groups in the probabilities of death for most

diagnostic categories. This was probably because the number of dogs (n) in the database subjected to analysis was not large enough and the statistical power of detection was insufficient at most age groups and for most diagnostic categories. Further analyses are needed using data of a larger number of dogs to test if there are significant differences in the probability of death between different breed groups.

This study attempted to estimate the life expectancy and causes of death of dogs in Japan, by using data of insured dogs. This study provides useful epidemiological information on possible risk factors affecting the longevity of pet dogs in Japan, which could be used by pet owners, veterinary clinicians and breeders, to introduce measures to reduce their impact and so promote the health care of dogs in general and of certain breeds at different ages in particular.

## Chapter II

# Age, breed, sex and pattern of diagnosis for veterinary care in insured dogs in Japan during fiscal year 2010

This chapter represents a revised version of the paper published in Preventive Veterinary Medicine Volume 2015, 119, 54-60 with the following co-authors:

Atsuhiko Hasegawa

Yuta Hosoi and

Katsuaki Sugiura

## **Abstract**

I calculated the annual prevalence of diseases of 18 diagnostic categories in the insured dog population in Japan, using data from 299,555 dogs insured between April 2010 and March 2011. The prevalence was highest for dermatological disorders (22.6% for females and 23.3% for males), followed by otic diseases (16.4% for females and 17.2% for males) and digestive system disorders (15.7% for females and 16.4% for males). The prevalence of cardiovascular, urinary, neoplasia and endocrine disorders, increased with age; infectious diseases and injuries showed a high prevalence at young ages, and the prevalence of musculoskeletal and respiratory disorders showed a bimodal peak at young and old ages. A large variation in prevalence was observed between breeds for dermatological, otic, digestive, ophthalmological and cardiovascular disorders.



## **2.1. Introduction**

In Japan, no large scale and comprehensive epidemiological study has been conducted on dog diseases except for the ones conducted by the Ministry of Agriculture, Forestry and Fisheries in 2001 (MAFF, 2002) and a local study group of veterinary clinicians (TJRK, 2008). These studies used data obtained from veterinary clinics and hospitals. Because no information was available to them about the background population, it was not possible to calculate the disease risk or prevalence.

The purpose of this study was to estimate the annual prevalences of different diseases of dogs and compare these prevalences for different sexes, ages and breeds using data of insured dogs.

## **2.2. Materials and Methods**

### **2.2.1. Data management**

Data on all dogs of ages 0-18 years that entered an insurance program or renewed the insurance policy during fiscal year 2010 (1 April 2010-31 March 2011) were entered into a database for this study. These dogs were observed for one year from the date of entrance into or renewal of the insurance program. The variables included in the database were breed, sex and age at entrance into or renewal of the insurance program. Data on claims for veterinary care, including the reasons for claims were entered into the database. Those dogs that cancelled the insurance program during the observation period were considered to be censored. A total of 299,555 dogs

were observed for one year and subjected to the analysis in this study. Their distributions by sex and age and by breed are shown in Tables 11 and 12. Of the 299,555 dogs, 177,242 (59.2%) had at least one insurance claim for veterinary care. The reasons for claims stated on the claim form were used as diagnostic information and were divided into one of the 18 diagnostic categories by body system or type of disease. These were disorders of cardiovascular, respiratory, digestive, urinary, reproductive, neuromuscular and musculoskeletal systems; hepatobiliary and exocrine pancreatic disorders; ophthalmological, otic, dental and dermatological diseases; immunological and endocrine disorders; infectious diseases, parasitic diseases, injuries, neoplasia and unknown. These diagnostic categories have been developed by Anicom based on ICD-10 (WHO, 2011), which is also a mixture of organ system and process categories. Veterinarians, when they complete the insurance claim form for the owners, supposedly choose one of these diagnostic categories as well as symptoms that resulted in the veterinary care. In cases where two or more diagnostic categories are stated on the claim form, I considered the first diagnostic category to be the main cause and entered it into the database. In cases where the cause stated on the claim form is only symptomatic diagnosis, such as loss of appetite, diarrhoea, etc. and unclassifiable into any of these categories, the cause was classified as 'unknown'.

### **2.2.2. Calculation of annual prevalence**

I used annual prevalence as an epidemiological indicator of dog diseases in this study. I calculated the annual prevalence as the proportion of the

number of dogs that had at least one insurance claim for the respective diagnostic categories during the one year observation period to the total number of dogs that survived or died during the one year observation period. A dog which had two or more claims submitted for one diagnostic category appeared once in the numerator. A dog with claims submitted for different diagnostic categories appeared in the numerator for both these diagnostic categories. Of the 299,555 dogs subjected to the analysis, 74,463 dogs had claims for one diagnostic category, 102,779 dogs had claims for two or more diagnostic categories and the rest had no claims for veterinary care (presumably remained healthy).

I calculated the diagnosis specific annual prevalence for each sex and age. To correct the age distributions and enable comparison between breeds I also calculated annual prevalence standardized for ages for 17 major breeds, using a population of all breeds combined as standard population. The 95% confidence intervals of the annual prevalence was calculated using the formula  $Pre \pm 1.96 \times ([Pre \times (1-Pre)]/n)^{0.5}$ , where Pre is the prevalence (Martin, 1987). I tested the differences between sexes and calculated P values using Pearson's chi square method. I used software STATA Ver. 12 (Stata Corp LP, College Station, Texas) for statistical analysis.

### **2.3. Results**

Table 13 shows the annual prevalence by sexes and diagnostic categories for insured dogs in Japan. The prevalence was highest for dermatological disorders (22.6% for females and 23.3% for males), followed by otic diseases

(16.4% for females and 17.2% for males) and digestive system disorders (15.7% for females and 16.4% for males). The prevalence was significantly different between male and female for most diagnostic categories. The highest ratio between sexes was observed for reproductive system disorders (with a ratio of 1.9), followed by urinary tract disorders (with a ratio of 1.5) and neoplasia (with a ratio of 1.2).

The age specific prevalence by sex for 18 diagnostic categories is shown in Figure 5. Diagnostic categories can be classified into 4 groups according to the age pattern of prevalence that they represent. The first group, including cardiovascular, hepatobiliary and exocrine pancreatic, urinary, neuromuscular, ophthalmologic, endocrine, dental, immunological disorders and neoplasia, showed an increase in prevalence with age. The second group including dermatological and otic disorders showed a high prevalence (14.8-30.8%) through all ages. The third group including infectious and parasitic diseases and injuries showed a high prevalence at young ages, which remained low at older ages. The fourth group included digestive, respiratory, reproductive and musculoskeletal disorders and showed a high prevalence at both young and old ages.

Table 14 shows the breeds with the highest prevalence standardized for ages for the 12 most common diagnostic categories. There was a large variation in prevalence between breeds for most diagnostic categories: French Bulldog and Pug had an annual prevalence of >40% for dermatological disorders. Pug, Golden Retriever and French Bulldog had an annual prevalence of >30% of otic diseases. French Bulldog, Cavalier King Charles Spaniel and

Yorkshire Terrier had an annual prevalence of ca. 20% for digestive system disorders. The French Bulldog was in the top five breeds for 9 of the 12 most common diagnostic categories. Crossbred dogs did not appear in the top five breeds in any of the diagnostic categories. The largest variation was observed for cardiovascular disorders, for which the Cavalier King Charles Spaniel had annual prevalence 5.2 times higher than the average of the insured dog population.

## **2.4. Discussion**

This study is the first comprehensive study that analyzed the prevalence of dog diseases using pet insurance data in Japan. The annual prevalence that I obtained for different diagnostic categories were comparable with the results of a study by (O'Neill et al., 2014a). O'Neill et al (2014a) conducted a large scale study on the prevalence of dog diseases using data from primary care veterinarians in the United Kingdom. O'Neill et al (2014a) reported that, in organ system categories, dermatology had the highest prevalence (36.3%) followed by digestive (29.5%) and musculoskeletal (14.8%). My results are consistent with their results in terms of the order of diseases but my study resulted in lower values of annual prevalence than theirs. This difference might partly be due to the difference of diagnostic categories used in the two studies. In their study, in classifying the diseases they used two-layer categorization of organ systematic and process categories. In my study, which used mixture of organ system and process categories, some of the skin cancer and skin infection cases might have been categorized into

neoplasia or infectious diseases. The same tendency was noted for diseases of low prevalence.

My results are also consistent with the results of a study conducted by Egenvall et al. (2000c) using pet insurance data. Egenvall et al. (2000c) reported that the diseases of highest incidence risk were dermatological (3.15%) and digestive (2.70%). The values of the annual prevalence in this study were much higher than their values of annual incidence risk. This is not only because of the difference of the epidemiological indicators used in the two studies but also probably due to the difference of insurance policies that applied to owners between the two companies. They used annual incidence risk which only took account of the new cases, while my study used annual prevalence which not only considered the new cases but also those cases carried over from the previous year. Their insurance policy had a minimal deductible amount, underestimating the risk because the cases under the minimal deductible amount are not claimed; therefore mild cases with low veterinary cost were not taken into account in calculating the risk. The Anicom insurance does not have a fixed deductible amount, therefore all the veterinary cares that insured dogs receive are most likely to result in a claim.

Egenvall et al. (2000c) reported that the breeds with the highest risk of dermatological disorders in Sweden are Doberman, Boxer, Standard Schnauzer, Giant Schnauzer and Great Dane. In my study the French Bulldog, Pug, Shih Tzu appeared to suffer most from dermatological disorders. Although Doberman and Boxer were not subjected to the

comparison between breed in my study because they were not one of the 17 main breeds, they showed a high prevalence of skin diseases (32.3% and 29.0% respectively).

The results in this study on age-dependent prevalence for some diagnostic categories are consistent with a previous study by Egenvall et al. (2000c). In both studies, the prevalence of cardiovascular, urinary, endocrine disorders and neoplasia, increased with age, infectious diseases and injuries showed a high prevalence at young ages, and the prevalence of musculoskeletal and respiratory disorders showed a bimodal peak at young and old ages.





## Chapter III

# Describing the morbidity pattern by age, sex and breed in insured cats in Japan during 2008-2013

This chapter represents a revised version of the paper that has been published ahead of print on 18 November 2015 in Journal of Feline Medicine and Surgery in September 2015, with the following co-authors:

Atsuhiko Hasegawa and  
Katsuaki Sugiura

## **Abstract**

To describe the morbidity pattern of different diagnostic categories in insured cats in Japan by age, sex and breed, I calculated the annual incidence rates of having at least one insurance claim using data of insured cats between April 2008 and March 2013. The overall annual incidence rate of having at least one insurance claim was 4,632 (95% CI 4,608-4,656) cats per 10,000 cat-years at risk. The highest annual incidence rate was obtained for digestive system disorders, followed by urinary tract disorders and dermatological disorders. The incidence rates varied between breeds for most diagnostic categories: in cardiovascular system disorder, Scottish Fold, American Shorthair, Persian, Maine Coon, Norwegian Forest Cat, Ragdoll and Bengal had higher annual incidence rate than crossbreeds.

### **3.1. Introduction**

Despite substantial medical advances at an individual cat level, there is a shortage of health information on cats at a population level (O'Neill et al., 2014c). The purpose of the study in this chapter was to describe the pattern of morbidity in cats, as reflected by claims for veterinary care insurance in cats insured by the Anicom insurance company during 2008-2013. Findings are presented overall and stratified by age, sex, breed and diagnosis.

### **3.2. Materials and Methods**

#### **3.2.1. Data management**

Data on all cats of ages 0-21 years that entered an insurance program or renewed the insurance policy during 1 April 2008 - 31 March 2013 were entered into a database for the calculation of annual incidence in this study. The variables included in the database were age, sex and breed at entrance into or renewal of the insurance program. Sex was either male or female because recording and timing of neutering were not reliable in the database. In the insurance data, 55 breed codes were used. Data on claims for veterinary care, including the reasons for claims were also entered into the database. The reasons for claims stated on the claim form were used as diagnostic information and were divided into one of the 18 diagnostic categories by type of disease or body system. These were disorders of cardiovascular, respiratory, digestive, urinary, reproductive, neuromuscular and musculoskeletal systems; hepatobiliary and exocrine pancreatic disorders; ophthalmological, otic, dental and dermatological diseases;

immunological and endocrine disorders; infectious diseases, parasitic diseases, injuries, neoplasia and unknown. These diagnostic categories have been developed by Anicom based on International Classification of Diseases (ICD-10), which is also a mixture of organ system and process categories. The process categories were infectious diseases, parasitic diseases, injuries and neoplasia. Diseases overlapping organ and process were classified priori to process categories, e.g. liver tumor was classified as neoplasia. Veterinarians, when they complete the insurance claim form for the owners, supposedly choose one of these diagnostic categories as well as symptoms that resulted in the veterinary care. In cases where the cause stated on the claim form is only symptomatic diagnosis, such as loss of appetite, diarrhea, etc. and unclassifiable into any of these categories, the cause was classified as 'unknown'.

### **3.2.2. Calculation of annual incidence rates**

The annual incidence rate was used as an epidemiological indicator of cat diseases in this study. The annual incidence rates of having at least one veterinary care event were calculated overall and stratified by age, sex, breed, fiscal year and diagnostic categories. The annual incidence was calculated with the number of cats that had at least one insurance claim for the respective diagnostic categories during the one year observation period as numerator, and the exact time at risk (cat-years at risk (CYAR)) as the denominator. The CYAR was calculated without excluding the time after the date of the claim. A cat with claims submitted for different diagnostic categories appeared in the numerator for all of these diagnostic categories.

The incidence rates were expressed as the number of cat with a claim per 10,000 CYAR. Cats were at risk from either 1 April 2008 or the start date of insurance until 31 March 2013 or the date of cancelation of the insurance program. A total of 64,575 cats were observed and contributed to the number of CYAR.

I calculated the diagnosis specific annual incidence rates for each age and sex. To correct the age distributions and enable comparison between breeds I also calculated annual incidence rates standardized for ages for pure breeds, using the direct standardization method (Martin et al., 1987) with a population of crossbreed as standard population. The 95% confidence intervals (CIs) of the annual incidence rate were calculated using the formula  $IR \pm 1.96 \times ([IR \times (1-IR)]/n)^{0.5}$ , where IR is the incidence rate and n is the number of CYAR (Martin et al., 1987). Non-over-lapping 95% CIs were used as evidence of statistical difference (Martin et al., 1987). I used spreadsheet software Microsoft Excel 14.0 (Microsoft Corporation) for statistical analysis.

### **3.3. Results**

#### **3.3.1. The population and overall morbidity**

The total number of CYAR was 166,075. The numbers of CYAR by sex, breed and age are shown in Table 15. Figure 6 shows the distribution of CYAR by age category. Cats at age 0, 1 and 2 consisted of 20.8%, 13.8% and 10.9% respectively in terms of the number of CYAR. The median and mean age at enrollment of the cats subjected to this study was 2.1 and 3.4 years

respectively, and more than half the cats had been enrolled before 3 year of age. The number of CYAR was 89,629 (54.0%) for males and 76,446 (46.0%) for females. The breed with highest CYAR was crossbreed (36.2%), followed by Scottish Fold (13.9%) and American Shorthair (12.8%). Figure 7 shows the distribution of CYAR by fiscal year. The number of CYAR increased over the years from 21,456 in 2008 to 48,187 in 2012. The overall annual rate of at least one veterinary care event was 4,632 (95%CI: 4,608-4,656) cats per 10,000 CYAR. The lowest and the highest rates were 4,174 (95%CI: 4,108-4,240) cats in 2008 and 4,947 (95%CI: 4,903-4,992) cats in 2012 per 10,000 CYAR respectively.

### **3.3.2. The cause specific morbidity by age, sex and breed**

Table 16 shows the annual incidence rates of having one insurance claim for each diagnostic category by sex and breed for insured cats in Japan. The most common diagnostic category was digestive system disorders with the annual incidence rate of 1,172 (95%CI: 1,156-1,187) cats per 10,000 CYAR.

The second major diagnostic category was urinary diseases with an annual incidence of 1,091 (95%CI: 1,076-1,106) cats per 10,000 CYAR.

Dermatological disorders were found to be the third most common cause of morbidity, with the annual incidence rate of 838 (95%CI: 825-851) cats per 10,000 CYAR. The fourth common diagnostic category was ophthalmological disorders with an incidence rate of 698 (95%CI: 686-711) cats per 10,000 CYAR.

The incidence rates were significantly different between male and female cats for most diagnostic categories. The highest ratio between sexes was

observed for reproductive system disorder (female was higher than male with a ratio of 6.0) followed by cardiovascular system disorders (male was higher than female with a ratio of 1.4) and dental diseases (male was higher than female with a ratio of 1.3).

The pure breeds had a higher ratio over crossbreed for cardiovascular system disorders (with a ratio of 2.0), followed by otic disease (with a ratio of 1.8), reproductive system disorders (with a ratio of 1.6), and musculoskeletal disorders (with a ratio of 1.5). The crossbreeds had a higher ratio over pure breeds observed for dental diseases (with a ratio of 2.1) followed by hepatobiliary and exocrine pancreatic disorders (with a ratio of 1.6), injuries (with a ratio of 1.6) and parasitosis diseases (with a ratio of 1.3).

The age specific incidence rates by sex for 18 diagnostic categories are shown in Figure 8. The incidence rates increased with age in eight of the 18 diagnostic categories: cardiovascular, hepatobiliary and exocrine pancreatic, urinary, neuromuscular, dental, immunological, endocrine disorders and neoplasia. Reproductive, ophthalmologic, otic, infectious and parasitic diseases and injuries showed a high incidence rate at younger ages, which remained low at older ages. Dermatological diseases had high incidence rates through all ages. The remaining categories, including respiratory, digestive and musculoskeletal disorders showed a high incidence rate at both young and old ages.

Figure 9 shows the incidence rates standardized for ages of the different diagnostic categories for the major 16 breeds whose CYAR were over 1,000. There was a large variation in incidence rates between breeds for most

diagnostic categories, e.g. in cardiovascular system disorder, Scottish Fold, American Shorthair, Persian, Maine Coon, Norwegian Forest Cat, Ragdoll and Bengal had a higher annual incidence rate than crossbreeds, and Somali had a lower incidence rate than crossbreeds. The incidence rate of cardiovascular system disorder was 9.1 times higher in Maine Coon than in Somali. The Scottish Fold had higher incidence rates also for otic and musculoskeletal diseases compared with the crossbreeds. American Curl had high incidence rates for neuromuscular and otic diseases compared to other breeds. The crossbreeds had lower incidence rates compared with pure breeds for most diagnostic categories except for dental disorders and injuries.

### **3.4. Discussion**

A similar trend of morbidity in digestive disorder with two peaks at young and old ages was reported in a study using the primary veterinary care data in UK (O'Neill et al., 2014c) and a study using pet insurance data in Sweden (Egenvall et al., 2010). For young cats, gastrointestinal parasites might be the major cause of digestive diseases (Beugnet et al., 2014), and for old cats, inflammatory bowel diseases, endocrine diseases such as thyroid disease, diabetes mellitus and neoplasia might be involved (Caney et al., 2009; Willard et al., 2012).

The urinary diseases, the second major diagnostic category, consist of diseases in the upper part (including the kidney and ureter) and the lower part (including the bladder and urethra). In a Swedish study (Egenvall et



al., 2010), the morbidity of lower urinary system diseases was 109 (95%CI: 103-115) cats per 10,000 CYAR and that for upper was 41 (95%CI: 37-45) cats per 10,000 CYAR. In a UK study (O'Neill et al., 2014c), the prevalence did not differ significantly between lower and upper urinary systems (4.4% and 4.2% respectively). In the present study, the proportional morbidity was 46.2% and 24.1% for lower and upper urinary diseases (no information available for the remainder 29.7%) (data not shown). This difference might be caused by a difference in breed distribution between the respective countries, because several breeds have been identified as a risk factor for FLUTD in the US (Lekcharoensuk et al., 2001) and Sweden (Egenvall et al., 2010).

The morbidity of dermatological disorders did not yield significant difference between ages, sexes and breeds (purebred/crossbreed) in this study as in a UK study (O'Neill et al., 2014c).

In this study, the annual incidence rate of injuries was low compared with previous studies conducted by Egenvall and O'Neill. This is probably because most cats insured in Japan are kept indoors (93.9% of cats are kept indoors according to unpublished data from a questionnaire survey conducted by Anicom in 2015).



## Chapter IV

# Association between breed, sex and age in relation to cardiovascular disorders in insured dogs in Japan

This chapter represents a revised version of the paper that has been published ahead of print on 12 October 2015 in Journal of Veterinary Medical Science with the following co-authors:

Atsuhiko Hasegawa,

Yuta Hosoi and

Katsuaki Sugiura

## **Abstract**

The association between breed, sex and age and cardiovascular disorders in the insured dog population in Japan was investigated, using logistic regression analysis and data from 299,555 dogs insured between April 2010 and March 2011. The overall annual prevalence of cardiovascular disorder diagnosis was 2.1%. Using the Miniature Dachshund as the reference breed, Cavalier King Charles Spaniel had the highest odds of cardiovascular disorder with a ratio of 16.2 (95% confidence interval: 14.4-18.2), followed by Maltese, Pomeranian, Chihuahua and Shih Tzu. Male dogs had increased odds of 1.2 (1.1-1.3). The dogs had increased odds of having cardiovascular disorder by 1.5 times as their age increased by one year.

#### **4.1. Introduction**

Cardiovascular disorders in the dog are of major importance in terms of animal health and welfare. Much literature supports the predisposition of dogs to cardiovascular disorders by breed, sex and age, but quantitative information on relative or increased risk of disease by these parameters is lacking (Asher et al., 2009; Gough et al., 2010; Summers, et al., 2010).

Epidemiological analysis by breed, sex, age, and habitat has been conducted using data from insured dogs on mammary tumors (Egenvall et al., 2005), atopic dermatitis (Nodtvedt et al., 2006a; Nodtvedts et al., 2006b; Nodtvedt et al., 2007), lymphoma (Edwards et al., 2003) and bone tumors (Egenvall et al., 2007). A few epidemiological studies have been conducted to describe the sex, age and breed pattern of diagnoses including cardiovascular disorders in insured dogs in Sweden (Egenvall et al., 2000b) and to investigate the association between breed, sex and cardiovascular disorders in the UK (Thrusfield et al., 1985). In this study I assessed the effect of breed, sex and age on the prevalence of cardiovascular disorders in dogs insured by Anicom, using logistic regression analysis.

#### **4.2. Materials and Methods**

Data on all dogs aged 0-18 years that entered an insurance program or renewed the insurance policy during fiscal year 2010 (1 April 2010-31 March 2011) were entered into a database for this study. These dogs were observed for one year from the date of entrance into, or renewal of, the insurance program. The variables included in the database were breed, sex and age at

entrance into or renewal of the insurance program. Data on claims for veterinary care, including the reasons for claims were entered into the database. If an owner cancelled the insurance program during the observation period data was excluded from the study. A total of 299,555 dogs were observed for one year and subjected to the analysis in this study. Their distributions by sex, age, and breed are shown in Table 17.

Data of these 299,555 dogs were analyzed with respect to breed, sex and age. A total of 6,211 dogs had at least one claim for cardiovascular disorder, representing 2.1% of the study population (annual prevalence).

Those dogs that had at least one claim for cardiovascular disorder were considered to have that disorder. I estimated the odds ratios for cardiovascular disorder using logistic regression analysis. The independent variables used were breed, sex and age. I selected the top 19 represented breeds including Miniature Dachshund, Toy Poodle, Shiba, Yorkshire Terrier, Pomeranian, Pembroke Welsh Corgi, Papillon, Shih Tzu, Miniature Schnauzer, French Bulldog, Labrador Retriever, Cavalier King Charles Spaniel, Golden Retriever, Maltese, Pug, Jack Russel Terrier, Beagle, and Miniature Pinscher. I placed all other breeds and crossbreeds as 'other breeds'. I generated dummy variables for different breeds. I used Miniature Dachshund (the breed with the highest frequency) as the reference dog breed. I used the age as a linear variable after comparing between a model with the age as linear variable and a model with the age as categorical variable using the AIC.

We performed the statistical analysis using StatTools Version 6 (Palisade, Ithaca, New York). I also predicted the annual prevalence using the logistic regression model and the obtained odds ratios as input variables. To incorporate the uncertainty of the model results arising from the uncertainty of input variables, I used Monte Carlo simulation and ran 10,000 iterations. The simulations were performed using software @Risk 6.3 (Palisade) added into the spreadsheet software Excel 14.0 (Microsoft Corporation).

#### **4.3. Results and discussion**

Table 18 shows the effect of sex, age and breed on the annual prevalence of cardiovascular disorder. Using the Miniature Dachshund as the reference breed, Cavalier had the highest odds of cardiovascular disorder with a ratio of 16.2 (95% confidence interval: 14.4-18.2), followed by Maltese, Pomeranian, Chihuahua and Shih Tzu. Male dogs had increased odds of 1.19 (1.13-1.25). The odds ratio of the linear variable age was 1.50 (1.49-1.52). This indicates that the odds of dogs having cardiovascular disorder increased 1.5 times as their age increased by one year.

Figure 10 shows the predicted annual prevalence of cardiovascular disorder for different sexes of the reference breed (Dachshund) and three breeds with highest odds ratios (Cavalier King Charles Spaniel, Maltese and Pomeranian). The annual prevalence of cardiovascular disorder actually observed was mostly within the 95% confidence interval of the predicted annual prevalence, indicating the validity of the logistic regression model that I used.

In the study in this chapter, I used the age, breed and sex as independent variables for the analysis because they are the only risk factors on which information was available using the insurance database. However, there are other potential risk factors that might affect the occurrence of cardiovascular disorders, such as obesity, diet, exercise, and habitat.

To account for other potential risk factors, further studies are needed with additional information on these factors.

The odds ratios that I obtained for different breeds were consistent with the result in Chapter II using the same data, in which increased annual prevalence was observed in Cavalier King Charles Spaniel, Maltese, Chihuahua, Pomeranian and Shi Tzu (Chapter II). The results in this chapter were mostly consistent with the results of previous studies in other countries: Egenvall et al. (2000a) reported that, using data of insured dogs in Sweden, Cavalier King Charles Spaniel, Irish Wolfhound, St. Bernard, Pekingese and Great Dane have the highest risk of cardiovascular disorders (In this study the last four breeds were classified as 'other breeds'). Thrusfield et al. (1985) conducted an observational study of a veterinary clinic population in the United Kingdom and concluded that Miniature Pinscher, Standard Poodle, King Charles Spaniel, Miniature Poodle, Toy Poodle and Chihuahua had higher odds of having canine heart valve incompetence than other breeds and that males were more susceptible than females to this disease.

Among cardiovascular disorders, heart valve incompetence, endocarditis, cardiomyopathy, angiosarcoma, valvular disease and patent ductus



arteriosus (PDA) are relatively common to companion dogs. In this study, no distinction was made between these diseases. However, there might be different risk factors involved in the occurrence of these respective diseases. Further studies are needed to identify the risk factors of these diseases.



## General Conclusion

The study in Chapter I is the first study that estimated the life expectancy of dogs using insurance data in Japan. The studies in Chapters II and III are the first comprehensive studies that analyzed the prevalence or incidence of companion animal diseases in Japan. These studies provide useful epidemiological information on possible risk factors affecting the longevity of companion dogs and risk of diseases in dogs and cats in Japan. The study in Chapter IV attempted to quantify the effect of age, sex and breed as the risk factors that might affect the risk of cardiovascular system disorders in dogs. The information obtained from these studies could be used by pet owners, veterinary clinicians and breeders, to introduce measures to reduce the impact of these risk factors and so promote the health care of dogs and cats in general and of certain breeds at different ages in particular.

#### **Potential biases of insurance data**

In generalizing the results of these studies using insurance data, there are some potential biases. Firstly, because the pet insurance is a growing industry and most of dogs and cats enter insurance programs at young ages, the insured populations are likely to be biased toward younger age compared with the general populations. Secondly, there will likely be higher proportions of pure breed dogs and cats insured: according to survey conducted by the Japan Pet Food Association in 2014, crossbred dogs and cats represent 18.9% and 79.8% of the dog and cat populations in Japan respectively (JPFA 2004), while they represent 5.0% and 36.2% of the insured dog and cat population used in the studies in this thesis. Thirdly, given the fact that the proportion of insured dogs and cats are higher in urban areas than in rural areas, dogs and cats living in urban areas are overrepresented in the insured populations (data of insured dogs and cats are not shown). Fourthly, according to unpublished data from a questionnaire survey conducted by Anicom, 95.7% of dogs (2014) and

93.9% of cats (2015) are kept indoors, while 80.5% and 71.6% are kept indoor respectively in the general population (JPFA 2014). Therefore, dogs and cats living indoors might be overrepresented than those living outdoors. Fifthly, I excluded the clinical diagnoses that presented only symptoms without specifying one of the 18 diagnostic categories. This might have resulted in systematic exclusion of the cases of some specific diagnostic categories. In addition, insured dogs and cats will be more likely to receive expensive veterinary care than uninsured animals. The first two biases (biased age and breed distributions) were corrected by using standardization and logistic regression analysis in the respective studies.

Because of these potential biases, the extrapolation of the results of studies in this thesis to the general dog and cat population must be done with due consideration and caution. For example, in calculating the life expectancy of dogs in Chapter I, better accessibility of insured dogs to veterinary care than non-insured dogs might have led to overestimation of the life expectancy. Also, the annual prevalence and incidence of injuries of dogs and cats might have been underestimated in Chapters II and III, if animals living indoors are overrepresented and those living outdoors are underrepresented in the insured populations. To account for these potential sources bias, further studies are needed with additional information on these sources.

### **Need for validation of insurance data**

In the studies in this thesis, I assumed that the diagnostic categories stated in the insurance claim forms reflect the actual diseases for which the veterinary care claims were made. In cases where more than two diagnostic categories are stated on the claim, I assumed the first diagnostic category stated on the form to be the actual diseases without interrogating the veterinarians. Data errors may arise due to transcription, translation or omission (Lloyd and Rissing,

1985; Pollari et al., 1996). Every time information is recorded or transcribed either on paper or electronically, there is a possibility for errors to occur. In addition, diagnostic information is often subjective and open to interpretation by the clinician, the recorder or the researcher. Regardless of the source of errors, they many affect estimates of disease occurrence. Although allowable error rates in data are not established, efforts to quantify the data quality should be made to all studies using secondary data (Roos et al, 1979; Ray et al., 1992; Meehan et al., 1995). In veterinary medicine, the validity of an insurance company's database was assessed by Egenvall et al. (1998; 2009). They found an agreement of 80% or above on diagnostic information between insurance claims and hospital records in all the categories assessed. In Japan there is no official classification system of diseases diagnosis of companion animals. Therefore, I used the 18 diagnostic categories developed by an insurance company abased on ICD-10 classification (WHO, 2011), in calculating the causes of death and annual prevalence and incidence. There is a need to conduct a study to verify the accuracy of diagnostic information of insured dogs in Japan.

### **Future use of insurance data**

Despite these potential biases and a need for data validation, I conclude that insurance data can and should be used for research purposes in companion animals. The insurance data are simply a very useful resource because they can be used for both descriptive and analytical epidemiological research to fill gaps left by other types of research. The studies in this thesis have shown that the insurance data can be successfully used to quantify disease patterns and other animal health features that may have been hitherto assumed, but unmeasured.

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Table 1

Published studies (n = 48) based on data from insured animals or using insured animals as a sampling frame in chronological order

Source	Year	Country	Species	Main focus/disease
Bergsten et al. (1978)	1975-1977	Sweden	Dog	Morbidity and mortality; general and by cause
Greenhall et al. (1979)	1978-1979	US	Horse	Mortality; by cause
Häggström et al. (1992)	1980-1990	Sweden	Dog	Mortality and morbidity; myxomatous valve disease
Bergsten et al. (1983)	1973-1981	Sweden	Horse	Mortality; locomotor problem
Clausen et al. (1990)	1977-1987	Germany	Horse	Morbidity; general. by cause
Hommerich et al. (1995)	1984-1994	Germany	Horse	Mortality; by cause
Bonnett et al. (1997)	1992,1993	Sweden	Dog	Mortality; general and by cause
Egenvall et al. (2000a)	1995,1996	Sweden	Dog	Morbidity and mortality; general
Egenvall et al. (2000b)	1996	Sweden	Dog	Morbidity; general, by cause
Egenvall et al. (2000c)	1995,1996	Sweden	Dog	Mortality; general
LeBlond et al. (2000)	1995	France	Horse	Mortality; general, by cause
Egenvall et al. (2001)	1995,1996	Sweden	Dog	Morbidity; pyometra
Dobson et al. (2002)	1997-1998	UK	Dog	Morbidity; neoplasia
Edwards et al. (2003)	1997-1998	UK	Dog	Morbidity: lymphoma
Bonnett et al. (2005)	1995-2000	Sweden	Dog	Mortality; general, by cause
Davison et al. (2005)	Not stated	UK	Dog	Diabetes mellitus
Egenvall et al. (2005a)	1995-2000	Sweden	Dog	Mortality; general, by cause

Egenvall et al. (2005b)	1995-2002	Sweden	Dog	Morbidity and mortality; mammary tumours
Egenvall et al. (2005c)	1997-2000	Sweden	Horse	Morbidity; general
Penell et al. (2005)	1997-2000	Sweden	Horse	Morbidity; by cause
Bergström et al. (2006)	1995-2002	Sweden	Dog	Morbidity; Caesarean section
Egenvall et al. (2006a)	1995-2002	Sweden	Dog	Mortality; heart disease
Nødtvedt et al. (2006)	1995-2002	Sweden	Dog	Morbidity; atopic dermatitis
Egenvall et al. (2006b)	1997-2000	Sweden	Horse	Mortality; general, by cause
Egenvall et al. (2006c)	1997-2002	Sweden	Horse	Mortality; general, locomotor problems
Higuchi (2006)	2001-2003	Japan	Horse	Morbidity and mortality; colic
Nødtvedt et al. (2007)	1995-2002	Sweden	Dog	Morbidity; atopic dermatitis, spatial distribution
Egenvall et al. (2007)	1995-2002	Sweden	Dog	Morbidity and mortality; osteosarcoma
Fall et al. (2007)	1995-2004	Sweden	Dog	Morbidity and mortality; diabetes mellitus
McCann et al. (2007)	2003	UK	Cat	Morbidity; diabetes mellitus
Egenvall et al. (2008a)	1997-2002	Sweden	Horse	Morbidity; general, locomotor problems
Egenvall et al. (2008b)	1997-2002	Sweden	Horse	Morbidity and mortality; colic
Egenvall et al. (2009a)	1999-2006	Sweden	Cat	Mortality; general
Egenvall et al. (2009b)	1997-2002	Sweden	Horse	Morbidity and mortality; riding schools horses, locomotor problems
Bonnett et al. (2010)	1995-2006	Sweden	Dog, cat and horse	Morbidity and mortality; general
Malm et al. (2010)	1995-2004	Sweden	Dog	Morbidity and mortality; hip dysplasia
Egenvall et al. (2010)	1999-2006	Sweden	Cat	Morbidity; general
Vilson et al. (2013)	1995-2006	Sweden	Dog*	Morbidity; general
Hagman et al. (2014)	1999-2006	Sweden	Cat	Morbidity; pyometra

Heske et al. (2014)	1995-2006	Sweden	Dog	Morbidity and mortality; epilepsy
Pelander et al. (2015)	1995-2006	Sweden	Dog	Morbidity and mortality; kidney disease
Bremer et al. (2015)	1995-2006	Sweden	Dog**	Morbidity ; Immune mediated disease
Öhlund et al. (2015)	2009-2013	Sweden	Cat	Morbidity; diabetes mellitus
Inoue et al. (2015)	2010-2011	Japan	Dog	Life Expectancy and mortality; general
Inoue et al. (2015)	2010-2011	Japan	Dog	Morbidity ; general
Inoue et al. (2015)	2010-2011	Japan	Dog	Morbidity ; cardiovascular disorder
Inoue et al. (2015)	2008-2013	Japan	Cat	Morbidity ; general

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\* German Shepherd \*\*Nova Scotia Duck Tolling Retriever

Table 2

Summary statistics of the insured dog population used in the study in Chapter I

	Number	Males (percent)	Mean age	Median age	Age range
Dogs commencing or renewing insurance in fiscal year 2010*	299,555	52.8	3.6	3	0-18
Dogs included in the study	278,441	52.6	3.8	3	0-18
Dogs subjected to cause of death analysis	4,169	53.7	8.4	9	0-18

\* Fiscal year 2010 is from 1 April 2010 to 31 March 2011.



Table 3

Number of breeds and dogs by age grouped into four groups according to their body weight\* in Chapter I

Age	Breed groups					Total
	Toy <sup>a</sup>	Small <sup>b</sup>	Medium <sup>c</sup>	Large <sup>d</sup>	Giant <sup>e</sup>	
0	23,466	15,316	5,368	1,616	321	46,087
1	20,207	15,469	5,458	1,938	342	43,414
2	12,545	10,105	3,621	1,191	180	27,642
3	13,661	13,174	4,490	1,481	240	33,046
4	11,083	13,107	4,347	1,535	252	30,324
5	9,201	12,272	4,258	1,409	219	27,359
6	6,872	11,288	3,823	1,642	195	23,820
7	4,251	8,252	2,870	1,432	160	16,965
8	2,127	5,047	1,929	1,226	120	10,449
9	1,288	3,320	1,297	1,002	69	6,976
10	908	2,470	975	772	49	5,174
11	539	1,609	628	538	19	3,333
12	303	922	397	345	7	1,974
13	192	466	209	194	3	1,064
14	108	250	108	97	1	564
15	53	89	39	15	0	196
16	9	21	9	4	0	43
17	3	4	1	0	0	8
18	0	3	0	0	0	3
Total	106,816	113,184	39,827	16,437	2177	278,441

\*The body weight is defined as ideal body weight by the Japan Kennel Club (2013). <sup>a</sup> Toy group includes 13 breeds of body weight <5kg, such as Chihuahua, Toy poodle, Yorkshire Terrier, Pomeranian and Maltese. <sup>b</sup> Small group includes 44 breeds of ideal body weight 5-10kg, such as Miniature Dachshund, Papillon, Miniature Schnauzer, Shih Tzu, Cavalier King Charles Spaniel and Pug. <sup>c</sup> Medium group includes 43 breeds of ideal body weight 10-20kg, such as Shiba, Pembroke Welsh Corgi and French bulldog. <sup>d</sup> Large group includes 58 breeds of ideal body weight 20-40kg, such as Golden Retriever and Labrador Retriever. <sup>e</sup> Giant group includes 24 breeds of ideal body weight >40kg, such as Great Dane, Newfoundland and Saint Bernard.

Table 4

Number of dogs dead by cause subjected to analysis of causes of death in

Chapter I

Diagnostic category	Number of dogs	(%)
Neoplasia	622	(14.9 )
Cardiovascular system disorders	380	(9.1 )
Urinary system disorders	258	(6.2 )
Digestive system disorders	245	(5.9 )
Neuromuscular system disorders	208	(5.0 )
Respiratory system disorders	184	(4.4 )
Hepatobiliary and exocrine pancreatic disorders	178	(4.3 )
Immunological disorders	110	(2.6 )
Musculoskeletal system disorders	102	(2.4 )
Injuries	86	(2.1 )
Skin diseases	77	(1.8 )
Endocrine disorders	76	(1.8 )
Infectious diseases	41	(1.0 )
Reproductive system disorders	32	(0.8 )
Eye diseases	31	(0.7 )
Ear diseases	31	(0.7 )
Teeth diseases	14	(0.3 )
Parasitic diseases	6	(0.1 )
Unknown*	1,488	(35.7 )
Total	4,169	(100.0)

\* Unknown include dogs which died with no claim for veterinary care submitted within one month before the date of death as well as those with claim for veterinary care submitted but no diagnostic category being stated.

Table 5

Current life table of insured dogs in Japan (all breeds combined)

Age interval in years	Probability of dying in interval (x,x+1)	Number living at age x	Number dying in interval (x,x+1)	Fraction of last year of life	Number of years lived in interval (x,x+1)	Total number of years lived beyond age x	Expectation of life at age x
$x \text{ to } x+1$	$\hat{q}_x$	$l_x$	$d_x$	$\hat{d}_x$	$L_x$	$T_x$	$\hat{e}_x$
0-1	0.0107	10000	107	0.48	9945	136580	13.7
1-2	0.0049	9893	48	0.45	9867	126636	12.8
2-3	0.0041	9845	41	0.48	9824	116769	11.9
3-4	0.0048	9804	47	0.54	9783	106945	10.9
4-5	0.0066	9757	64	0.51	9726	97163	10.0
5-6	0.0082	9693	79	0.51	9654	87437	9.0
6-7	0.0102	9614	98	0.53	9568	77783	8.1
7-8	0.0152	9516	145	0.51	9445	68215	7.2
8-9	0.0254	9371	238	0.49	9250	58770	6.3
9-10	0.0388	9133	354	0.49	8952	49520	5.4
10-11	0.0606	8778	532	0.50	8512	40568	4.6
11-12	0.0877	8246	723	0.51	7889	32056	3.9
12-13	0.1266	7523	953	0.48	7024	24167	3.2
13-14	0.1688	6570	1109	0.45	5961	17143	2.6
14-15	0.2678	5461	1463	0.49	4708	11181	2.0
15-16	0.3739	3999	1495	0.45	3178	6473	1.6
16-17	0.4715	2504	1181	0.38	1777	3295	1.3
17+	1.0000	1323	1323	-	1518	1518	1.1

Table 6

Current life table of insured dogs in Japan (toy breeds)

Age interval in years	Probability of dying in interval (x,x+1)	Number living at age x	Number dying in interval (x,x+1)	Fraction of last year of life	Number of years lived in interval (x,x+1)	Total number of years lived beyond age x	Expectation of life at age x
$x$ to $x+1$	$\hat{q}_x$	$l_x$	$d_x$	$\hat{a}_x$	$L_x$	$T_x$	$\hat{e}_x$
0-1	0.0099	10000	99	0.46	9946	138463	13.8
1-2	0.0043	9901	42	0.43	9877	128517	13.0
2-3	0.0034	9859	33	0.50	9842	118640	12.0
3-4	0.0036	9826	36	0.58	9811	108798	11.1
4-5	0.0051	9790	50	0.50	9765	98987	10.1
5-6	0.0060	9740	58	0.47	9709	89222	9.2
6-7	0.0074	9682	71	0.53	9648	79512	8.2
7-8	0.0133	9611	128	0.46	9541	69864	7.3
8-9	0.0217	9483	206	0.42	9364	60323	6.4
9-10	0.0272	9277	253	0.42	9130	50959	5.5
10-11	0.0554	9025	500	0.47	8761	41829	4.6
11-12	0.0982	8525	837	0.49	8101	33067	3.9
12-13	0.1377	7688	1059	0.51	7171	24967	3.2
13-14	0.1531	6629	1015	0.39	6006	17795	2.7
14-15	0.2804	5614	1574	0.48	4803	11789	2.1
15-16	0.3579	4040	1446	0.52	3340	6986	1.7
16-17	0.5294	2594	1373	0.36	1711	3646	1.4
17+	1.0000	1221	1221	-	1935	1935	1.6

Table 7

Current life table of insured dogs in Japan (small breeds)

Age interval in years	Probability of dying in interval (x,x+1)	Number living at age x	Number dying in interval (x,x+1)	Fraction of last year of life	Number of years lived in interval (x,x+1)	Total number of years lived beyond age x	Expectation of life at age x
$x$ to $x+1$	$\hat{q}_x$	$l_x$	$d_x$	$\hat{a}_x$	$L_x$	$T_x$	$\hat{e}_x$
0-1	0.0112	10000	112	0.49	9943	141961	14.2
1-2	0.0048	9888	47	0.47	9863	132018	13.4
2-3	0.0043	9841	43	0.51	9820	122155	12.4
3-4	0.0048	9798	47	0.52	9776	112335	11.5
4-5	0.0059	9751	58	0.51	9723	102559	10.5
5-6	0.0067	9693	65	0.52	9662	92836	9.6
6-7	0.0096	9628	92	0.51	9583	83174	8.6
7-8	0.0118	9536	113	0.51	9480	73592	7.7
8-9	0.0158	9423	149	0.50	9348	64111	6.8
9-10	0.0284	9274	263	0.50	9143	54763	5.9
10-11	0.0445	9011	401	0.51	8814	45620	5.1
11-12	0.0666	8610	573	0.53	8339	36807	4.3
12-13	0.0972	8037	781	0.46	7615	28467	3.5
13-14	0.1348	7256	978	0.46	6732	20853	2.9
14-15	0.1949	6277	1224	0.51	5673	14121	2.2
15-16	0.3477	5054	1757	0.42	4029	8448	1.7
16-17	0.4031	3297	1329	0.39	2483	4418	1.3
17+	1.0000	1968	1968	-	1936	1936	1.0

Table 8

Current life table of insured dogs in Japan (medium breeds)

Age interval in years	Probability of dying in interval (x,x+1)	Number living at age x	Number dying in interval (x,x+1)	Fraction of last year of life	Number of years lived in interval (x,x+1)	Total number of years lived beyond age x	Expectation of life at age x
$x \text{ to } x+1$	$\hat{q}_x$	$l_x$	$d_x$	$\hat{a}_x$	$L_x$	$T_x$	$\hat{e}_x$
0-1	0.0137	10000	137	0.52	9934	136114	13.6
1-2	0.0061	9863	60	0.48	9832	126180	12.8
2-3	0.0047	9802	46	0.36	9773	116349	11.9
3-4	0.0061	9756	59	0.54	9729	106576	10.9
4-5	0.0095	9697	92	0.52	9653	96847	10.0
5-6	0.0112	9605	107	0.49	9550	87194	9.1
6-7	0.0117	9497	111	0.58	9450	77644	8.2
7-8	0.0161	9386	151	0.56	9319	68194	7.3
8-9	0.0365	9235	337	0.52	9072	58875	6.4
9-10	0.0384	8898	342	0.51	8731	49803	5.6
10-11	0.0583	8556	499	0.54	8325	41071	4.8
11-12	0.0767	8057	618	0.51	7755	32747	4.1
12-13	0.1270	7439	945	0.48	6947	24992	3.4
13-14	0.1568	6494	1018	0.44	5921	18044	2.8
14-15	0.2058	5476	1127	0.46	4870	12123	2.2
15-16	0.3238	4349	1408	0.46	3588	7253	1.7
16-17	0.5316	2941	1563	0.38	1966	3666	1.2
17+	1.0000	1378	1378	-	1700	1700	1.2

Table 9

Current life table of insured dogs in Japan (large breeds)

Age interval in years	Probability of dying in interval (x,x+1)	Number living at age x	Number dying in interval (x,x+1)	Fraction of last year of life	Number of years lived in interval (x,x+1)	Total number of years lived beyond age x	Expectation of life at age x
$x \text{ to } x+1$	$\hat{q}_x$	$l_x$	$d_x$	$\hat{a}_x$	$L_x$	$T_x$	$\hat{e}_x$
0-1	0.0112	10000	112	0.70	9966	125332	12.5
1-2	0.0071	9888	70	0.38	9845	115366	11.7
2-3	0.0065	9818	64	0.47	9784	105522	10.7
3-4	0.0081	9754	79	0.39	9706	95737	9.8
4-5	0.0181	9675	176	0.38	9566	86031	8.9
5-6	0.0150	9500	143	0.49	9428	76465	8.0
6-7	0.0213	9357	200	0.50	9258	67037	7.2
7-8	0.0416	9157	381	0.52	8975	57780	6.3
8-9	0.0584	8777	513	0.52	8530	48805	5.6
9-10	0.0831	8264	686	0.50	7920	40275	4.9
10-11	0.1140	7577	864	0.51	7151	32355	4.3
11-12	0.1355	6713	910	0.51	6266	25204	3.8
12-13	0.1665	5803	966	0.51	5328	18938	3.3
13-14	0.2852	4837	1380	0.49	4134	13610	2.8
14-15	0.3296	3458	1140	0.49	2875	9476	2.7
15-16	0.3279	2318	760	0.49	1928	6601	2.8
16+	1.0000	1558	1558	-	4673	4673	3.0

Table 10

Current life table of insured dogs in Japan (giant breeds)

Age interval in years	Probability of dying in interval (x,x+1)	Number living at age x	Number dying in interval (x,x+1)	Fraction of last year of life	Number of years lived in interval (x,x+1)	Total number of years lived beyond age x	Expectation of life at age x
$x \text{ to } x+1$	$\hat{q}_x$	$l_x$	$d_x$	$\hat{d}_x$	$L_x$	$T_x$	$\hat{e}_x$
0-1	0.0233	10000	233	0.46	9875	105697	10.6
1-2	0.0151	9767	148	0.34	9669	95822	9.8
2-3	0.0130	9620	125	0.48	9554	86153	9.0
3-4	0.0142	9494	135	0.49	9426	76599	8.1
4-5	0.0476	9359	446	0.36	9074	67173	7.2
5-6	0.0666	8914	594	0.56	8655	58099	6.5
6-7	0.1106	8320	920	0.50	7856	49444	5.9
7-8	0.0800	7400	592	0.51	7108	41587	5.6
8-9	0.1204	6808	820	0.49	6394	34479	5.1
9-10	0.1724	5989	1033	0.48	5453	28085	4.7
10-11	0.2470	4956	1224	0.39	4205	22632	4.6
11-12	0.1794	3732	669	0.51	3404	18427	4.9
12-13	0.3419	3063	1047	0.30	2326	15023	4.9
13+	1.0000	2015	2015	-	12698	12698	6.3



Table 11

Number of dogs by sexes and ages subjected comparison between sexes and ages in Chapter II

Age	Male	Female	Total
0	30,910	28,206	59,116
1	24,591	22,121	46,712
2	14,865	13,835	28,700
3	17,727	16,337	34,064
4	16,477	14,665	31,142
5	14,877	13,201	28,078
6	13,231	11,126	24,357
7	9,531	7,717	17,248
8	5,689	4,905	10,594
9	3,756	3,295	7,051
10	2,715	2,513	5,228
11	1,691	1,672	3,363
12+	1,998	1,904	3,902
Total	158,058	141,497	299,555

Table 12

Number of dogs of the seventeen major breeds in the insured dog population subjected to comparison between breeds in Chapter II.

Breed	Number of dogs
Miniature Dachshund	50,323
Chihuahua	46,414
Toy Poodle	45,382
Shiba	14,647
Yorkshire Terrier	10,622
Pomeranian	9,365
Pembroke Welsh Corgi	9,031
Papillon	8,965
Shih Tzu	8,239
Miniature Schnauzer	8,123
French Bulldog	6,804
Labrador Retriever	6,422
Cavalier King Charles Spaniel	5,743
Golden Retriever	5,377
Maltese	5,056
Pug	4,245
Crossbred*	15,416
Others**	39,381
Total	299,555

\*Crossbreds are dogs mixes breeds between two or more purebreds and mongrel.

\*\*Others include pure breeds other than the 16 pure breeds and crossbreds.

Table 13

Annual prevalence by diagnostic categories and sexes for insured dogs in Japan

Diagnostic categories	Male		Female		P-value*	Total	
	Annual prevalence (95%CI) (%)		Annual prevalence (95%CI) (%)			Annual prevalence (95%CI) (%)	
Cardiovascular	2.2	(2.2 - 2.3)	1.9	(1.8 - 2.0)	<0.0001	2.1	(2.0 - 2.1)
Respiratory	2.9	(2.8 - 2.9)	2.7	(2.6 - 2.7)	0.0006	2.8	(2.7 - 2.8)
Digestive	16.4	(16.2 - 16.6)	15.7	(15.5 - 15.9)	<0.0001	16.1	(15.9 - 16.2)
Hepatobiliary and pancreatic	2.8	(2.7 - 2.9)	2.9	(2.8 - 3.0)	0.1428	2.8	(2.8 - 2.9)
Urinary	3.9	(3.8 - 4.0)	5.8	(5.7 - 5.9)	<0.0001	4.9	(4.8 - 4.9)
Reproductive	1.2	(1.1 - 1.2)	2.3	(2.2 - 2.3)	<0.0001	1.7	(1.7 - 1.8)
Neuromuscular	2.5	(2.4 - 2.6)	2.0	(2.0 - 2.1)	<0.0001	2.3	(2.2 - 2.3)
Ophthalmology	9.5	(9.3 - 9.6)	9.2	(9.0 - 9.3)	0.0031	9.3	(9.2 - 9.4)
Otic	17.2	(17.0 - 17.4)	16.4	(16.2 - 16.6)	<0.0001	16.8	(16.7 - 16.9)
Dentistry	2.7	(2.7 - 2.8)	2.9	(2.8 - 3.0)	0.0199	2.8	(2.7 - 2.9)
Musculoskeletal	8.2	(8.1 - 8.4)	7.8	(7.6 - 7.9)	<0.0001	8.0	(7.9 - 8.1)
Dermatology	23.3	(23.1 - 23.5)	22.6	(22.4 - 22.9)	<0.0001	22.9	(22.8 - 23.1)
Hematology and immunology	0.4	(0.4 - 0.4)	0.5	(0.5 - 0.6)	<0.0001	0.5	(0.4 - 0.5)
Endocrine	1.0	(0.9 - 1.0)	1.1	(1.0 - 1.1)	0.0236	1.0	(1.0 - 1.1)
Infectious diseases	0.9	(0.9 - 1.0)	0.9	(0.9 - 1.0)	0.8032	0.9	(0.9 - 1.0)
Parasitosis	1.5	(1.4 - 1.5)	1.4	(1.3 - 1.4)	0.0237	1.4	(1.4 - 1.5)
Injury	4.9	(4.8 - 5.0)	4.5	(4.4 - 4.7)	<0.0001	4.7	(4.6 - 4.8)
Neoplasia	3.8	(3.7 - 3.9)	4.7	(4.6 - 4.9)	<0.0001	4.3	(4.2 - 4.3)

\*The P-value was calculated to compare the differences between genders by using Pearson's chi-squared method

Table 14

Breeds with the highest annual prevalence for ten major diagnostic categories

Diagnostic categories	Breeds*	Annual prevalence** (95%CI) %
Dermatology	French Bulldog	53.8 (52.7 - 55.0)
	Pug	44.4 (42.9 - 45.9)
	Shih Tzu	36.8 (35.8 - 37.8)
	Golden Retriever	35.5 (34.2 - 36.7)
	Shiba	29.0 (28.3 - 29.8)
Otic	Pug	34.5 (33.1 - 35.9)
	Golden Retriever	33.7 (32.5 - 35.0)
	French Bulldog	31.3 (30.2 - 32.4)
	Labrador Retriever	27.1 (26.0 - 28.1)
	Shih Tzu	26.3 (25.4 - 27.3)
Digestive	French Bulldog	22.0 (21.0 - 23.0)
	Cavalier King Charles Spaniel	21.0 (19.9 - 22.0)
	Yorkshire Terrier	19.4 (18.7 - 20.2)
	Golden Retriever	18.6 (17.8 - 19.4)
	Pembroke Welsh Corgi	17.9 (16.8 - 18.9)
Ophthalmology	Shih Tzu	24.7 (23.8 - 25.6)
	Pug	21.4 (20.1 - 22.6)
	Cavalier King Charles Spaniel	18.5 (17.5 - 19.5)
	French Bulldog	15.5 (14.7 - 16.4)
	Maltese	13.5 (12.5 - 14.4)
Musculoskeletal	Pomeranian	11.8 (11.0 - 12.6)
	French Bulldog	10.8 (10.1 - 11.4)
	Papillon	10.0 (9.4 - 10.6)
	Cavalier King Charles Spaniel	10.0 (9.2 - 10.8)
	Yorkshire Terrier	8.4 (7.8 - 8.9)
Neoplasia	Golden Retriever	9.2 (8.4 - 9.9)
	French Bulldog	7.5 (6.7 - 8.3)
	Labrador Retriever	7.4 (6.7 - 8.0)
	Pug	7.4 (6.8 - 7.9)
	Miniature Schnauzer	5.8 (5.3 - 6.4)
urinary	Pug	10.4 (9.5 - 11.3)
	Miniature Schnauzer	8.9 (8.3 - 9.5)
	French Bulldog	7.7 (7.1 - 8.3)
	Pembroke Welsh Corgi	7.3 (6.7 - 7.8)
	Shih Tzu	6.9 (6.4 - 7.5)
Injury	French Bulldog	7.2 (6.5 - 7.8)
	Labrador Retriever	6.9 (6.3 - 7.5)
	Golden Retriever	6.5 (5.8 - 7.2)
	Pembroke Welsh Corgi	6.2 (5.7 - 6.7)
	Cavalier King Charles Spaniel	5.2 (4.6 - 5.8)
Dental	Poodle, Toy	4.3 (4.1 - 4.5)
	Yorkshire Terrier	4.2 (3.8 - 4.6)
	Papillon	3.4 (3.0 - 3.8)
	Maltese	3.4 (2.9 - 3.9)
	Dachshund, Miniature	3.2 (3.1 - 3.4)
Hepatobiliary and pancreatic	Maltese	4.5 (4.0 - 5.1)
	Miniature Schnauzer	4.4 (3.9 - 4.8)
	Papillon	4.1 (3.7 - 4.5)
	Yorkshire Terrier	3.8 (3.5 - 4.2)
	Pomeranian	3.8 (3.4 - 4.2)
Cardiovascular	Cavalier King Charles Spaniel	10.9 (10.1 - 11.8)
	Maltese	4.9 (4.3 - 5.5)
	Chihuahua	4.1 (3.9 - 4.3)
	Pomeranian	3.9 (3.5 - 4.3)
	Shih Tzu	3.1 (2.8 - 3.5)
Neuromuscular	French Bulldog	4.7 (4.2 - 5.2)
	Pug	3.4 (2.8 - 3.9)
	Chihuahua	3.1 (2.9 - 3.2)
	Cavalier King Charles Spaniel	2.9 (2.5 - 3.3)
	Yorkshire Terrier	2.8 (2.5 - 3.1)

\* 17 major breeds whose sample size (n) &gt;4000 are subjected to the comparison between breeds.

\*\*The annual prevalences were standardized using a population of all breeds combined as standard population.

Table 15

Number of cat-years at risk (CYAR) by sex, age and breed in the insured cat population in Chapter III

Age		0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12+	Total
Sex	Male	18,549	12,466	9,841	8,121	7,200	6,800	5,914	5,091	4,259	3,497	2,919	1,999	2,973	89,629
	Female	16,067	10,514	8,199	6,855	5,916	5,574	4,916	4,230	3,657	3,067	2,657	1,879	2,915	76,446
Breed	Crossbreed*	4,911	5,260	5,195	4,979	4,951	5,167	5,025	4,825	4,571	4,206	3,884	2,785	4,394	60,153
	Scottish Fold	7,227	4,251	2,990	2,272	1,795	1,540	1,164	855	581	358	210	125	118	23,033
	American Shorthair	5,493	3,309	2,543	2,024	1,728	1,600	1,342	1,073	834	616	491	312	491	21,309
	Russian Blue	2,481	1,595	1,285	1,111	943	860	733	571	437	311	201	110	100	10,738
	Persian	1,657	1,057	857	792	765	749	649	549	433	345	276	207	329	7,761
	Abyssinian	1,155	863	729	655	597	556	466	402	305	216	144	92	110	6,290
	Maine Coon	1,566	1,017	762	648	524	412	347	253	175	118	87	60	65	6,034
	Norwegian Forest Cat	1,784	1,032	674	455	331	304	228	176	141	94	48	32	48	5,347
	Ragdoll	1,441	851	624	454	338	263	177	121	76	47	30	18	18	4,458
	Munchkin	2,094	979	485	233	120	84	50	33	17	9	4	2	0	4,055
	Somali	1,172	693	511	362	247	189	130	76	50	32	24	15	22	3,523
	American curl	637	395	292	203	154	133	104	73	60	32	21	10	9	2,123
	Bengal	613	357	263	189	154	123	88	51	37	16	17	9	9	1,926
	British Shorthair	714	329	178	104	65	50	33	19	12	10	5	2	0	1,521
	Singapura	398	227	140	89	73	59	43	33	22	19	15	5	8	1,131
	Himalayan	140	95	86	96	91	79	74	69	60	59	42	41	75	1,007
	Others**	1,133	670	426	310	240	206	177	142	105	76	77	53	92	5,666
Total		34,616	22,980	18,040	14,976	13,116	12,374	10,830	9,321	7,916	6,564	5,576	3,878	5,888	166,075

\*Crossbreeds are cat mixes breeds between two or more purebreds and mongrel. \*\*Others include pure breeds other than the 15 pure breeds and Crossbreed.

Table 16

Annual incidence rates (IR) per 10,000 CYAR by diagnostic category, sex and breed for insured cats in Japan in Chapter III

Diagnostic categories	Male		Female		Pure breed		Crossbreed		Total	
	Annual IR (95%CI)		Annual IR (95%CI)		Annual IR (95%CI)		Annual IR (95%CI)		Annual IR (95%CI)	
Cardiovascular	203	(193 - 212)	141	(133 - 149)	224	(217 - 231)	114	(109 - 119)	174	(168 - 180)
Respiratory	416	(403 - 429)	355	(342 - 368)	379	(370 - 388)	404	(394 - 413)	388	(379 - 398)
Digestive	1,239	(1217 - 1261)	1,093	(1071 - 1115)	1,161	(1145 - 1176)	1,203	(1187 - 1218)	1,172	(1156 - 1187)
Hepatobiliary and pancreatic	205	(196 - 215)	175	(165 - 184)	162	(156 - 168)	256	(248 - 264)	191	(185 - 198)
Urinary	1,220	(1198 - 1241)	939	(919 - 960)	1,114	(1099 - 1130)	1,121	(1106 - 1136)	1,091	(1076 - 1106)
Reproductive	9	(7 - 11)	61	(55 - 66)	39	(36 - 42)	25	(23 - 28)	33	(30 - 36)
Neuromuscular	61	(56 - 66)	51	(46 - 56)	57	(53 - 60)	59	(55 - 63)	56	(53 - 60)
Ophthalmology	684	(668 - 701)	715	(696 - 733)	694	(681 - 706)	735	(722 - 747)	698	(686 - 711)
Otic	494	(480 - 508)	456	(441 - 471)	553	(542 - 564)	313	(304 - 321)	476	(466 - 487)
Dentistry	257	(246 - 267)	194	(184 - 204)	155	(149 - 161)	330	(321 - 338)	228	(221 - 235)
Musculoskeletal	154	(146 - 162)	156	(148 - 165)	170	(164 - 177)	116	(110 - 121)	155	(149 - 161)
Dermatology	820	(802 - 838)	859	(839 - 879)	813	(800 - 827)	886	(872 - 900)	838	(825 - 851)
Hematology and immunology	54	(49 - 59)	48	(43 - 52)	51	(48 - 55)	54	(51 - 58)	51	(48 - 55)
Endocrine	98	(92 - 105)	80	(73 - 86)	86	(82 - 91)	94	(89 - 99)	90	(85 - 94)
Infectious diseases	202	(193 - 211)	181	(172 - 190)	181	(175 - 188)	190	(183 - 196)	192	(186 - 199)
Parasitosis	148	(140 - 156)	146	(137 - 154)	134	(128 - 139)	172	(166 - 178)	147	(141 - 153)
Injury	365	(353 - 377)	291	(280 - 303)	280	(272 - 288)	442	(433 - 452)	331	(323 - 340)
Neoplasia	156	(148 - 164)	160	(151 - 169)	156	(150 - 161)	177	(171 - 184)	158	(152 - 164)

Table 17

Summary statistics for the insured dog population used in the analysis in Chapter IV

	Number of dogs in the population	%	Number of dogs that had at least one claim for cardiovascular disorders (annual prevalence in %)	
Total	299,555	100.0	6,211	(2.1)
Sex				
Male	158,058	52.8	3,535	(2.2)
Female	141,497	47.2	2,676	(1.9)
Breed				
Miniature Dachshund	50,323	16.8	682	(1.4)
Chihuahua	46,414	15.4	1,066	(2.3)
Toy Poodle	45,382	15.1	366	(0.8)
Shiba	14,647	4.9	118	(0.8)
Yorkshire Terrier	10,622	3.6	286	(2.7)
Pomeranian	9,365	3.1	298	(3.2)
Pembroke Welsh Corgi	9,031	3.0	80	(0.9)
Papillon	8,965	3.09	170	(1.9)
Shih Tzu	8,239	2.8	569	(6.9)
Miniature Schnauzer	8,123	2.7	187	(2.3)
French Bulldog	6,804	2.3	52	(0.8)
Labrador Retriever	6,422	2.1	123	(1.9)
Cavalier King Charles Spaniel	5,743	1.9	779	(13.6)
Golden Retriever	5,377	1.8	143	(2.7)
Maltese	5,056	1.7	296	(5.9)
Pug	4,245	1.4	48	(1.1)
Jack Russell Terrier	3,840	1.3	34	(0.9)
Beagle	3,379	1.1	93	(2.8)
Miniature Pinscher	3,152	1.1	34	(1.1)
Others	44,426	14.8	787	(1.8)
Age				
0	59,116	19.7	256	(0.4)
1	46,712	15.6	173	(0.4)
2	28,700	9.6	130	(0.5)
3	34,064	11.4	217	(0.6)
4	31,142	10.4	299	(1.0)
5	28,078	9.4	418	(1.5)
6	24,357	8.1	598	(2.5)
7	17,248	5.8	702	(4.1)
8	10,594	3.5	666	(6.3)
9	7,051	2.4	634	(9.0)
10	5,228	1.7	609	(11.6)
11	3,363	1.1	562	(16.7)
12+	3,902	1.3	947	(24.3)

Table 18

Effect of age, sex and breed on the prevalence of cardiovascular disorders

Variable	Coefficient	Odds ratio	(95% CI)	P value
Constant	-6.89	-		< 0.0001
Age	0.407716231	1.50	(1.49, 1.52 )	< 0.0001
Sex				
Female (reference)	0.00	1.00		
Male	0.17	1.19	(1.13, 1.25 )	< 0.0001
<i>Breed</i>				
Min. Dachshund (reference)	0.00	1.00		
Chihuahua	1.34	3.81	(3.44, 4.21 )	< 0.0001
Poodle, Toy	0.51	1.66	(1.46, 1.90 )	< 0.0001
Shiba	-0.21	0.81	(0.67, 0.99 )	0.0438
Yorkshire Terrier	0.82	2.27	(1.96, 2.63 )	< 0.0001
Pomeranian	1.39	4.02	(3.47, 4.65 )	< 0.0001
Pembroke Welsh Corgi	-0.65	0.52	(0.41, 0.66 )	< 0.0001
Papillon	0.42	1.52	(1.27, 1.81 )	< 0.0001
Shih Tzu	1.22	3.38	(2.99, 3.82 )	< 0.0001
Miniature Schnauzer	0.81	2.24	(1.89, 2.66 )	< 0.0001
French Bulldog	0.30	1.34	(1.01, 1.79 )	0.0435
Labrador Retriever	-0.31	0.74	(0.60, 0.90 )	0.0026
Cavalier King Charles	2.78	16.2	(14.4, 18.2)	< 0.0001
Spaniel				
Golden Retriever	0.26	1.30	(1.07, 1.57 )	0.0069
Maltese	1.70	5.48	(4.71, 6.38 )	< 0.0001
Pug	0.14	1.15	(0.85, 1.56 )	0.3582
Jack Russell Terrier	0.23	1.25	(0.88, 1.78 )	0.2073
Beagle	0.35	1.43	(1.13, 1.79 )	0.0025
Miniature Pinscher	0.40	1.49	(1.04, 2.13 )	0.0279
Others	0.40	1.49	(1.34, 1.65 )	< 0.0001



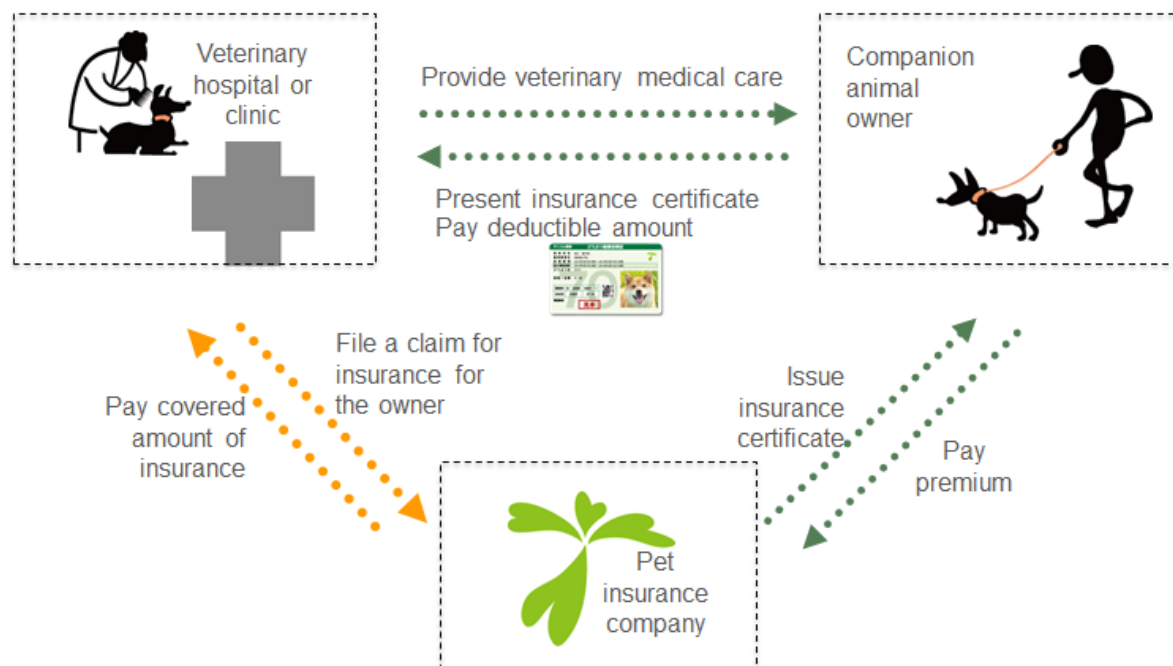


Figure 1

Insurance system by Anicom, set up in the same way as the health insurance system for people. The pet owner presents insurance certificate at the veterinary hospital/clinic, and only pays the deductible amount for the veterinary care services provided. The veterinary hospital/clinic confirms the insurance coverage and the identity of the covered animal, decides whether or not the required care is covered by the insurance plan, calculates the amount covered by the insurance, collects the deductible from the pet owner, and files a claim for the covered amount as part of its monthly dealings with the pet insurance company.

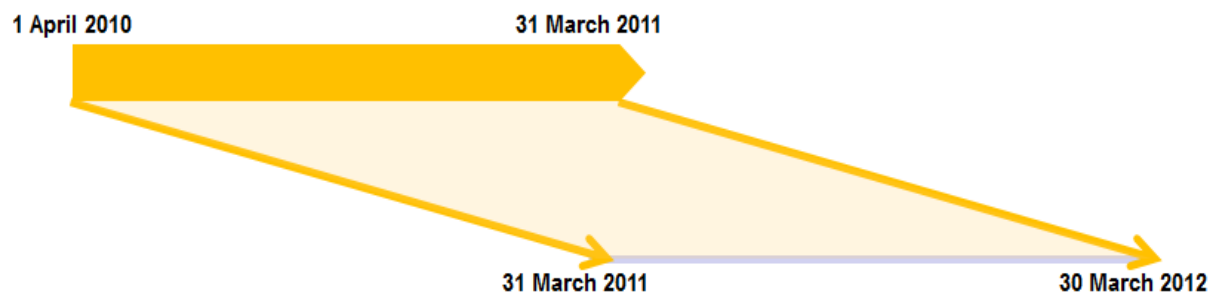


Figure 2

Each of the 299,555 dogs that entered an insurance program or renewed the insurance policy any time during fiscal year 2010 was observed for one year from the entrance into the insurance program or renewal of it.

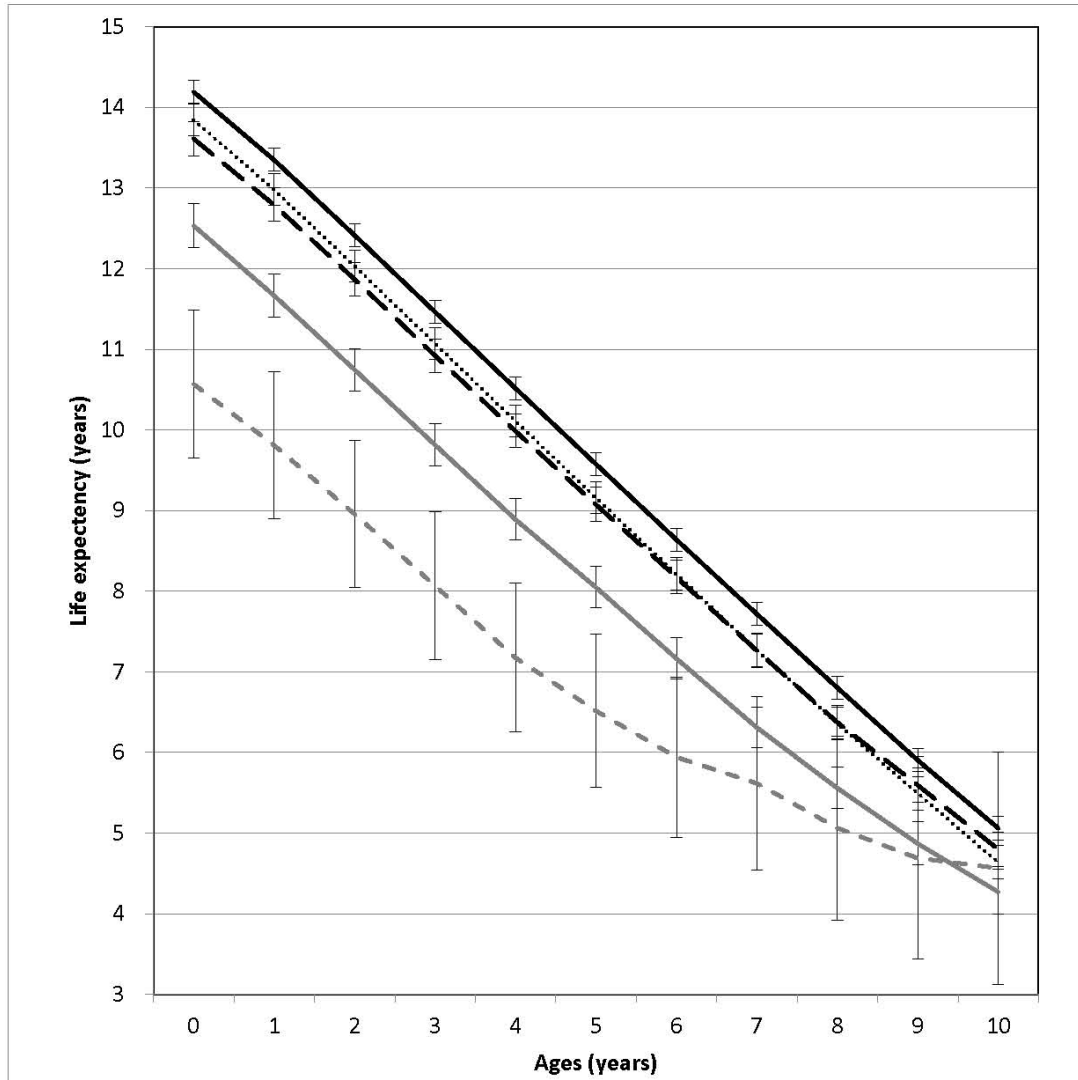


Figure 3

Life expectancy up to 10 years of age of toy, small, medium, large and giant breeds of insured dogs in Japan. Dotted, solid, dashed, gray and gray dashed lines indicate toy, small, medium, large and giant breed groups respectively. The error bars indicate 95% confidence intervals.

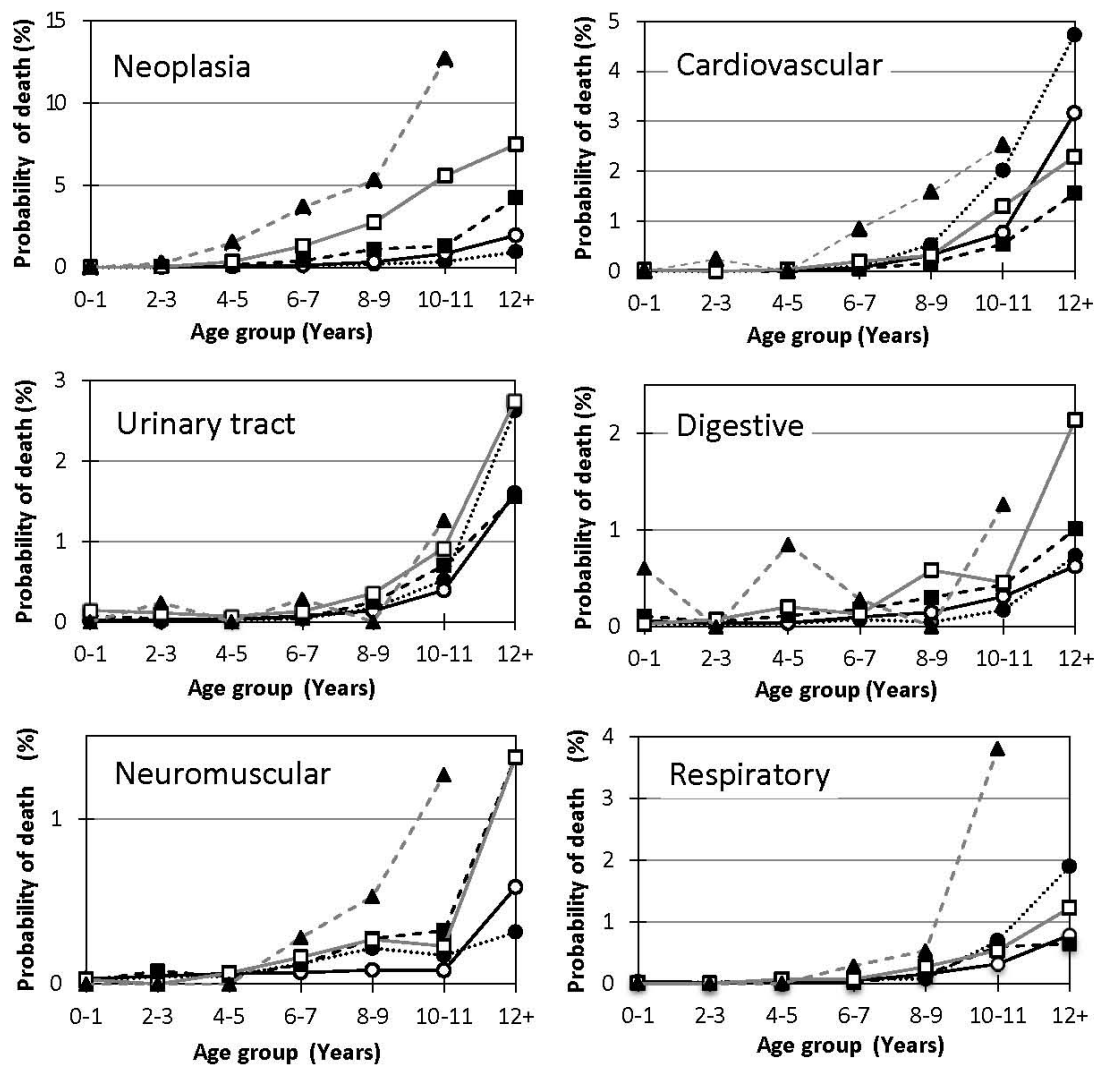


Figure 4

Probability of death of insured dogs in Japan at difference ages by six major causes. Closed circle with dotted line, open circle with solid line, closed square with dashed line, open square with gray line and closed triangle with gray dashed line indicate toy, small, medium, large and giant breed groups respectively.

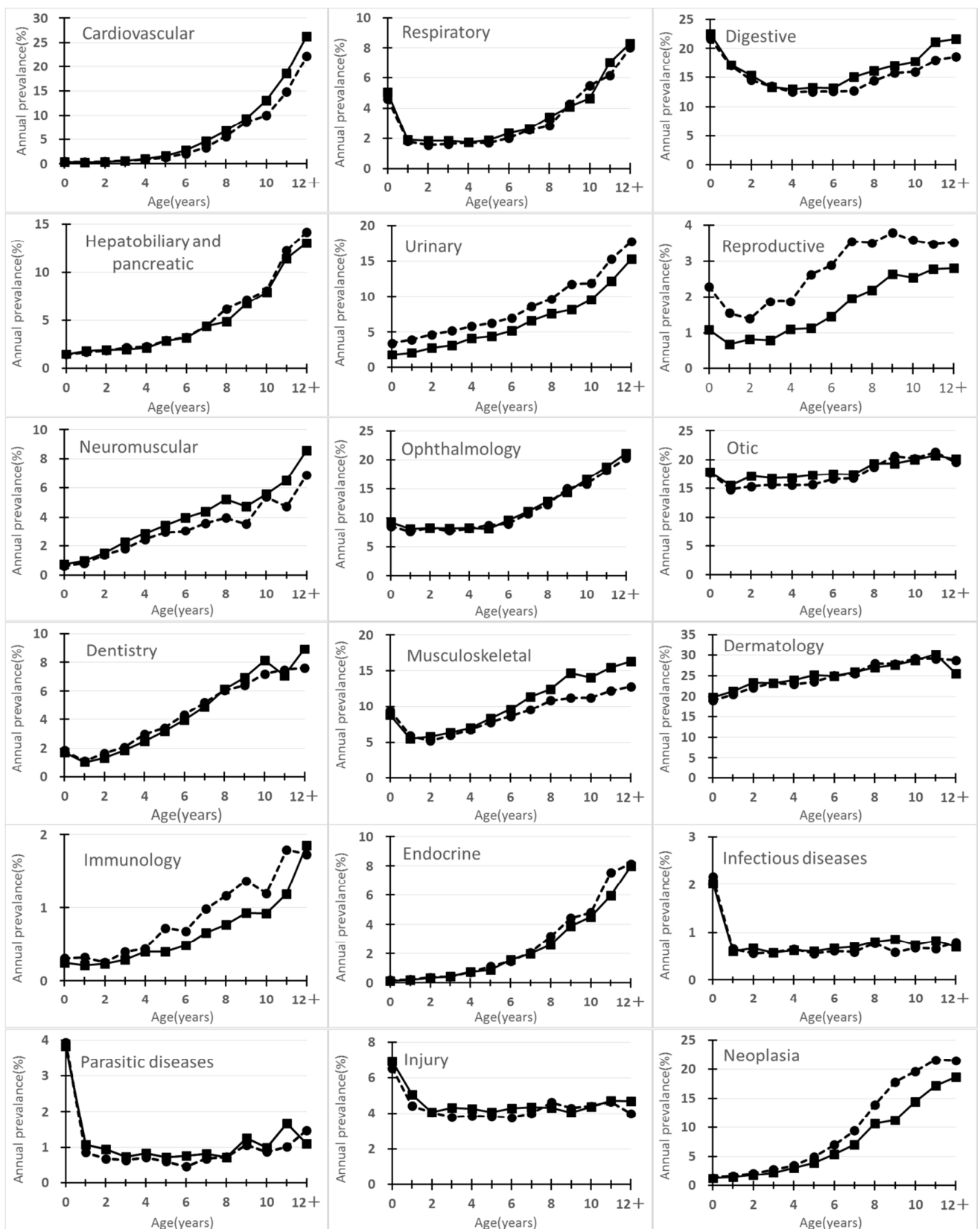


Figure 5

Annual prevalence of insured dogs in Japan for 18 diagnostic categories, by sex and age. The solid lines with square makers and dashed lines with round markers indicate male and female respectively.

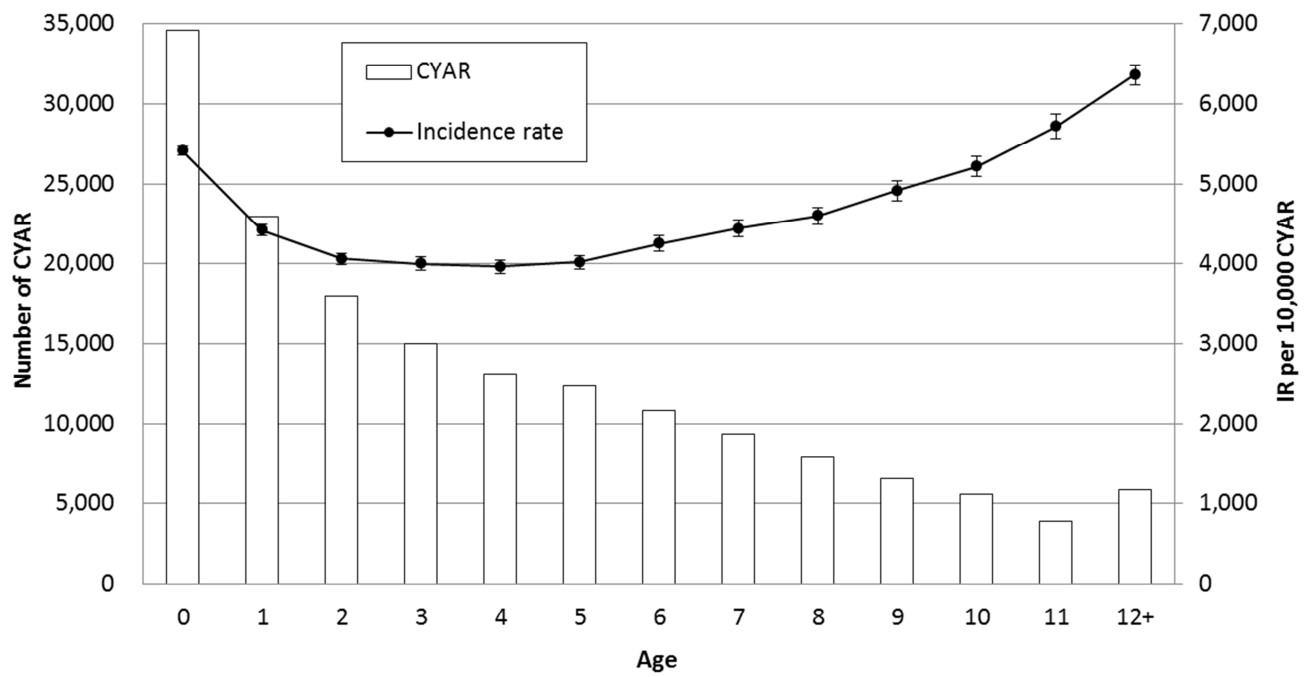


Figure 6  
Number of cat-years at risk (CYAR) and annual incidence rates (IR) by age

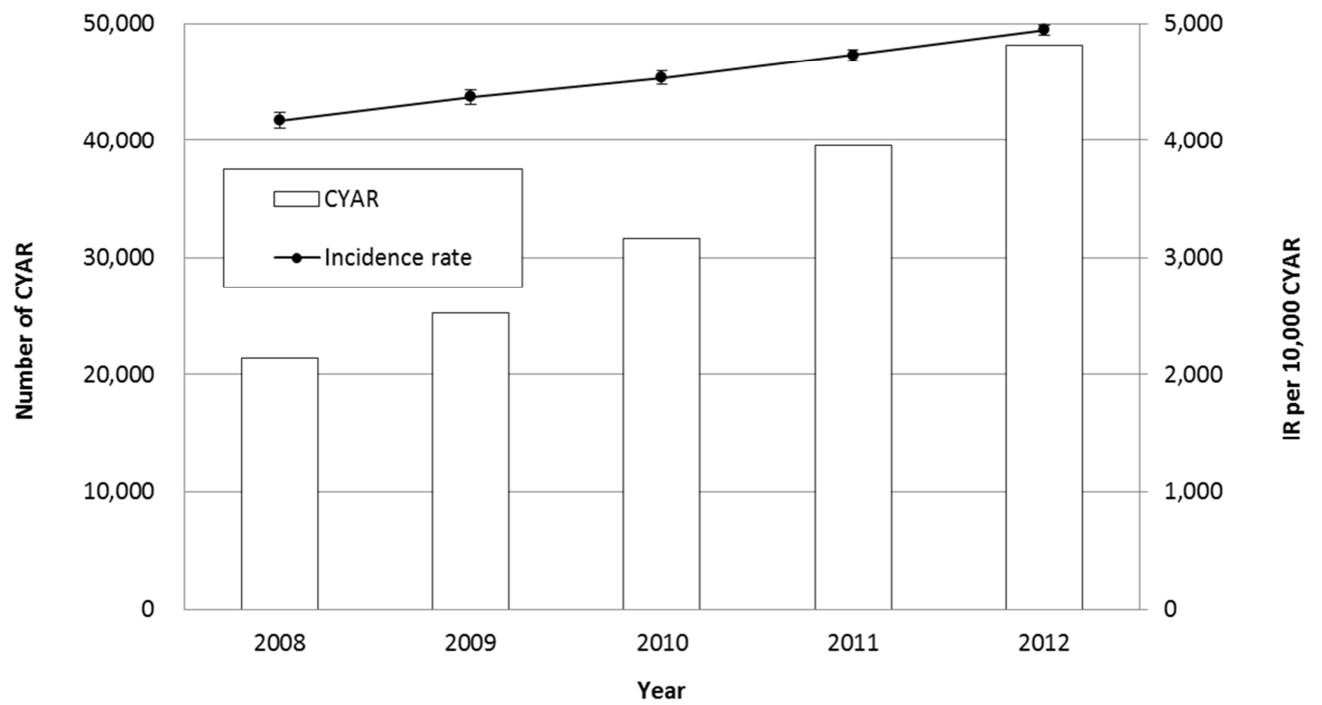


Figure 7  
Number of cat-years at risk (CYAR) and annual incidence rates (IR) by fiscal year

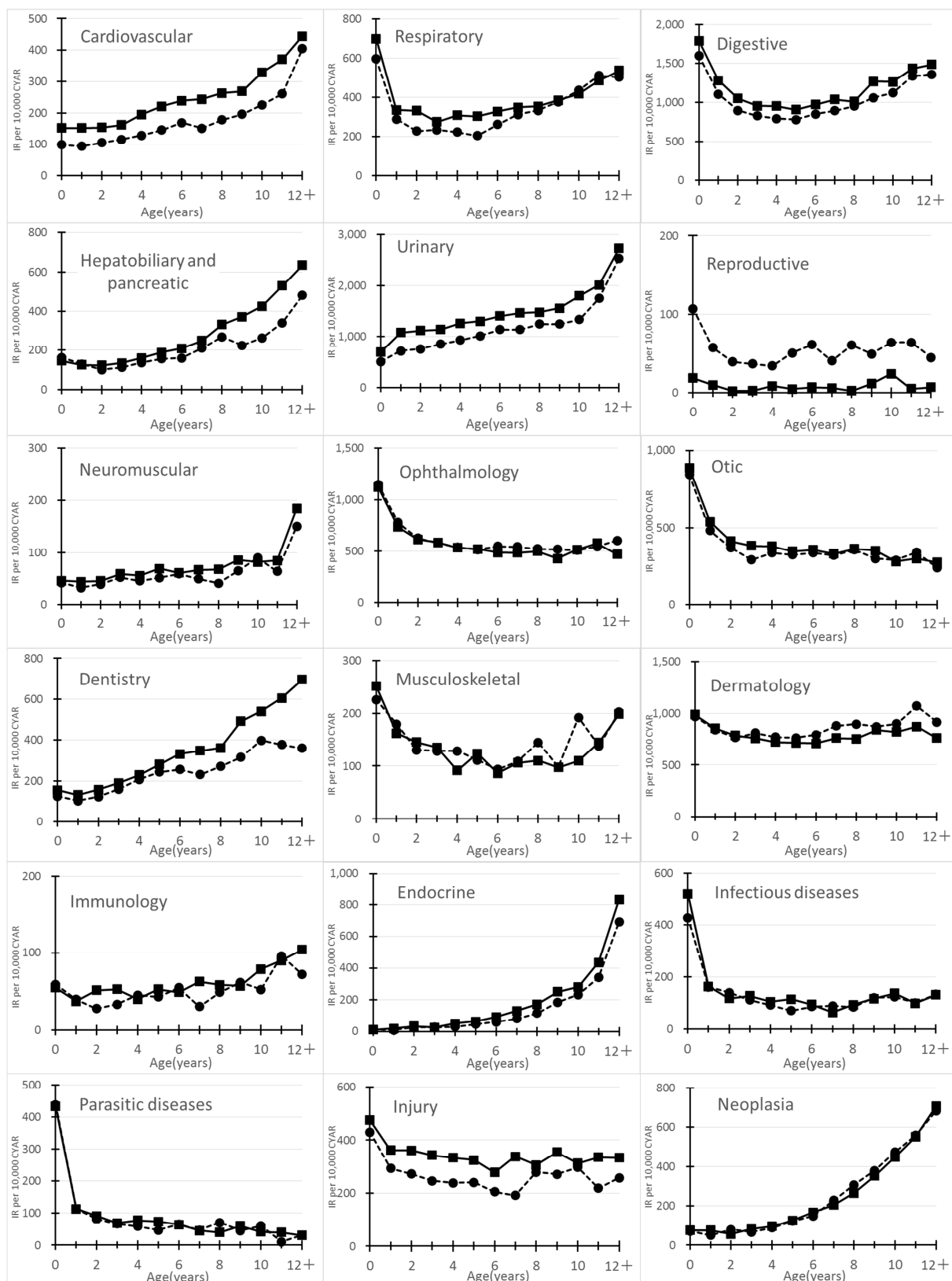


Figure 8

Annual incidence rates (IR) per 10,000 CYAR of insured cats in Japan for 18 diagnostic categories, by sex and age. The solid lines with square makers and dashed lines with round markers indicate male and female respectively.



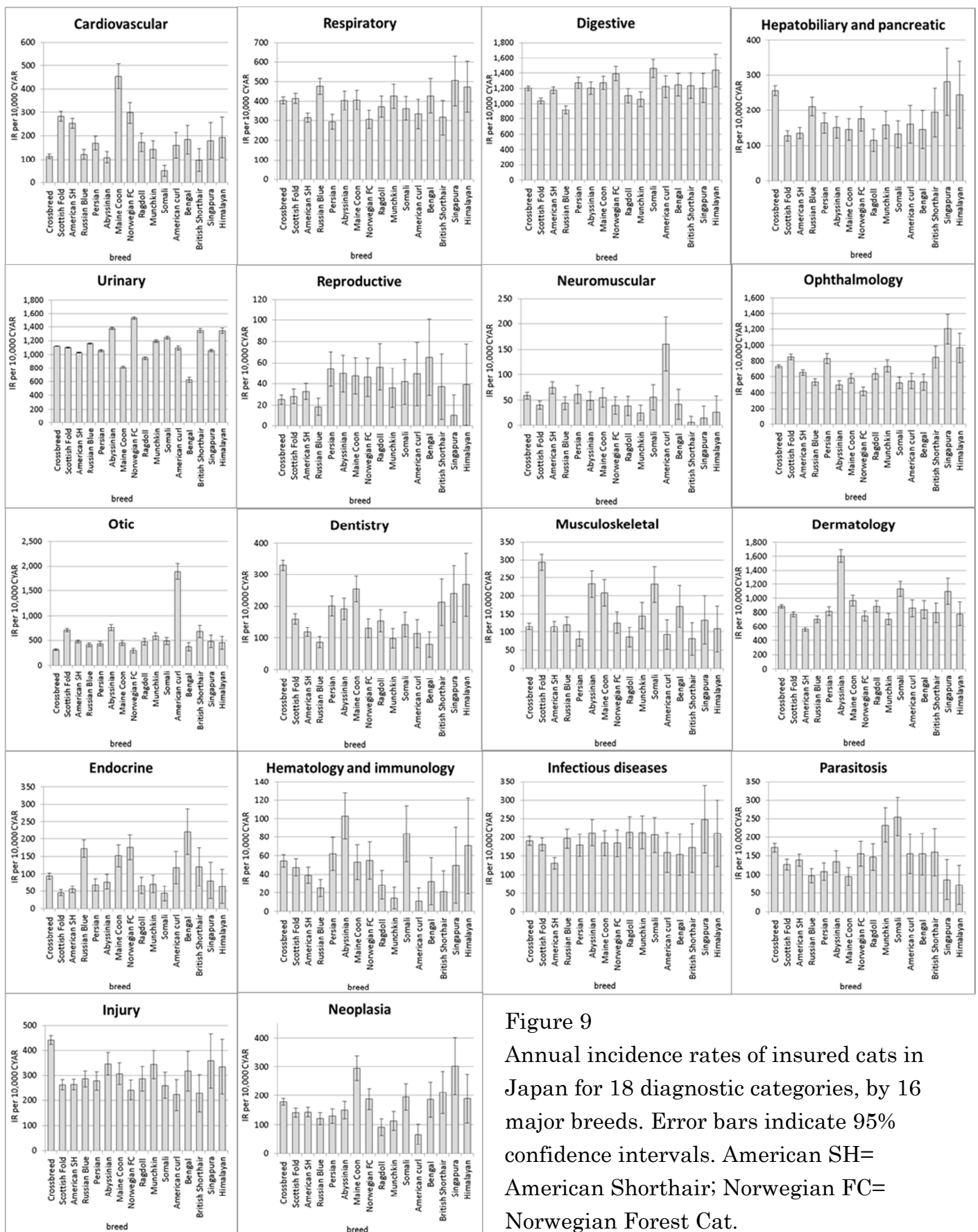


Figure 9  
Annual incidence rates of insured cats in Japan for 18 diagnostic categories, by 16 major breeds. Error bars indicate 95% confidence intervals. American SH= American Shorthair; Norwegian FC= Norwegian Forest Cat.

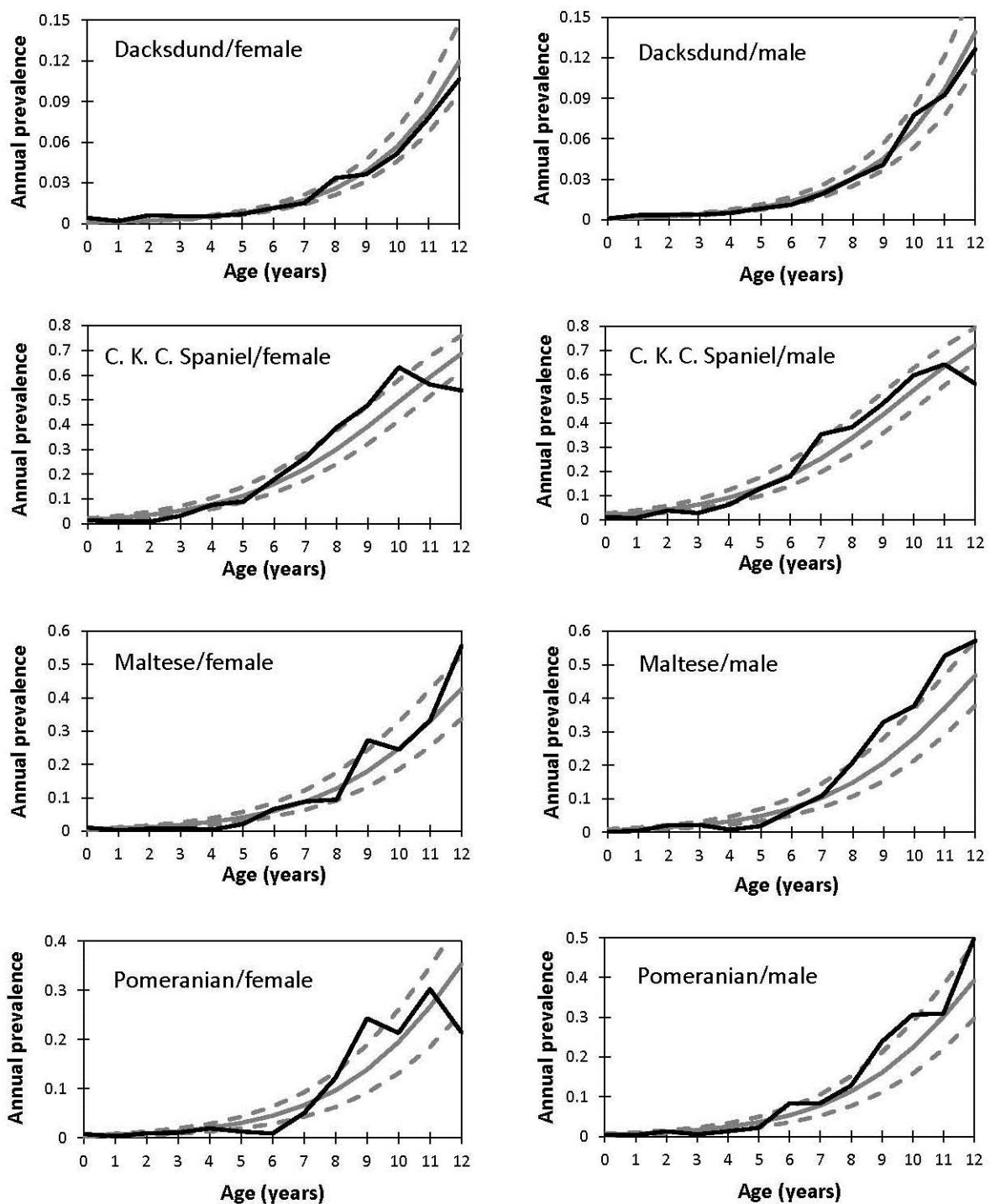


Figure 10

Predicted annual prevalence of cardiovascular disorder for different sexes of four breeds. Gray solid lines indicate the mean estimates, and gray dashed lines 95% confidence intervals. Solid lines indicate the annual prevalence actually observed.

## 論文の内容の要旨

論文題目 Epidemiological studies on diagnostic patterns and life expectancy of insured dogs and cats in Japan  
(保険金支払いデータを活用した家庭飼育犬および猫の寿命並びに疾患に関する記述疫学的研究)

氏 名 井上 舞

近年、犬や猫は家族の一員として飼育され社会的地位が向上した。犬猫に与えられる食物も変化し、その結果、犬猫の健康状態は改善され、寿命が延びている。また、各家庭で生活する犬猫の割合の増加に伴い、犬猫の疾患パターンも変化してきた。かつては、事故や感染症が主な死因であったが、室内飼育による交通事故の減少や、犬糸状虫症の予防薬の普及により、これらの事故や疾患で死亡する犬は激減した。さらに、飼主との密着した生活は、皮膚病や消化器症状などの早期発見を通じ、生存率の向上に貢献している。一方で寿命が延びたことに伴い腫瘍や循環器病といった老齢性の疾患が頻繁に認められるようになった。特に、犬については、様々な用途や体形を求め独特の品種が作出されたため品種別の遺伝性疾患・形態学的疾患が多くみられる。

診療獣医師にとって、年齢別、性別、品種別の発生頻度を知ることが、検査前の事前確率を想定して臨床診断を進めることができるため正確な診断に有用である。飼主にとっても、あらかじめ注意すべき症状やケガなどの知識を得ておくことで疾患による影響の低減に備えることができる。ブリーダーにとっても疾患頻度を知ることによって繁殖計画を戦略的に考えることが可能となる。

ペットの医療費を対象とする医療保険については 1924 年に犬を対象とする保険がスウェーデンで誕生して以降、欧米を中心に普及している。我が国においては 2000 年よりペット保険が普及し始め、現在は約 5 % の犬や猫が加入していると推定される。保険システムを通じ、保険会社には、加入時に生年月日、性別、品種、飼育地などの情報が登録され、保険事故となる疾患が発生した際に疾患名や診療日、医療費などの情報が提供される。また、死亡時には、死亡年月日などの情報が提供される。本研究では、日本の主要ペット保険会社であるアニコム損保に登録されたこれらの情報からデータベースを作成し、犬や猫の生存状況や疾患頻度を記述疫学的に明らかにすることを試みたものであり、以下の 4 章からなる。

### 第 1 章 保険金支払いデータを基にした犬の生命表の作成および死亡原因

2010 年に保険に加入または更新した犬 29,555 頭のデータをもとにカレント生命表を作成し、平均寿命を推定した。その結果、日本で飼育されている保険加入犬の平均寿命

は13.7歳であり、80年代の報告と比較して平均寿命が延びている傾向にあることが明らかとなった。また、犬のサイズ別にみると、トイ（標準体重5kg未満）13.8歳、小型（同5～10kg）14.2歳、中型（同10～20kg）13.6歳、大型（同20～40kg）12.5歳、ジャイアント（同40kg以上）10.6歳と、サイズが小さいほど寿命が長い傾向が認められたが、トイ犬種とスモール犬種については逆転していた。死亡原因の調査では上位より腫瘍疾患（死亡した犬の全体の14.9%）、循環器系疾患（9.1%）、泌尿器疾患（6.2%）であり、これらの疾患への対策が犬の寿命を延ばすうえで重要であることが示唆された。また、死亡原因は体重群別に頻度が異なる傾向が見られ、大型犬種では腫瘍疾患、小型犬種では循環器疾患が高頻度で観察された。

## 第2章 保険金支払いデータを基にした犬の疾患頻度

保険金の請求書に請求理由として記載する18の疾患群ごとに有病率を求めたところ、最も有病率が高い疾患は皮膚疾患で22.9%であった。続いて高い値を示したのは耳の疾患（16.8%）、消化器疾患（16.1%）であった。年齢別の比較では加齢とともに有病率が増加する疾患（腫瘍や循環器疾患）、年齢にかかわらず高い疾患（皮膚疾患、耳の疾患）、若齢と高齢の2峰性を示す疾患（呼吸器疾患や消化器疾患）、若齢のみで高値を示す疾患（感染症や外傷等）と、4つのパターンが見られた。品種別の比較では、交絡因子としての年齢の影響を排除するために母集団の年齢構成を標準集団として各年齢の契約頭数の標準化を行ったうえで品種間の有病率の比較を行った。その結果、皮膚疾患においてフレンチブルドッグが53.8%（95%信頼区間 52.7～55.0）と顕著に高い値を示した。

## 第3章 保険金支払いデータを基にした猫の疾患頻度

1年間の観察期間に少なくとも1回の保険金請求があったことをもって疾患の発生と定義し、年間発生率を計算したところ10,000頭年あたり4,632（95%信頼区間4,608-4,656）頭であった。疾患群別の調査では消化器疾患が最も高く、10,000頭年あたり1,172（95%信頼区間 1,156-1,187）頭であり、さらに泌尿器疾患（10,000頭年あたり1,091頭）、皮膚疾患（10,000頭あたり838頭）と続いた。性別には生殖器疾患が最も差が見られ、雌は雄の約6倍の発症率であった（10,000頭あたり雌61頭、雄9頭）。次に循環器疾患（雄は雌の1.4倍）、歯科疾患（雄は雌の1.3倍）であった。年齢別の調査では、2章での犬の有病率と同様の4つのパターンが見られたが、犬では加齢とともに増加した眼科疾患や全年齢で高い値を示した耳科疾患が幼齢で高い発症率を示し、これは感染症や寄生虫の影響があるものと考えられた。また、いくつかの疾患群では品種間での差が見られ、循環器疾患ではスコティッシュ・フォールド、アメリカン・ショートヘア、ペルシャ、メインクーン、ノルウェー・ジャズ・キャット、ラグドール、ベンガルが混血猫と比較して高い年間発症率を示した。

#### 第4章 保険金支払いデータを基にした犬の循環器疾患の罹患に及ぼす年齢、性別および品種の影響の定量化

第2章で最も犬種間での有病率のばらつきが大きかった循環器疾患について、罹患の有無を応答変数、年齢、性別および品種を独立変数としてロジスティック回帰分析を実施したところ、キャバリア・キング・チャールズスパニエルが基準犬種のミニチュアダックスフンドに比べ16.2と最も高いオッズ比を示した。このような多重解析を用いることで、年齢や性別の影響を定量化することができる。

以上の結果から、犬の寿命が推定されるとともに、犬および猫の年齢別、性別品種別の疾患頻度が明らかとなった。保険請求データを用いた疫学研究の結果については、いくつかのバイアスを考慮する必要がある。第一に年齢構成がある。ペット保険の加入経路としてペットショップが主であるために保険加入の犬や猫は幼齢個体が多い。次に、同様の理由から、品種構成が異なる。ペットフード協会のデータと比較すると、雑種に比べ純粋種の割合が大きい。また、都心部ほど保険加入が多いという地域性や、経済負担が軽減されるため医療へのアクセシビリティなどの違いを考慮する必要があり、日本の家庭飼育犬および猫全体への一般化にあたっては注意が必要である。また、保険請求理由と実際の診断名が合致しているかどうかといった精度検証も必要となる。しかしながら、保険データを用いた疫学研究はデータの規模と利用コスト、分析の持続性に優れており、年別変化、性別、品種間の頻度の違いを推定する上で非常に有用であることが示された。本研究の成果が診療獣医師、犬猫の飼い主、ブリーダーなどにより利用され、より正確な診断、疾患の発生予防、繁殖計画の改善などに役立てられることを望む。