Paper

Incidence of and mortality from kidney disease in over 600,000 insured Swedish dogs

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Kidney disease is an important cause of morbidity and mortality in dogs. Knowledge about the epidemiology of kidney disease in the dog population is valuable and large-scale epidemiological studies are needed. The aim of the present study was to use insurance data to estimate kidney-related morbidity and mortality in the Swedish dog population. Insurance company data from insured dogs during the years 1995–2006 were studied retrospectively. Incidence and mortality were calculated for the whole group of dogs as well as divided by sex and breed. The total number of veterinary care insured dogs was 665,245. The total incidence of kidney disease in this group of dogs was 15.8 (15.3–16.2) cases/10,000 dog-years at risk. The number of dogs in the life insurance was 548,346 and in this group the total kidney-related mortality was 9.7 (9.3–10.2) deaths/10,000 dog-years at risk. The three breeds with the highest incidence of kidney disease were the Bernese mountain dog, miniature schnauzer and boxer. The three breeds with the highest mortality caused by kidney disease were the Bernese mountain dog, Shetland sheepdog and flat-coated retriever. In conclusion, the epidemiological information provided in this study concerning kidney disease in dogs can provide valuable information for future research.

Introduction

Kidney disease (KD) is a major contributor to morbidity and mortality in dogs. Diseases affecting the kidneys can be acute or chronic, progressive or non-progressive. When kidney injury is extensive, clinical signs such as inappetence, weight loss, vomiting and polyuria/polydipsia might develop.

Prevalence of chronic kidney disease (CKD) in different dog populations has been reported to range widely between 0.37 and 7.8 per cent (Sosnar and others 2003, O'Neill and others 2013). Many estimations of prevalence of different diseases are based on hospital populations of dogs and may not reflect the situation in the general dog population. In these cases, the overall population at risk is not taken into account, but only the population of dogs examined at veterinary clinics or hospitals. If studies are conducted at referral institutions there is also a possibility that they overestimate or underestimate the prevalence and incidence of a particular disease, referred to as 'referral bias' (Bartlett and others 2010). Numbers in the range of 0.5–1.5 per cent are generally considered a realistic estimation of the prevalence of CKD in the general population(Brown 2007, Polzin 2009). Because diagnosis of early stages of CKD might be difficult, these numbers probably underestimate the true prevalence. Incidences are not known for either chronic or acute KD (Langston 2009). Estimates of the incidence of specific KDs in the dog population as a whole and in subpopulations, such as different breeds, may be useful for clinicians because they aid in diagnostic decision-making. In a dog belonging to a breed affected by familial KD, non-specific signs compatible with renal disease could justify early diagnostic investigation. Epidemiological information may also be useful when planning dog-breeding strategies. Recognition of a disease in a specific breed of dog is the starting point to reduce the incidence of the disease in question and to gain more knowledge about it. Subsequently, this knowledge can also provide insight into the prognosis for affected dogs.

However, in order to establish reliable estimates of disease frequency, large-scale epidemiological studies are needed. Such studies require knowledge of the population at risk, which is often unknown. No known large-scale epidemiological studies have been performed to investigate incidence and mortality due to KD in dogs.

In Sweden, a large proportion (approximately 77 per cent) of all dogs is insured and the largest animal insurance company (Agria) covers about 50 per cent of these dogs (SKC 2012, I. Ahlén Personal communication, 2013). This large percentage of insured dogs provides a unique opportunity for epidemiological research. In the database of AGRIA, claim records as well as information on when the dog entered and exited the insurance programme (dead or alive) can be obtained, which makes it possible to calculate incidences and mortalities for different diseases. Epidemiology of various dog diseases has previously been studied using this database (Haggstrom and others 1992, Nodtvedt and others 2006, Egenvall and others 2007, Fall and others 2007, Bergknut and others 2012, Jitpean and others 2012). However, KDs in this group of dogs have not previously been studied.

Knowledge of the patterns and distribution of KD in dog populations may be valuable in the clinical setting, for breeding purposes, and for planning future research concerning diseases

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affecting specific breeds of dogs. The aim of this study was to use data obtained from the AGRIA Pet insurance database to estimate morbidity and mortality related to KD in a Swedish population of insured dogs. A second aim was to evaluate if the occurrence of KD changed over time from 1995 to 2006 in the same population of dogs.

Material and methods

Study population

The study population comprised all dogs with veterinary care and/or life insurance at any time during the years 1995–2006 at AGRIA Pet Insurance, Sweden. There were two available types of insurance at AGRIA Pet Insurance during this time. Dogs were life insured up to the age of 10 years, and when they were euthanased (or died), owners were reimbursed. Dogs were insured for veterinary care up to the age of 12 years, and owners were reimbursed when the cost for veterinary care was higher than the deductible (approximately 150 Euros). The insurance database contains all disease claims regardless if they are reimbursed or not.

Data collection

The AGRIA database was analysed using the software package SAS V.9.3 (SAS Institute, Cary, North Carolina, USA). The following information was assembled for each dog: date of birth, date of death, sex, breed, type of insurance (veterinary care/life insurance), date on which the dog entered and left the insurance programme, date of claim and diagnostic code for every kidney-related claim. The diagnostic codes are a national standard system developed by the Swedish Association of Veterinary Clinics and Hospitals. Diagnostic codes are assigned to each case by the veterinarian responsible for the case management.

Aetiology groups

The diagnostic codes were divided into 10 aetiology groups (0—aetiology not determined, 1—congenital/developmental, 2—metabolic/nutritional/dystrophic, 3—circulatory, 4—infectious/inflammatory, 5—immune mediated, 6—neoplastic, 7—trauma/thermal, 8—toxic injury and 9—idiopathic/multifactorial).

Incidences and mortalities

The incidences and mortalities were calculated with exact denominators. Each animal contributed to the denominator with the exact time it was insured (dog years at risk, DYAR). Incidences and mortalities (per DYAR) were then multiplied by 10,000 to be interpreted as cases (or deaths, respectively) per 10,000 DYAR. The 95% CIs are presented in brackets.

Kidney-related veterinary care and mortality, all dogs

The total number of dogs with a claim for KD was divided by the number of DYAR in the veterinary care insurance, yielding the total incidence for KD during 1995–2006. Only the first claim for each dog was included because KD is often chronic, and even acute kidney injury may lead to development of chronically progressive disease. In this study no attempt was made to differentiate between acute kidney injury and CKD. The total number of dogs with reimbursed life insurance because of KD was then divided by the DYAR in the life insurance, yielding the total mortality for KD in this population of dogs during the 12-year period. The age of all dogs at the time of the first claim for KD was calculated, and so was the age of all dogs at the time of kidney-related death. The above calculations were also performed separately for females and males, respectively.

Aetiology groups of KD and case distributions over time

The total number of dogs with claims for veterinary care corresponding to the different aetiology groups was also counted, in order to provide an overview of the most common reasons for KD in this population of dogs. The total number of dogs with reimbursed life insurance for each aetiology group was also counted in order to provide an overview of the most common reasons for kidney-related mortality. Yearly incidences for kidney-related diagnoses were calculated by dividing reimbursements of veterinary care with DYAR for every year.

Breed-specific calculations

Calculations yielding incidences and mortalities were performed within all breeds contributing with more than 10,000 DYAR to the database. For all breeds described above, age at first kidney diagnosis and age at kidney-related death was calculated. In addition, the incidence and the mortality for both sexes of every breed were determined. Among the breeds described above, the 15 breeds with the highest incidences of KD were identified. For each of these 15 breeds, the number of kidney-related diagnoses corresponding to the different aetiology groups was counted. Similarly, the 15 breeds with the highest kidney related mortalities were identified and the number of deaths corresponding to the different aetiology groups was counted.

Results

Kidney-related veterinary care, all dogs

The total number of dogs with veterinary care insurance in AGRIA during the years 1995–2006 was 665,245. These dogs together contributed 2,792,325 DYAR to the database. Of these dogs, 4390 had a veterinary care claim of KD during their life. This corresponds to a total incidence of 15.8 (15.3–16.2) cases/10,000 DYAR. The incidences for female and male dogs were 15.9 (15.3–16.6) and 15.6 (14.9–16.2)cases/10,000 DYAR, respectively. The mean age of all dogs when they had their first registered episode of KD was 6.9±3.3 years. The mean age for females was 6.6±3.4 years and for males 7.1±3.2 years.

Kidney-related mortality, all dogs

The total number of dogs with mortality insurance in AGRIA during the years 1995–2006 was 548,346. These dogs together contributed 2,036,398 DYAR to the database. Of these dogs, 1981 died or were euthanased due to kidney-related disease. This corresponds to a total kidney-related mortality of 9.7 (9.3–10.2) deaths/10,000 DYAR. The total mortalities for female and male dogs were 10.8 (10.2–11.5) and 8.6 (8.0–9.2) deaths/10,000 DYAR, respectively. The mean age of all dogs that died of KD was 6.5±2.7 years. The mean age for females was 6.3±2.7 years and for males 6.6±2.6 years. table 1 summarises data for all dogs.

Aetiology groups of KD

Most of the kidney-related diagnoses in this population of AGRIA-insured dogs belonged to the aetiology-groups 'aetiology not determined' and 'infectious/inflammatory'. The distribution of dogs in the different aetiology groups for kidney-related veterinary care and for kidney-related mortality are shown in Fig 1a, b.

Case distributions over time

There was no consistent change over time in the incidences of KD in the group of veterinary care-insured dogs during the years 1995–2006 (Fig 2).

Breed-specific calculations

A list of breeds (contributing with at least 10,000 DYAR) with an incidence of KD exceeding the mean total incidence for all breeds (15.8 cases per 10,000 DYAR), including age at kidney-related diagnosis, is provided in Table 2.

The breeds (contributing with at least 10,000 DYAR) with the lowest incidences of KD were Swedish elkhound, Siberian husky and Finnish spitz (5 cases/10,000 DYAR), followed by German wirehaired pointer (6 cases/10,000 DYAR) and drever, border collie, Jack Russell terrier, Norwegian elkhound, English setter, mixed breeds, dachshund, Finnish hound and standard schnauzer (all 8 cases/10,000 DYAR).

TABLE 1 Study population

	Veterinary care insurance	Incidence (95% CI) (cases/10,000 dog-years at risk)	Life insurance	Mortality (95% CI) (deaths/10,000 dog-years at risk)
Total number of insured dogs	666,245		548,346	
Mean age (all insured dogs)	4.0		3.7	
Number of dogs with kidney disease	4390	15.8 (15.3 to 16.2)	1981	9.7 (9.3 to 10.2)
Males	2134	15.6 (14.9 to 16.2)	871	8.6 (8.0 to 9.2)
Females	2256	15.9 (15.3 to 16.6)	1110	10.8 (10.2 to 11.5)
Mean age±SD	6.9±3.3 years	–	6.5±2.7 years	–
Median (range) age	7.4 (0–12)		7.1 (0–10)	
Age males±SD	7.1±3.2 years	–	6.6±2.6 years	–
Median (range) age male dogs	7.6 (0–12)		7.2 (0–10)	
Age females±SD	6.6±3.4 years	–	6.3±2.7 years	–
Median (range) age female dogs	7.2 (0–12)		7.0 (0–10)	

General data for all dogs and dogs with kidney disease in the 'veterinary care insurance' and the 'life insurance' groups

A list of breeds with a mortality of KD exceeding the mean total mortality for all breeds (9.7 deaths per 10,000 DYAR) including age at kidney-related death is provided in Table 3.

The breed with the lowest mortality of KD was the miniature dachshund (2 deaths/10,000 DYAR), followed by border terrier and Jack Russell terrier (3 deaths/10,000 DYAR), dachshund, standard schnauzer, Swedish elkhound, border collie and German wirehaired pointer (4 deaths/10,000 DYAR), mixed breed and Finnish spitz (5 deaths/10,000 DYAR).

The distribution of KD aetiologies within each of the 15 breeds with the highest incidences of KD is shown in Table 4. Similarly, the distribution of aetiologies of KD responsible for

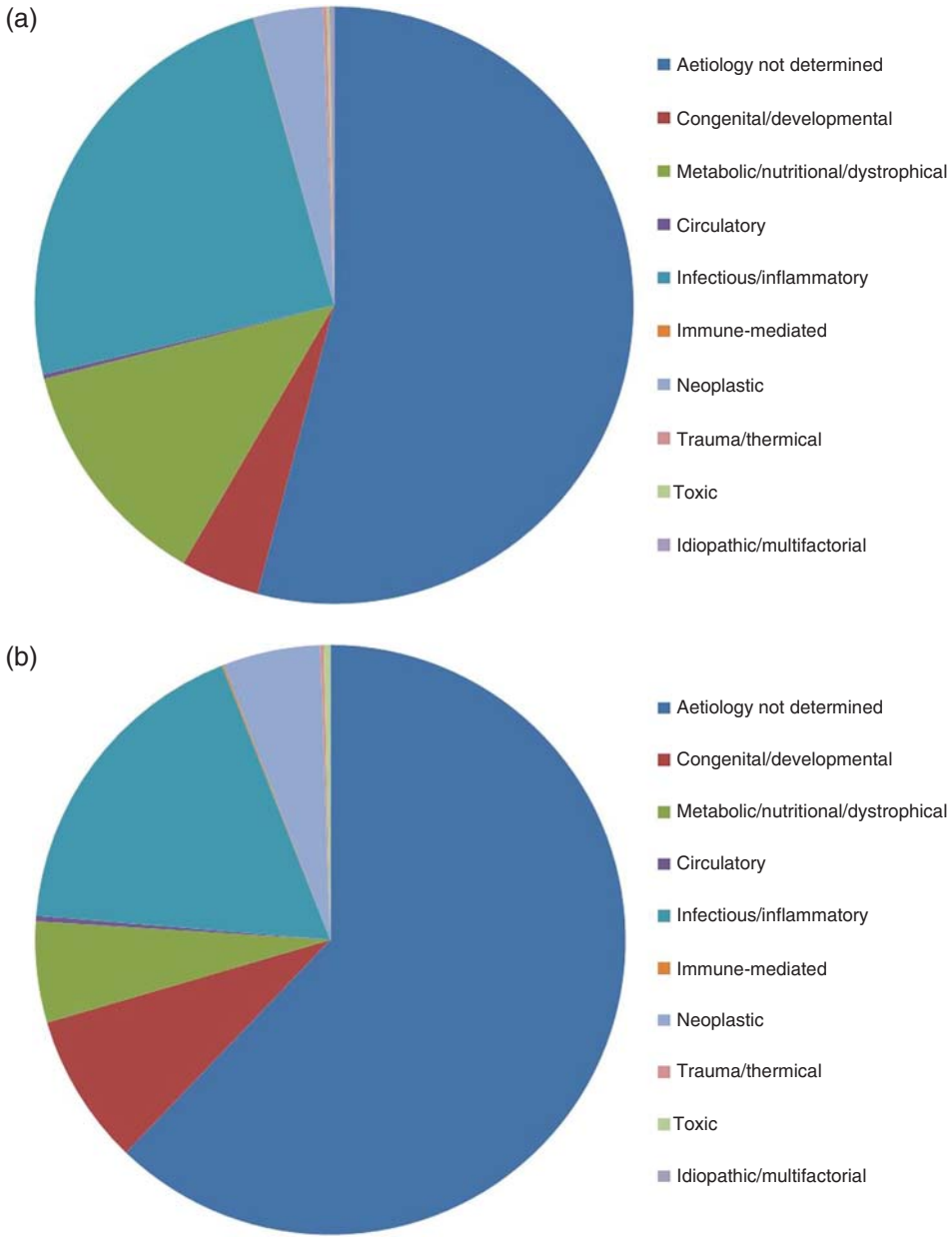

FIG 1: Kidney-related disease by aetiology group. (a) kidney disease diagnosis, (b) kidney-related mortality

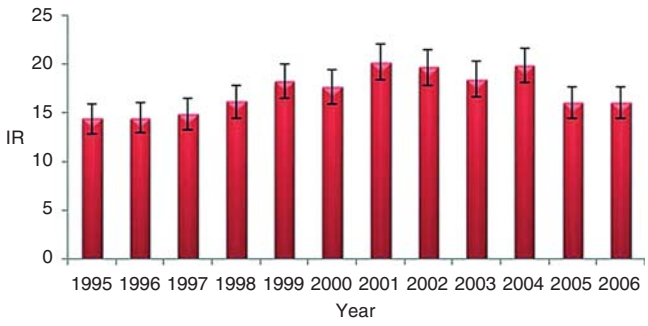

FIG 2: Yearly total incidence rates of kidney disease, 1995 through 2006

kidney-related death in the 15 breeds with the highest kidney-related mortalities is shown in table 5.

Discussion

This study has shown an incidence of 15.8 cases of KD/10,000 DYAR in a population of 665,245 insured Swedish dogs. This is the first known study to provide an estimate incidence of KD in dogs. An alternative interpretation of this result is to consider 10,000 DYAR approximately the equivalent of 1000 dogs (each living 10 years). Out of these 1000 dogs, almost 16 (1.6 per cent) developed KD. This estimate, although comprising both acute and chronic KD, is comparable to the number that is generally considered to be a realistic estimation of the prevalence of CKD in the general dog population (0.5–1.5 per cent) (Polzin 2009). However, common to all estimations of incidence and prevalence of CKD in the dog (and cat) is that they probably underestimate the true occurrence, partly because pets are not presented until the clinical signs of the disease are obvious, and partly because of our inability to diagnose some cases of early stages of KD despite routine screening of renal health. This is especially true if patients are not proteinuric.

The incidences of 15.8 cases/10,000 DYAR for KD can be compared with the calculated incidences of a few other diseases investigated in this particular insurance database. The incidences of intervertebral disc degenerative disease was 27.8 cases/10,000 DYAR, atopic dermatitis: 17 cases/10,000 DYAR, diabetes mellitus: 13 cases/10,000 DYAR, bone tumours: 5.5 cases/10,000 DYAR and pyometra: 199 cases/10,000 DYAR (Nodtvedt and others 2006, Egenvall and others 2007, Fall and others 2007, Bergknut and others 2012, Jitpean and others 2012). Pyometra is a common clinical diagnosis in Sweden compared with many other countries because bitches are not routinely spayed. In contrast with some of these diseases, KD refers to a heterogeneous syndrome of many aetiologies leading to common pathologies of an entire organ system and therefore numbers are not necessarily directly comparable.

The mortality of KD in this population of life-insured dogs was 9.7 deaths/10,000 DYAR. For comparison, the mortality of heart disease in this database was 21.3 deaths/10,000 DYAR and the mortality of intervertebral disc degenerative disease was 9.4 deaths/10,000 DYAR (Egenvall and others 2006, Bergknut and others 2012).

The mean age of all dogs (in the veterinary care insurance) when they had their first episode of KD was 6.9 years and the mean age at which dogs (in the life insurance) died of KD was 6.5 years. This might seem contradictory but the result is possible because the dogs with registered KD are not exactly the same dogs as those registered to have died because of KD. Some dogs might have died for other reasons, and some dogs might have been euthanased shortly after diagnosis. Also, if the cost for veterinary care does not exceed the deductible, owners are not

TABLE 2 Kidney disease incidence by breed

	Breed	DYAR	Cases	Incidence (95% CI)	Incidence females (95% CI) (cases/10,000 DYAR)	Incidence males (95% CI) (cases/10,000 DYAR)	Mean (median) age at diagnosis
1	Bernese mountain dog	18,641	95	51 (41 to 61)	60 (44 to 75)	41 (28 to 55)	5.0 (4.7)
2	Miniature schnauzer	28,000	108	39 (31 to 46)	40 (30 to 51)	37 (27 to 47)	6.8 (7.2)
3	Boxer	19,190	69	36 (27 to 44)	45 (32 to 59)	26 (16 to 37)	5.3 (5.9)
4	Yorkshire terrier	21,313	73	34 (26 to 42)	33 (22 to 43)	36 (25 to 47)	7.6 (8.1)
5	Dalmatian	17,374	59	34 (25 to 43)	27 (17 to 38)	42 (28 to 57)	5.9 (6.3)
6	Shetland sheepdog	38,330	119	31 (25 to 37)	27 (20 to 35)	35 (27 to 43)	8.0 (8.3)
7	Fox terrier	11,024	34	31 (20 to 41)	28 (14 to 41)	34 (19 to 49)	8.2 (8.5)
8	Shih tzu	19,103	58	30 (23 to 38)	25 (15 to 35)	35 (24 to 47)	7.0 (7.3)
9	Soft-coated wheaten terrier	24,330	73	30 (23 to 37)	30 (21 to 40)	30 (20 to 40)	6.2 (6.4)
10	Cairn terrier	35,931	106	30 (24 to 35)	30 (22 to 38)	29 (21 to 37)	7.6 (8.6)
11	Giant schnauzer	10,655	31	29 (19 to 39)	29 (16 to 44)	29 (14 to 44)	5.0 (5.2)
12	Bearded collie	24,010	69	29 (22 to 36)	25 (16 to 33)	33 (23 to 43)	8.3 (9.6)
13	Standard poodle	24,950	70	28 (21 to 35)	25 (16 to 33)	32 (22 to 42)	7.3 (7.5)
14	Papillon	28,226	78	28 (22 to 34)	26 (17 to 34)	30 (21 to 39)	8.2 (8.5)
15	Flat-coated retriever	33,897	92	27 (22 to 33)	41 (31 to 50)	13 (7 to 18)	6.4 (7.6)
16	Rottweiler	40,409	106	26 (21 to 31)	26 (19 to 33)	27 (19 to 34)	6.7 (7.3)
17	Bichon frisé	26,674	66	25 (19 to 31)	28 (19 to 37)	21 (14 to 29)	7.5 (7.9)
18	Cavalier King Charles spaniel	55,839	134	24 (20 to 28)	25 (19 to 31)	23 (17 to 28)	6.5 (6.8)
19	Collie	41,079	98	24 (19 to 29)	33 (25 to 40)	15 (10 to 20)	6.1 (5.9)
20	English springer spaniel	60,031	138	23 (19 to 27)	21 (16 to 26)	25 (19 to 31)	7.6 (8.5)
21	American cocker spaniel	13,687	31	23 (15 to 31)	19 (9 to 29)	27 (15 to 39)	6.6 (6.4)
22	Whippet	12,899	28	22 (14 to 30)	18 (8 to 28)	26 (13 to 38)	8.6 (9.5)
23	English cocker spaniel	42,548	90	21 (17 to 26)	22 (16 to 28)	21 (14 to 27)	7.7 (8.5)
24	Greyhound	8,535	18	21 (11 to 31)	16 (4 to 27)	27 (11 to 43)	6.3 (7.8)
25	Rhodesian ridgeback	10,619	21	20 (11 to 28)	28 (14 to 43)	11 (2 to 20)	5.3 (4.4)
26	West highland white terrier	24,082	47	20 (14 to 25)	19 (11 to 27)	20 (12 to 28)	8.4 (9.2)
27	Newfoundland	11,754	22	19 (11 to 27)	16 (6 to 26)	22 (10 to 35)	7.1 (7.2)
28	Doberman pinscher	12,536	23	18 (11 to 26)	27 (15 to 40)	8 (1 to 16)	6.2 (7.1)
29	Samoyed	15,479	28	18 (11 to 25)	20 (10 to 30)	16 (7 to 25)	7.3 (6.7)
30	Tibetan spaniel	15,115	25	17 (10 to 23)	12 (4 to 20)	21 (11 to 31)	5.2 (4.9)
31	Golden retriever	156,459	257	16 (14 to 18)	19 (16 to 23)	13 (11 to 16)	7.0 (7.3)

Breeds with an incidence of kidney disease exceeding the mean total incidence for all breeds (15.8 cases/10,000 DYAR). Only breeds with >10,000 DYAR in the database are included in the breed analysis
DYAR, dog-years at risk

TABLE 3 Kidney-related mortality by breed

	Breed	DYAR	Deaths	Mortality (95% CI)	Mortality females (95% CI) (deaths/10,000 DYAR)	Mortality males (95% CI) (deaths/10,000 DYAR)	Mean (median) age at kidney-related death
1	Bernese mountain dog	16,220	80	49 (39 to 60)	65 (48 to 82)	33 (21 to 46)	5.2 (5.0)
2	Shetland sheepdog	27,840	73	26 (20 to 32)	23 (15 to 31)	30 (21 to 39)	7.3 (7.9)
3	Flat-coated retriever	27,207	69	25 (19 to 31)	39 (29 to 49)	11 (6 to 17)	6.3 (7.1)
4	Boxer	14,914	35	23 (16 to 31)	36 (22 to 50)	11 (3 to 18)	5.4 (4.9)
5	Soft-coated wheaten terrier	19,769	43	22 (15 to 28)	25 (15 to 35)	18 (10 to 27)	6.2 (6.3)
6	Cairn terrier	26,033	51	20 (14 to 25)	18 (10 to 25)	21 (14 to 29)	7.1 (7.7)
7	Yorkshire terrier	14,496	28	19 (12 to 26)	18 (8 to 28)	21 (10 to 31)	6.9 (7.4)
8	Rottweiler	32,965	63	19 (14 to 24)	21 (14 to 28)	17 (10 to 23)	7.1 (7.7)
9	Doberman pinscher	10,033	19	19 (10 to 27)	25 (11 to 38)	13 (3 to 23)	6.9 (7.2)
10	Cavalier King Charles spaniel	44,159	73	17 (13 to 20)	19 (13 to 25)	14 (9 to 19)	6.3 (6.9)
11	Shih tzu	12,916	20	15 (9 to 22)	14 (5 to 23)	17 (7 to 27)	5.8 (5.8)
12	Bearded collie	17,441	25	14 (9 to 20)	14 (6 to 21)	15 (7 to 23)	7.0 (7.8)
13	Standard poodle	18,827	26	14 (9 to 19)	9 (3 to 15)	19 (10 to 28)	6.5 (6.8)
14	English cocker spaniel	30,406	40	13 (9 to 17)	14 (8 to 20)	12 (6 to 17)	7.0 (8.4)
15	Collie	29,682	39	13 (9 to 17)	16 (9 to 22)	11 (5 to 16)	5.0 (4.9)
16	Papillon	19,054	22	12 (7 to 16)	9 (3 to 15)	14 (6 to 21)	7.6 (7.9)
17	Tibetan spaniel	10,460	12	11 (5 to 18)	8 (0 to 16)	15 (5 to 25)	6.2 (6.5)
18	English springer spaniel	46,437	53	11 (8 to 14)	10 (6 to 14)	13 (9 to 18)	7.5 (8.2)
19	Hamilton hound	31,594	36	11 (8 to 15)	12 (7 to 17)	11 (6 to 17)	8.0 (8.2)
20	Dalmatian	12,709	14	11 (5 to 17)	10 (3 to 18)	12 (3 to 21)	5.9 (7.0)
21	Miniature schnauzer	20,173	21	10 (6 to 15)	8 (3 to 14)	13 (6 to 19)	4.9 (5.6)
22	Golden retriever	115,811	117	10 (8 to 12)	15 (12 to 19)	5 (3 to 7)	6.5 (6.9)
23	Norwegian elkhound	35,696	35	10 (7 to 13)	9 (4 to 14)	11 (6 to 15)	5.7 (5.5)

Breeds with a mortality of kidney disease exceeding the mean total mortality for all breeds (9.7 deaths/10,000 DYAR). Only breeds with >10,000 DYAR in the database are included in the breed analysis
DYAR, dog-years at risk

reimbursed and consequently, any diagnoses made during such visits are not communicated to AGRIA. It is tempting to speculate that the dogs with a diagnosis of KD had a short mean survival time but this conclusion cannot be drawn from the total mean ages. Exact survival times of the dogs diagnosed with KD was not investigated in this study.

Ignoring breed, there was no difference between males and females in the total incidence of KD. In the total mortality of KD, females were more commonly affected. Within most breeds, incidences and mortalities were similar between males and females. In the veterinary care insurance group, there were three breeds where the CIs for females and males did not overlap. These were the flat-coated retriever, collie and golden retriever. In all three breeds, females were over-represented. In the life insurance group, there were four breeds where CIs did not overlap. These were the Bernese mountain dog, flat-coated retriever, boxer and golden retriever. In all four breeds, females were over-represented.

Many of the breeds with the highest incidences and mortalities for KD in this study are breeds that are predisposed to familial renal diseases. The Bernese mountain dog has an increased risk for immune-mediated glomerulonephritis, the English cocker spaniel for a glomerular basement membrane disorder, the soft-coated wheaten terrier for a podocytopathy and the cairn terrier for polycystic KD (McKenna and Carpenter 1980, Reusch and others 1994, Davidson and others 2007, Littman and others 2013). Dogs of the Doberman pinscher, Dalmatian and rottweiler breeds have been suggested to be at risk for glomerulopathies (Picut and Lewis 1987, Hood and others 2002b, Wakamatsu and others 2007). The following breeds have been suggested to be at increased risk for KDs not primarily affecting the glomerulus: the Shih tzu, Bernese mountain dog, boxer, soft-coated wheaten terrier, miniature schnauzer and standard poodle (O'Brien and others 1982, DiBartola and others 1983, Eriksen and Grondalen1984, Nashand others 1984, Morton and others 1990, Chandler and others 2007, Lees 2009, Bergman 2010, Vaden and others 2013). Most likely, many KDs that are not hereditary have also contributed to morbidity and mortality in dogs of all breeds in this study.

Five breeds in which KD is neither extensively reported nor recognised as a frequent occurrence appeared to be predisposed

TABLE 4 Kidney diagnosis distribution by breed

Breed	Total no of diagnoses	Not determined	Congenital/ developmental	Metabolic/ nutritional/ dystrophical	Circulatory	Infectious/ inflammatory	Neoplastic	Trauma/thermal
Bernese mountain dog	104	65 (62%)	6 (6%)	6 (6%)	0	25 (24%)	1 (1%)	1 (1%)
Miniature schnauzer	121	48 (39%)	2 (2%)	44 (36%)	1 (1%)	25 (21%)	0	1 (1%)
Boxer	80	41 (52%)	5 (6%)	4 (5%)	0	21 (26%)	9 (11%)	0
Yorkshire terrier	84	48 (58%)	1 (1%)	23 (27%)	0	12 (14%)	0	0
Dalmatian	70	35 (51%)	0	17 (24%)	0	17 (24%)	1 (1%)	0
Shetland sheepdog	133	86 (65%)	3 (2%)	13 (10%)	0	27 (20%)	4 (3%)	0
Fox terrier	38	21 (55%)	0	10 (26%)	0	6 (16%)	1 (3%)	0
Shih tzu	62	35 (56%)	2 (3%)	16 (26%)	0	9 (15%)	0	0
Soft-coated wheaten terrier	83	42 (51%)	10 (12%)	4 (5%)	0	26 (31%)	1 (1%)	0
Cairn terrier	118	57 (48%)	4 (3%)	19 (16%)	0	35 (30%)	3 (3%)	0
Giant schnauzer	35	15 (43%)	4 (11%)	3 (9%)	1 (3%)	7 (20%)	5 (14%)	0
Bearded collie	75	49 (66%)	0	4 (5%)	0	21 (28%)	1 (1%)	0
Standard poodle	83	53 (64%)	0	9 (11%)	0	19 (23%)	2 (2%)	0
Papillon	88	37 (42%)	0	28 (32%)	1 (1%)	20 (23%)	2 (2%)	0
Flat-coated retriever	114	65 (57%)	12 (11%)	6 (5%)	0	24 (21%)	7 (6%)	0

Distribution of kidney-related diagnoses, divided into aetiology groups, for the 15 breeds with the highest incidences for kidney disease. Any dog can have more than one diagnosis. No diagnoses were reported in the 'immune mediated', 'toxic injury' or 'idiopathic/multifactorial' aetiology groups

TABLE 5 Kidney diagnosis distribution, related to mortality, by breed

Breed	Total (dogs)	Not determined	Congenital/ developmental	Metabolic/ nutritional/ dystrophical	Infectious/ inflammatory	Immune-mediated	Neoplastic	Trauma/thermal	Toxic
Bernese mountain dog	80	46 (58%)	8 (10%)	6 (7%)	20 (25%)	0	0	0	0
Shetland sheepdog	73	58 (80%)	3 (4%)	3 (4%)	5 (7%)	0	2 (3%)	1 (1%)	1 (1%)
Flat-coated retriever	69	36 (52%)	13 (19%)	2 (3%)	14 (20%)	0	4 (6%)	0	0
Boxer	35	19 (54%)	3 (9%)	0	6 (17%)	1 (3%)	6 (17%)	0	0
Soft-coated wheaten terrier	43	23 (54%)	11 (26%)	1 (2%)	8 (6%)	0	0	0	0
Cairn terrier	51	26 (51%)	4 (8%)	7 (14%)	11 (22%)	0	3 (6%)	0	0
Yorkshire terrier	28	23 (82%)	1 (4%)	0	4 (14%)	0	0	0	0
Rottweiler	63	36 (58%)	4 (6%)	4 (6%)	15 (24%)	0	4 (6%)	0	0
Doberman pinscher	19	11 (58%)	0	2 (11%)	5 (26%)	0	1 (5%)	0	0
Cavalier King Charles spaniel	73	48 (66%)	8 (11%)	4 (5%)	11 (15%)	0	2 (3%)	0	0
Shih tzu	20	14 (70%)	4 (20%)	1 (5%)	1 (5%)	0	0	0	0
Bearded collie	25	17 (68%)	0	2 (8%)	6 (24%)	0	0	0	0
Standard poodle	26	18 (69%)	2 (8%)	3 (11%)	3 (12%)	0	0	0	0
English cocker spaniel	40	26 (65%)	4 (10%)	4 (10%)	5 (12%)	0	1 (3%)	0	0
Collie	39	24 (61%)	5 (13%)	2 (5%)	7 (18%)	0	1 (3%)	0	0

Distribution of reasons for kidney-related mortality, divided into aetiology groups, for the 15 breeds with the highest incidence for kidney disease. No deaths were reported in the 'circulatory' or 'idiopathic/multifactorial' aetiology groups

to KD in the present data: Shetland sheepdog, bearded collie, Cavalier King Charles spaniel, Collie and giant schnauzer. Cavalier King Charles spaniels and cocker spaniels in the UK were recognised as breeds predisposed to CKD in a recent study (O'Neill and others 2013). Future studies are needed to further characterise diseases affecting the kidneys in the breeds identified with a possible predisposition for KD in this study.

Some breeds with a known predisposition for KD were not identified in this study. These breeds may not be common enough in Sweden to contribute enough DYAR to this database, or the disease itself could be uncommon and not diagnosed often enough in the dog population in the present study. Alternatively, specific breeds may be insured to a great extent at other Swedish insurance companies, or not at all. Another explanation may be that a recognised predisposition for KD in a particular breed is not shared by the Swedish dogs of that same breed. An example is the bull terrier, which is associated with a form of hereditary glomerulopathy and with polycystic KD (Hood and others 2002a, O'Leary and others 2009). This breed had very high incidence (69 cases/10,000 DYAR) and mortality (77 deaths/10,000 DYAR), but the breed only contributed about 2000 DYAR in both insurance groups, and was therefore not included in the breed analysis. Inclusion of dog breeds with less than 10,000 DYAR in the database would provide incidences and mortalities for a greater number of breeds, but it would also increase the risk of introduction of bias into the calculations.

Limitations to this study include inherent problems with the use of secondary databases in research. Advantages with insurance databases are their sample size and that they are highly representative of the clinical population, but their limitation is the resolution of the data (Sorensen and others 1996). The kidney-related diseases were diagnosed by different veterinarians and with no predefined criteria for the diagnosis. The level of diagnostic performance varies with expertise and diagnostic availability from clinic to clinic, and no practice records were available to the authors.

General limitations and benefits of using insurance data in veterinary epidemiological research have been described in detail (Egenvall and others 2009). A validation of the data in the AGRIA database against veterinary practice records has been performed (Egenvall and others 1998). The general agreement between data in the AGRIA database and practice records was excellent for information regarding breed and sex and fair for date of birth and for specific diagnoses.

Dogs in the life insurance group are only insured up to the age of 10 years and dogs in the veterinary care insurance up to the age of 12 years, which means that there is information missing concerning both KD diagnoses and kidney-related death in older dogs.

Also, data do not indicate whether dogs died or were euthanased. In Sweden, dogs are often euthanased before their general condition deteriorates to the point of spontaneous death. As a result, the present data describing canine mortality may be interpreted as age at euthanasia.

Because large breeds tend to have higher serum concentrations of creatine than small breeds (Misbach and others 2014), a diagnosis of KD in some large breed dogs with normal kidney function may have been made. Although the reference range for creatine is likely to be different in different breeds, in practice the same range is used for dogs of all breeds. However, many of the breeds with the highest incidence for veterinary care also had high mortality, which make the effect of breed on creatinine less likely to have a major impact on the results of this study, because owners are less likely to euthanise their dog because of a laboratory value.

In summary, this study provides an incidence of 15.8 cases /10,000 DYAR and a mortality of 9.7 deaths/10,000 DYAR for KD in a large population of Swedish insured dogs. The Bernese mountain dog was the breed with the highest incidence and mortality for KD of all breeds contributing with more than 10,000 DYAR to the database. The epidemiological information provided in this study concerning KD in dogs can provide valuable information both in the clinical and research settings. In addition, the information concerning kidney morbidity and mortality in predisposed breeds may indicate that further studies to identify the exact nature of KD within these breeds are needed. Results from such studies could be of great value in future breeding planning.

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