TITLE: Epidemiology, clinical management, and outcomes of dogs involved in road traffic accidents in the United Kingdom (2009–2014)

AUTHORS: Harris, G. L., Brodbelt, D., Church, D. , Humm, K. , McGreevy, P. D., Thomson, P. C. and O'Neill, D.

JOURNAL: Journal of Veterinary Emergency and Critical Care

PUBLISHER: Wiley

PUBLICATION DATE: 6 March 2018 (online)

DOI: https://doi.org/10.1111/vec.12704

Road Traffic Accidents (RTA) in dogs in the UK: epidemiology, clinical management and outcomes

Authors:

Georgina Harris*
BVetMed MRCVS
Department of Veterinary Sciences and Services
The Royal Veterinary College
Hawkshead Lane
North Mymms
Hatfeild
AL97TA

Dr Dave Brodbelt
MA VetMB PhD DVA DipECVAA MRCVS
The Royal Veterinary College
Hawkshead Lane
North Mymms
Hatfield
Herts AL9 7TA

Professor David Church
BVSc PhD MACVSc MRCVS
Department of Veterinary Sciences and Services
The Royal Veterinary College
Hawkshead Lane
North Mymms
Hatfield
Herts AL9 7TA

Karen Humm
MA VetMB CertVA DACVECC DipECVECC FHEA MRCVS
Department of Veterinary Sciences and Services
The Royal Veterinary College
Hawkshead Lane
North Mymms
Hatfield
Herts AL9 7TA

Professor Paul D. McGreevy
BVSc PhD MACVSc MRCVS
R.M.C. Gunn Building (B19),
Faculty of Veterinary Science,
The University of Sydney, NSW 2006

Assoc. Professor Peter C. Thomson
BSc MSc MAppStat PhD
R.M.C. Gunn Building (B19),
Faculty of Veterinary Science,
The University of Sydney, NSW 2006

Dr Dan O'Neill*
MVB BSc(hons) GPCert(SAP) GPCert(FelP) GPCert(Derm) GPCert(B&PS) MSc(VetEpi)
PhD MRCVS
The Royal Veterinary College
Hawkshead Lane
North Mymms
Hatfield
Herts AL9 7TA

Corresponding author address and email address:

Georgina Harris,

The Stable House

London Colney

AL2 1BU

Gharris@rvc.ac.uk

Disclosure Statement

The authors declare no conflict of interest

Key Words

Trauma, Clinical Epidemiology, Small Animal Critical Care

Abstract

This study aims to estimate the prevalence and risk factors for road traffic accidents (RTA) and describe the management and outcome of RTA's in dogs attending primary-care veterinary practices in the UK.

Electronic-patient-records of dogs attending practices participating in the VetCompass Programme were assessed against selection criteria used to define RTA cases. The study population included 199,464 dogs attending 115 primary-care clinics across England. RTA cases were identified and manually verified to calculate prevalence. Univariable and multivariable logistic regression methods were used to evaluate associations between risk factors and RTA.

RTA prevalence was 0.41%. Of the RTA cases, 615 (74.9%) were purebred, 322 (39.2%) were female, and 285 (54.8%) were insured. The median age at RTA was 2.5 years. After accounting for the effects of other factors, younger dogs had increased odds of an RTA event: dogs aged under three years showed 2.9 times the odds and dogs aged between six and nine years showed 1.8 times the odds of an RTA event compared with dogs aged over 14 years. Males had 1.4 times the odds of an RTA event compared with females. Overall, 22.9% of cases died from a cause associated with RTA. Of dogs with information available, 34.0% underwent diagnostic imaging, 29.4% received intravenous fluid-therapy, 71.1% received pain relief, 46.0% were hospitalised and 15.6% had surgery performed under general anaesthetic.

This study identified important demographic factors associated with RTA in dogs, notably being young and male. This information can assist preventive action by highlighting dogs most at risk

Abbreviation list

RTA – Road traffic accident

MVA - Motor vehicle accident

UK – United k=Kingdom

EPR - (electronic patient record)

PMS - practice management systems

SQL - structured query language

CI - confidence intervals

RTC – road traffic collision

IQR - interquartile range

NSAIDS – non-steroidal anti-inflammatory drugs

Introduction

Road traffic accident (RTA) also known as motor vehicle accident (MVA) is one of the most common causes of blunt trauma in dogs [1]. Previous evidence has identified RTA as the fourth most common cause of death in dogs under three years of age, with 12.7% of deaths in young dogs occurring from RTA [2]. RTA has also been reported to be the cause of 55% of head trauma cases in dogs [3]. As well as the substantial welfare impact on affected animals, canine RTA events can also impose large financial and emotional strain on owners [4]. Despite this, the prevalence of RTA in dogs in the UK is unknown and risk factors for involvement in RTAs, such as breed and age, have not been described. Therefore, although epidemiologic information has been shown to be important for prevention, diagnosis, and management in many other disease processes, any potential in relation to RTA is unclear.

By contrast, in cats, 12.2% of deaths in cats of all ages and 47.3% of deaths in cats aged under 5 years are reported as being due to trauma [5] and 60% of these trauma-related deaths are reported to be from RTA.

A previous study examining cruciate disease proposed that younger dogs are more likely than older dogs to be involved in an RTA [6], but this has not been investigated in a wider RTA patient population. Similarly, dogs suffering from RTA-induced cruciate disease were more likely to be male [7] but whether this was due to inherent differences in cruciate ligament between the sexes or due to increased prevalence of males in RTAs is unknown. The authors are unaware of any other previous literature on the effect of breed or sex on canine RTA prevalence.

Several previous canine trauma studies have been performed in referral hospital settings in the USA, with reported survival proportions from 86 and 91.1% reported [1, 8]. One canine trauma study based on referral data reported an 88% survival from blunt trauma and that RTA represented 91.1% of trauma cases [1]. Two studies from the 1970s at the University of Pennsylvania showed a fatality rate following an RTA between 12-12.5% [9, 10]. However, it is unknown whether these survival data can be generalised to the UK dog population. On the one hand, survival may be higher in animals attending referral centres due to greater financial outlay by owners, and increased availability of equipment and resources (such as advanced diagnostic imaging modalities), products (such as blood products) and specialist personnel but, conversely, if only those cases with a more concerning presentation are referred, this could lead to a lower survival rate of RTA in referral practices. To reduce these biases and uncertainties, the current study uses clinical data from UK primary-care veterinary practices participating in the VetCompass Programme, which should give results that are more generalizable to the wider canine population.

The study aimed to report the prevalence of RTA and to evaluate purebred status, breed, sex, bodyweight, age, and insurance status as risk factors for the occurrence of RTA and to describe the clinical management and outcomes of affected dogs. It was hypothesized that younger dogs and male dogs were at increased risk of RTA compared to older dogs and female dogs respectively.'[2], [11].

Materials and methods

Ethics approval for this study was granted by the RVC Ethics and Welfare Committee (reference number 2014 0120H).

The VetCompass Programme collates de-identified EPR (electronic patient record) data from primary-care veterinary practices in the UK for epidemiological research [6, 7 12]. Participating practices can record summary diagnosis terms from an embedded standard nomenclature, the VeNom codes [13] at episodes of clinical care. EPR data were extracted from the practice management systems (PMS) using integrated clinical queries [14] and uploaded to a secure structured query language (SQL) database. Information available to the study included patient demographic (animal identification number, species, breed, date of birth, sex, neuter status, insurance status, and bodyweight) and clinical information (free-form text clinical notes, VeNom summary diagnosis terms and treatment, with relevant dates).

The study used a cross-sectional design on cohort data for risk estimation and risk factor analysis. The study-sampling frame included all dogs with at least one EPR (summary diagnosis term, clinical note, bodyweight or treatment) recorded within the VetCompass database from September 1st, 2009 to August 31, 2014. Sample size calculations estimated that a cross-sectional study would require 16,608 males and 16,608 females to identify an effect with an odds ratio of 1.5 or greater, a confidence interval (CI) of 95%, and power 80% when the ratio of exposed-to-unexposed was 1:1 and 0.5% of the unexposed animals were estimated to have an RTA outcome [15].

The case definition for an RTA case required that the EPR recorded an occurrence of an RTA event (or synonym) in a dog presenting to the practice. Potential RTA cases were identified from the overall VetCompass database by searching the clinical free-text and VeNom Code fields using multiple search terms: *hit by car, hit by a car, RTA, road traffic, ran over, run over, knocked over, knocked by, motorcycle, motorbike, lorry, truck, bus, vehicle collision, RTC, road traffic collision.* All potential cases identified from this preliminary search were aggregated and manually evaluated against the RTA case definition. All dogs from the study dataset that were not classified as RTA cases were included in the analyses as non-RTA animals.

The full clinical notes recorded during the study period for each confirmed RTA case dog were manually reviewed to extract data on additional study questions of interest relating to the RTA events. Further data extraction covered date of diagnosis, presented dead or alive, diagnostic imaging, treatment given, hospitalisation, surgery, and referral for secondary-care treatment. Data were also extracted on whether the patient died during the study and if so, the date of death, the method of death, and whether the death was associated with the RTA event. No dog in the study had more than one RTA event.

A binary *purebred* variable grouped all dogs recorded as a recognisable breed [16] as 'purebred' and all other dogs as 'crossbred'. A *breed* variable included any specific breeds with 10 or more RTA cases, any remaining breeds from the 14 most common breeds in the study overall, a grouped category of all remaining purebred dogs and a general grouping of crossbred dogs. *Neuter* described the neuter status recorded at the final EPR. *Insurance* described whether a dog was insured at any point during the study period. The age value described the age at the date of the RTA event for cases and the age at the midpoint between the dates of the first and final EPRs recorded during the study period for all other dogs. Age (years) was categorized into six groups (< 3.0, 3.0-5.9, 6.0-8.9, 9.0-11.9, ≥ 12.0, not recorded). *Actual bodyweigh*t (kilograms) described the maximum bodyweight recorded during the study period for dogs older than nine months and was categorised into six groups (0.0-9.9 kg, 10.0-19.9 kg, 20.0-29.9 kg, 30.0-39.9 kg, ≥ 40.0 kg, not recorded). The mean bodyweight of dogs older than nine months was calculated for each breed in the study. Each dog with a recorded bodyweight was then characterised as being either below or equal/above the mean bodyweight for its breed. This *breed-relative bodyweight* variable allowed the effect of variation of body weight within breeds to be assessed. The time contributed to the study for each dog described during the period from the dates of the earliest to the latest EPR.

Study data were exported from the VetCompass database to a spreadsheet (Microsoft Office Excel 2007, Microsoft Corp.) for checking and cleaning before further export to Stata Version

11.2 (Stata Corporation) for statistical analyses. Disorder prevalence values were estimated, with 95% confidence intervals (CI) based on approximation to the normal distribution d [17]. Demographic results were reported separately for the RTA and the non-RTA dogs. Risk factor analysis evaluated all demographic risk factors using univariable logistic regression; factors with a P-value < 0.20 were further evaluated using multivariable logistic regression. Because breed was a factor of primary interest for the study, *purebred* (collinear with breed) and absolute bodyweight (a defining characteristic of individual breeds) were excluded from multivariable modelling but univariable analysis results were reported. Model-building used manual backwards elimination. All eliminated factors were re-evaluated for confounding effects within the provisional-final model. Interactions between all final model variables were assessed to identify biologically important pairwise interactions. Clustering in the final model was evaluated using the clinic attended as a random effect [18]. Model-fit diagnostics were evaluated [19]. The threshold for statistical significance was set at P = 0.05.

Results

The overall study population comprised 199,464 dogs attending 115 primary-care clinics across central and south-eastern England. From these, 822 RTA cases were identified, yielding a prevalence of 0.41% (95% confidence interval (CI): 0.38-0.44). The median time contributed to the study per dog from the date of the earliest to the latest EPR was 0.6 years (interquartile range (IQR): 0.0-2.2, range: 0.0-5.0). Data completion varied between the variables assessed: breed 99.9%, sex 99.6%, neuter status 43.4%, insurance status 55.6%, age 99.9%, and bodyweight 65.3%.

Of the RTA cases with information available, 615 (74.9%) were purebred, 322 (39.2%) were female, 296 (83.4%) were neutered, and 285 (54.8%) were insured. The median bodyweight was 17.0 (IQR: 9.1-26.9, range: 2.0-70.0) kg and the median age at diagnosis was 2.5 (IQR: 1.1-5.5, range: 0.0-17.0) years (Figure 1). The most common breeds recorded with an RTA event were Staffordshire Bull Terrier (87, 10.6%), Labrador Retriever (74, 9.0%), Jack Russell Terrier (66, 8.0%), and Cocker Spaniel (32, 3.9%), along with crossbreds (206, 25.1%). The breeds with the highest inbreed prevalence of RTA were; Beagle (0.67%), Staffordshire Bull Terrier (0.56%), and Grey Hounds (0.52%).

Of the non-RTA dogs, 154,519 (77.8%) were purebred, 94,741 (47.9%) were female, 70,721 (82.1%) were neutered, and 47,200 (42.7%) were insured. The median bodyweight was 17.8 (IQR: 9.2-28.8, range: 0.68-109.0) kg and the median age was 4.0 (IQR: 1.3-8.1, range: 0.0-30.8) years. The most common breeds without a recorded RTA event were Labrador Retriever (17,031, 8.6%), Staffordshire Bull Terrier (15,454, 7.8%), Jack Russell Terrier (12,774, 6.4%), and Cocker Spaniel (7,368, 3.7%) along with crossbreds (44,000, 22.2%).

Information on clinical management was available on all 715 dogs that presented alive for veterinary care. Of these, 279 (38.5%) underwent diagnostic imaging, 241 (33.7%) received intravenous fluid therapy, 584 (80.6%) received therapeutic pain relief, 378 (52.9%) were hospitalised, 128 (17.9%) had surgery performed under a general anaesthetic, and 55 (7.7%) were referred for advanced clinical management (Table 3).

Overall, 188 of 821 (22.9%) RTA cases with information available died from a cause related to the RTA event. Indeed, 106 (12.9%) dogs were dead at presentation. Of the 715 dogs presented alive following RTA, 71 (9.9%) died during the study period from a cause associated with the RTA event, with a median time to death of 0.0 days (IQR: 0.0-0.0, range: 0.0-5.0) from the date of the RTA event. Of these deaths, 48 (67.6%) were by euthanasia, 22 (31.0%) were unassisted and 1 (1.4%) did not have the mechanism of death recorded. Of those animals that were referred follow up was available on survival and this was included in the main statistical analysis. Of those dogs alive at clinical presentation, insurance status was not significantly associated with the probability of death related to the RTA event (P = 0.332).

Univariable logistic regression modelling identified seven variables with liberally significant (P < 0.20) association with an RTA event: purebred status, breed, actual bodyweight, breed-relative bodyweight, age category, sex and insurance status (Table 2a and b). Following evaluation using multivariable regression, the final model comprised four risk factors: breed, age category, sex and insurance status. No biologically significant interactions were identified. The final model was improved by inclusion of the clinic attended as a random effect (P < 0.001, rho = 0.073, indicating that the clinic attended accounted for 7.3% of variation). The final non-clustered model showed acceptable discrimination (area under the ROC curve: 0.648). The Hosmer-Lemehshow test did not indicate poor model fit (P = 0.088).

Using a threshold for statistical significance set at P = 0.05, the univariable results did not identify that purebred status was significantly associated with an RTA outcome (P = 0.116). However, the univariable results did indicate that dogs weighing under 30 kg had higher odds of RTA compared with dogs weighing over 40 kg. After multivariable analysis that accounted for the effects of the other variables evaluated, no breeds showed increased odds of an RTA compared with crossbred dogs but three breeds showed reduced odds: Golden Retriever (OR: 0.2, 95% confidence interval (CI) 0.1-0.7, P = 0.006), Shih-tzu (OR: 0.5, 95% CI 0.2-0.9, P = 0.030), and West Highland White Terrier (OR: 0.4, 95% CI 0.2-0.8, P = 0.015).

Younger dogs had increased odds of an RTA event: dogs aged under three years showed 2.9 (95% CI 2.1-4.2, P < 0.001) times the odds and dogs aged between six and nine years showed 1.8 (95% CI 1.2-2.7, P = 0.002) times the odds of an RTA event compared with dogs aged over

14 years. Males had 1.4 (95% CI 1.2-1.6, $P < 0.001$) times the odds of an RTA event compared with females. Neuter status was not associated with the probability of an RTA event for either females ($P = 364$) or males ($P = 0.701$).

Insured dogs had 1.5 (95% CI 1.2-1.8, $P < 0.001$) times the odds of an RTA event compared with uninsured dogs (Table 4). Of those dogs alive at clinical presentation, insurance status was not significantly associated with the probability of referral ($P = 0.053$).

Discussion

This study, the first major exploration of RTA in dogs attending primary-care veterinary practices in England, reports a prevalence of 0.41%. It confirms that RTA is one of the major disorders in dogs, having a similar prevalence to other common disorders such as epilepsy (prevalence 0.62%),[14] cranial cruciate disease (0.56%),[20] chronic kidney disease (0.37%), [21] and diabetes mellitus (0.34%)[21].

This study also identified age, sex, and insurance status as significant risk factors for RTA. Although no breed was found to be predisposed to RTA, the study revealed that the Golden Retriever, West Highland White Terrier, and Shih-Tzu were at lower risk of RTA when compared with crossbreds. Breed predisposition has been reported for many disease processes [22, 23] and genetic influences are often hypothesised. The current finding could suggest increased owner-compliance within these breeds, with the dogs possibly being more responsive to owner control. In support of this theory, Golden Retrievers are reported to be underrepresented for behavioural problems [24] and it is acknowledged that compliant dogs are easier to recall from traffic [25]. Alternatively, low risk breeds may even be more problematic to train and owners may elect to keep them leashed in public. A third possibility is that the protected breeds may be more likely to be owned by people who simply take fewer risks and therefore keep them restrained, The low-risk breeds in the current study are not among those breeds with a strong tendency to chase[26] so they may be easier to manage in public.

The breeds with the highest inbreed prevalence of RTA were; Beagle (0.67%), Staffordshire Bull Terrier (0.56%), and Grey Hounds (0.52%). The breed predispositions reported here could simply reflect the use of leashes. Leash use is likely to reflect a breed's inclination to depart from the owner (because of distracting or enticing stimuli), tendency to remain with the owner (because of attachment or trainability) or relative lack of excitability[25]**.** So, some breeds (notably the sighthounds) are predisposed to chase and others are excitable are therefore more likely to be restrained in public while others (such as the retrievers) are more trainable and thus may be easier to recall**.**[26]

In support of the study hypothesis, the current study identified younger age as a risk factor for RTA, with dogs aged under three years having 2.9 times the odds of an RTA event compared with dogs aged over 14 years. This is consistent with data from previous studies in both dogs and cats [2, 5, 9, 10]. Older dogs may be less vulnerable to RTA because they are less active, have accumulated more training or perhaps have concurrent medical conditions resulting in reduced athleticism. Also, younger dogs have been reported to show increased straying tendencies and activity levels [27]. The mean age for presentation to a behaviourist for any cause has been reported as 3.7 years [24].These figures suggest that age as a risk factor for RTA may be due, at least in part, to behavioral problems. Though the current data did not capture what the animal was doing at the time of RTA, it would be useful if future studies could address this, as concurrent behaviour may be a significant risk factor to RTA. The predisposition of younger dogs to RTA events suggests the value of better road safety training and education for both owners and dogs during the early lives of dogs.

As hypothesised, this study also identified that males had 1.4 times the odds of an RTA event compared with females. Compared to 60.8% of males affected in the current study, a 2009 American referral study of 239 dogs involved in RTAs found that 53% were male but did not assess this figure for statistical significance [8]. The 2009 study did not compare the RTA dogs to the general hospital population which in this study was found to be 52.1% male. Clearly, the populations studied differ in terms of country (USA compared with UK in the current study) and case numbers (239 dogs compared with 822 in the current study). Possible explanations for male predisposition to RTA are unclear. Male dogs have been reported to be predisposed to behavioural problems [24] which may reflect poor training and recall, and this may lead to increased RTA risk[28] in addition, it has also been reported that male dogs have a greater tendency to stray [27]. However, the results of the current study showed that neutering did not increase the probability of an RTA, suggesting limited hormonal influences on RTA risk.

The current study revealed that insured animals had 1.5 times the odds of RTA compared with uninsured animals. It is possible that insured animals are more likely to be presented for veterinary care following an RTA event because of inherent differences between the owners of insured and uninsured dogs or because the owners of insured dogs perceive fewer financial constraints when considering veterinary treatment[29]. However, the study design, which considered any dog as having ‘insurance status’ if it had veterinary insurance at any point during the study period. So, it is also possible that some RTA cases became insured following their RTA event because owners were aware of the future risk of RTA to their animal and the potential financial implications of this, or any other disease process requiring veterinary treatment.

Of the dogs that presented alive analgesia was not administered to 47.1% of RTA dogs in this study. This may be due to minimal trauma in these dogs. However, concerns that adequate analgesia is not provided for dogs by veterinary surgeons have been raised in previous studies [30, 31] and it is also well accepted that recognition of pain in dogs can be difficult [32]. This has led to the development of pain scoring systems, such as the short form Glasgow composite measure pain scale[32]. Increased utilisation of these systems may be beneficial to improve case management in canine RTA, although it is recognised that there can be significant variation between assessors[33]. In addition, when analgesia was provided, NSAID administration was common. Cardiovascular instability due to blood loss can be seen in trauma patients, and this may not be readily apparent initially. Therefore, NSAID use may be best avoided in these patients on presentation. It is unknown in the study at what point these drugs were admitted, but given the high percentage of patients that were not hospitalised, it is likely many dogs were given NSAIDs very soon after RTA.

Diagnostic imaging was utilised in 38.5% of RTA cases that presented alive in this study, with radiography being the predominant modality. In human medicine, ultrasonography is the method of choice for abdominal blunt trauma but, despite its usefulness being shown for RTA-affected dogs[34], it was used to assess only 8.6% of cases in the current study. This low level of use may reflect lack of access to ultrasonography machines or limited confidence by clinicians in the interpretation of their output. The focussed assessment with sonography for trauma (FAST) method for canine trauma patients has been described and is claimed to be highly sensitive and specific for the detection of peritoneal, pleural, and pericardial fluid, as well as pneumothorax by veterinary surgeons with little ultrasonographic experience][35]. This non-invasive test may aid clinical decision-making in the early stages of the case-management process.

Human trauma survival rates vary depending on the trauma type, but a bimodal pattern of survival has been reported showing two peaks in mortality; the first is field-based immediately following the trauma event with a second hospital-based peak soon after admission[36]. In the current study, 22.9% of the overall RTA cases died due to their RTA event, i.e. the overall survival rate was 77.1%. However, for dogs presented alive to the veterinary practice, the survival rate was 90.1%. Those dogs that died after presentation, generally died very quickly, whether due to euthanasia or unassisted death, with the median time to death of 0 days being consistent with findings in human trauma patients[36]. Similar survival rates after trauma have been reported in other studies from veterinary referral hospitals[8, 11].

As with all retrospective analyses, there were some limitations to this study. Data were lacking in some areas due to incomplete records but the high number of cases in the study allowed strong statistical findings to be identified. Inclusion in this study relied on an RTA being witnessed or strongly suspected, which meant that some cases may have been unrecognised or conversely may have been falsely recorded as RTA. In addition, some minor RTA events which the owner deemed were unworthy of veterinary attention or some fatal RTA events may not have been reported to their veterinary practice and therefore not recorded on the veterinary PMS.

When considering the survival rate of dogs involved in RTAs, it is important to note that two-thirds of the dogs that initially presented alive but later died were euthanized and that the decision-making process for these assisted deaths was not evaluated in the current study. Although poor prognosis was likely a major factor in these decisions, it is also likely that other considerations such as ethical, financial and welfare factors and the concept of animal suffering would also contributed to the final decision.

Due to the limitations of the study and anonymous nature of data collection information such as postcode was not available. This information would be useful when looking at demographics such as urban and rural populations and how this affects odds of an RTA event.

This study is the first to report the prevalence of canine RTA in primary-care veterinary practices in the UK and revealed RTA to be a relatively common presentation. Younger animals and male dogs were predisposed to RTA and certain breeds were protected from an RTA event.

Diagnostic imaging, and particularly ultrasonography, may be under-utilised in this population and administration of analgesia was lower than might be expected. These findings can be used by clinicians to benchmark case management and possibly to inform better preventive and clinical management strategies.

.

Acknowledgments

Thanks to Peter Dron (RVC) for VetCompass database development and Noel Kennedy (RVC) for software and programming development. We acknowledge the Medivet Veterinary Partnership, Vets4Pets, Blythwood Vets, Vets Now and the other UK practices who collaborate in VetCompass. We are grateful to The Kennel Club, The Kennel Club Charitable Trust and Dogs Trust for supporting VetCompass.

431 **Tables**

Breed	No. dogs in study	No. RTA cases	Prevalence %	95% CI*
Crossbred	44203	206	0.47	0.40-0.53
Labrador Retriever	17105	74	0.43	0.34-0.54
Staffordshire Bull Terrier	15541	87	0.56	0.45-0.69
Jack Russell Terrier	12840	66	0.51	0.40-0.65
Cocker Spaniel	7400	32	0.43	0.30-0.61
German Shepherd Dog	6851	21	0.31	0.19-0.47
Yorkshire Terrier	6578	22	0.33	0.21-0.51
Border Collie	5226	21	0.40	0.25-0.61
West Highland White Terrier	5037	9	0.18	0.09-0.34
Chihuahua	4376	13	0.30	0.16-0.51
Cavalier King Charles Spaniel	4223	16	0.38	0.22-0.61
English Springer Spaniel	4062	10	0.25	0.12-0.45
Shih-tzu	3948	9	0.23	0.12-0.43
Golden Retriever	3573	4	0.11	0.04-0.29
Boxer	2796	6	0.21	0.10-0.47
Bichon	2686	13	0.48	0.26-0.83
Greyhound	2133	11	0.52	0.26-0.92

Beagle	1497	10	0.67	0.32-1.23
Other breeds	49389	192	0.39	0.34-0.45

*CI confidence interval

Table 1: Prevalence of road traffic accidents in commonly affected dog breeds attending primary-care veterinary practices in England.

Table 2a

Variable	Category	RTA No. (%)	Non-RTA No. (%)	Odds ratio	95% CI[a]	P-Value	Overall P-Value
Purebred status	Crossbred	206 (25.1)	44,000 (22.2)	Base			0.116
	Purebred	615 (74.8)	154,519 (77.8)	0.9	0.7-1.0	0.044	
	Unknown	1 (0.1)	123 (0.1)	1.7	0.2-12.5	0.583	
Common breeds	Crossbred	206 (25.1)	43,997 (22.2)	Base			< 0.001
	Labrador Retriever	74 (9.0)	17,031 (8.6)	0.9	0.7-1.2	0.582	
	Staffordshire Bull Terrier	87 (10.6)	15,454 (7.8)	1.2	0.9-1.5	0.151	
	Jack Russell Terrier	66 (8.0)	12,774 (6.4)	1.1	0.8-1.5	0.487	
	Cocker Spaniel	32 (3.9)	7,368 (3.7)	0.9	0.6-1.3	0.693	
	German Shepherd Dog	21 (2.5)	6,830 (3.4)	0.7	0.4-1.0	0.067	

	Yorkshire Terrier	22 (2.7)	6,556 (3.3)	0.7	0.5-1.0	0.138	
	Border Collie	21 (2.6)	5,205 (2.6)	0.9	0.5-1.4	0.517	
	West Highland White Terrier	9 (1.1)	5,028 (2.5)	0.4	0.2-0.7	0.005	
	Chihuahua	13 (1.6)	4,363 (2.2)	0.6	0.4-1.1	0.115	
	Cavalier King Charles Spaniel	16 (2.0)	4,207 (2.1)	0.8	0.5-1.4	0.424	
	English Springer Spaniel	10 (1.2)	4,052 (2.0)	0.5	0.3-1.0	0.048	
	Shih-tzu	9 (1.1)	3,939 (2.0)	0.5	0.3-1.0	0.035	
	Golden Retriever	4 (0.5)	3,569 (1.8)	0.2	0.1-0.6	0.005	
	Boxer	6 (0.7)	2,790 (1.4)	0.5	0.2-1.0	0.061	
	Bichon	13 (1.6)	2,673 (1.4)	1.0	0.6-1.8	0.895	
	Greyhound	11 (1.3)	2,122 (1.1)	1.1	0.6-2.0	0.743	
	Beagle	10 (1.2)	1,487 (0.8)	1.4	0.8-2.7	0.265	
	Other breeds	192 (23.4)	49,197 (24.8)	0.8	0.7-1.0	0.070	

436

Table 2b

Actual bodyweight (kg)	< 10.0	157 (19.1)	36,893 (18.6)	1.5	1.0-2.3	0.046	0.009
	10.0-19.9	176 (21.4)	34,539 (17.4)	1.8	1.2-2.7	0.004	
	20.0-20.9	126 (15.3)	28,640 (14.4)	1.6	1.0-2.4	0.035	
	30.0-30.9	80 (9.7)	20,041 (10.1)	1.4	0.9-2.2	0.115	
	≥ 40.0	27 (3.3)	9,615 (4.8)	Base			
	Not recorded	256 (31.1)	68,914 (34.7)	1.3	0.9-2.0	0.167	
Breed-relative bodyweight [b]	Lower	325 (39.5)	71,059 (35.8)	Base			0.044
	Equal/Higher	241 (29.3)	58,669 (29.5)	0.9	0.8-1.1	0.207	
	Not recorded	256 (31.1)	68,914 (34.7)	0.8	0.7-1.0	0.013	
Age category	< 3.0	436 (53.0)	82,661 (41.6)	3.0	2.1-4.2	< 0.001	< 0.001
	3.0 - 5.9	188 (22.9)	41,286 (20.8)	2.6	1.8-3.7	< 0.001	
	6.0 - 8.9	102 (12.4)	31,239 (15.7)	1.8	1.3-2.7	0.002	
	9.0 - 11.9	57 (6.9)	23,065 (11.6)	1.4	0.9-2.1	0.125	

	≥ 12.0	36 (4.4)	20,203 (10.2)	Base			
	Not recorded	3 (0.4)	188 (0.09)	9.0	2.7-29.3	< 0.001	
Sex	Female	322 (39.2)	94,741 (47.9)	Base			< 0.001
	Male	499 (60.7)	103,099 (51.9)	1.4	1.2-1.6	< 0.001	
	Not recorded	1 (0.1)	802 (0.4)	0.4	0.1-2.6	0.317	
Neuter status	Entire	59 (7.2)	15,426 (7.8)	Base			0.812
	Neutered	296 (36.0)	70,721 (35.6)	1.1	0.8-1.4	0.528	
	Not recorded	467 (56.8)	112,495 (56.6)	1.1	0.8-1.4	0.554	
Insurance status	Non-insured	235 (28.6)	63,233 (31.8)	Base			< 0.001
	Insured	285 (34.7)	47,200 (23.8)	1.6	1.4-1.9	< 0.001	
	Not recorded	302 (36.7)	88,209 (44.4)	0.9	0.8-1.1	0.346	

Table 2a and b: Descriptive and univariable logistic regression results for risk factors associated with road traffic accident (RTA) events in dogs attending primary-care veterinary practices in England.

[a] 95% confidence interval

[b] bodyweight relative to breed mean

Table 3

Case management	Categories	Freq.	Percent

Diagnostic imaging	No imaging performed	436	61.0
	Radiography only	218	30.5
	Ultrasonography only	19	2.7
	Radiology and Ultrasonography	42	5.9
Intravenous fluid therapy (IVFT)	IVFT used	241	33.7
	IVFT not used	474	66.3
Pain relief	No drug administered	131	18.3
	NSAIDS only	181	25.3
	Opioids only	114	15.9
	NSAIDS and opioids	289	40.4
Hospitalisation	Not hospitalised	337	47.1
	Hospitalised	378	52.9
Surgery under general anaesthetic	No surgery	587	82.1
	Surgery	128	17.9
Referred for advanced management	Not referred	660	92.3
	Referred	55	7.7

Table 2: Clinical management of road traffic accident events recorded in 725 dogs presented alive to primary-care veterinary practices in England.

447 Table 4

Variable	Category	Odds ratio	95% CI[a]	P-Value
Breed	Crossbreed	Base		
	Other breeds	0.8	0.6-0.9	0.011
	Beagle	1.2	0.7-2.3	0.523
	Bichon	0.9	0.5-1.6	0.687
	Boxer	0.5	0.2-1.0	0.059
	Chihuahua	0.6	0.3-1.0	0.051
	Border Collie	1.0	0.7-1.6	0.867
	Greyhound	1.5	0.8-2.8	0.191
	Golden Retriever	0.2	0.1-0.7	0.006
	Labrador Retriever	0.9	0.7-1.2	0.677
	German Shepherd Dog	0.7	0.4-1.1	0.119
	Shih-tzu	0.5	0.2-0.9	0.030
	Cavalier King Charles Spaniel	0.8	0.5-1.3	0.320
	Cocker Spaniel	0.9	0.6-1.3	0.574
	English Springer Spaniel	0.6	0.3-1.1	0.108
	Jack Russell Terrier	1.2	0.9-1.6	0.183
	Staffordshire Bull Terrier	1.2	0.9-1.5	0.242
	West Highland White Terrier	0.4	0.2-0.8	0.015
	Yorkshire Terrier	0.7	0.5-1.1	0.138

Age category (years)	<3.0 years	2.9	2.1-4.2	< 0.001
	3.0 - <6.0 years	2.5	1.7-3.5	< 0.001
	6.0 - <9.0 years	1.8	1.2-2.7	0.002
	9.0 - <12.0 years	1.4	0.9-2.1	0.118
	≥ 14.0 years	Base		
	Not recorded	10.5	3.1-35.2	< 0.001
Sex	Female	Base		
	Male	1.4	1.2-1.6	< 0.001
	Not recorded	0.3	0.0-2.3	0.258
Insurance status	Not insured	Base		
	Insured	1.5	1.2-1.8	< 0.001
	Not recorded	0.8	0.7-1.0	0.071

Table 3: Final multivariable logistic regression model for risk factors associated with a Road Traffic Accident (RTA) event in dogs attending primary-care veterinary practices in England.

[a] 95% confidence interval

[b] bodyweight relative to breed mean

References

1. Simpson SA, Syring R, Otto CM. Severe blunt trauma in dogs: 235 cases (1997-2003). *Journal of Veterinary Emergency and Critical Care*. 2009; **19**(6): 588-602.
2. O'Neill DG, Church DB, McGreevy PD, et al. Longevity and mortality of owned dogs in England. *Vet J*. 2013; **198**(3): 638-643.
3. Sharma D, Holowaychuk MK. Retrospective evaluation of prognostic indicators in dogs with head trauma: 72 cases (January-March 2011). *Journal of Veterinary Emergency and Critical Care*. 2015; **25**(5): 631-639.
4. Rochlitz I. The effects of road traffic accidents on domestic cats and their owners. *Animal Welfare*. 2004; **13**(1): 51-55.
5. O'Neill DG, Church DB, McGreevy PD, et al. Longevity and mortality of cats attending primary care veterinary practices in England. *Journal of Feline Medicine and Surgery*. 2015; **17**(2): 125-133.
6. Hayashi K, Manley PA, Muir P. Cranial cruciate ligament pathophysiology in dogs with cruciate disease: a review. *Journal of american animal hospital association* 2004; **40**(5): 385-390.
7. Guthrie JW, Keeley BJ, Maddock E, et al. Effect of signalment on the presentation of canine patients suffering from cranial cruciate ligament disease. *Journal of Small Animal Practice*. 2012; **53**(5): 273-277.
8. Streeter EM, Rozanski EA, Laforcade-Buress A, et al. Evaluation of vehicular trauma in dogs: 239 cases (January-December 2001). *Journal of the American Veterinary Medical Association*. 2009; **235**(4): 405-408.
9. Kolata RJ, Johnston DE. Motor vehicle accidents in urban dogs: a study of 600 cases. *Journal of the American Veterinary Medical Association*. 1975; **167**(10): 938-941.
10. Kolata RJ, Kraut NH, Johnston DE. Patterns of Trauma in Urban Dogs and Cats - Study of 1,000 Cases. *Journal of the American Veterinary Medical Association*. 1974; **164**(5): 499-502.
11. Hall KE, Holowaychuk MK, Sharp CR, Reineke E. Multicenter prospective evaluation of dogs with trauma. *Journal of the American Veterinary Medical Association*. 2014; **244**(3): 300-308.
12. VetCompass. VetCompass: Health surveillance for UK companion animals. London: RVC Electronic Media Unit; 2015.
13. The VeNom Coding Group. VeNom Veterinary Nomenclature. VeNom Coding Group; 2015.
14. Kearsley-Fleet L, O'Neill DG, Volk HA, et al. Prevalence and risk factors for canine epilepsy of unknown origin in the UK. *Veterinary Record*. 2013; **172**(13): 338.
15. Epi Info 7 CDC. Centers for Disease Control and Prevention (US): Introducing Epi Info 7. Atlanta, Georgia: CDC; 2015.
16. Irion DN, Schaffer AL, Famula TR, et al. Analysis of genetic variation in 28 dog breed populations with 100 microsatellite markers. *Journal of Heredity*. 2003; **94**(1): 81-87.
17. Kirkwood BR, Sterne JAC. Essential Medical Statistics. 2nd ed. Oxford, Blackwell Science; 2003.
18. Dohoo I, Martin W, Stryhn H. Veterinary Epidemiologic Research. 2nd ed. Charlottetown, Canada, VER Inc; 2009.
19. Hosmer DW, Lemeshow S, Sturdivant RX. Applied logistic regression. 3rd ed. ed. Hoboken, Wiley; 2013.
20. Taylor-Brown FE, Meeson RL, Brodbelt DC, et al. Epidemiology of Cranial Cruciate Ligament Disease Diagnosis in Dogs Attending Primary-Care Veterinary Practices in England. *Veterinary Surgery*. 2015; **44**(6): 777-783.
21. Mattin M, O'Neill D, Church D, et al. An epidemiological study of diabetes mellitus in dogs attending first opinion practice in the UK. *Veterinary Record*. 2014; **174**(14): 349.
22. Bellumori TP, Famula TR, Bannasch DL, et al. Prevalence of inherited disorders among mixed-breed and purebred dogs: 27,254 cases (1995-2010). *Journal of the American Veterinary Medical Association*. 2013; **242**(11): 1549-1555.
23. O'Neill DG, Church DB, McGreevy PD, et al. Prevalence of disorders recorded in dogs attending primary-care veterinary practices in England. *PLoS ONE*. 2014; **9**(3): 1-16.
24. Bamberger M, Houpt KA. Signalment factors, comorbidity, and trends in behavior diagnoses in dogs: 1,644 cases (1991-2001). *Journal of the American Veterinary Medical Association*. 2006; **229**(10): 1591-1601.

25. McGreevy PD. A Modern Dog's Life. Sydney, UNSW Press; 2009.

26. McGreevy PD, Georgevsky D, Carrasco J, et al. Dog behavior co-varies with height, bodyweight and skull shape. *PLoS One*. 2013; **8**(12): e80529.

27. Wells DL, Hepper PG. Prevalence of behaviour problems reported by owners of dogs purchased from an animal rescue shelter. *Applied Animal Behaviour Science*. 2000; **69**(1): 55-65.

28. McGreevy PD, Boakes RA. Carrots and Sticks: Principles of Animal Training. ISBN-13 978-0-521-68691-4 paperback ed. United states, Cambridge University Press; 2007.

29. Egenvall A, Nodtvedt A, Penell J, et al. Insurance data for research in companion animals: benefits and limitations. *Acta Veterinaria Scandinavica*. 2009; **51**: 42.

30. Capner CA, Lascelles BD, Waterman-Pearson AE. Current British veterinary attitudes to perioperative analgesia for dogs. *Veterinary Record*. 1999; **145**(4): 95-99.

31. Hugonnard M, Leblond A, Keroack S, et al. Attitudes and concerns of French veterinarians towards pain and analgesia in dogs and cats. *Veterinary Anaesthesia and Analgesia*. 2004; **31**(3): 154-163.

32. Reid J, AMHughes, JMLLascelles, DPawson, PScott, EM. Development of the short-form Glasgow Composite Measure Pain Scale (CMPS-SF) and derivation of an analgesic intervention score. Universities Federation of Animal Welfare; 2007; pp. 97-104.

33. Barletta M, Young CN, Quandt JE, Hofmeister EH. Agreement between veterinary students and anesthesiologists regarding postoperative pain assessment in dogs. *Veterinary Anaesthesia and Analgesia*. 2015.

34. Singh G, Arya N, Safaya R, et al. Role of ultrasonography in blunt abdominal trauma. *Injury*. 1997; **28**(9-10): 667-670.

35. Boysen SR, Rozanski EA, Tidwell AS, et al. Evaluation of a focused assessment with sonography for trauma protocol to detect free abdominal fluid in dogs involved in motor vehicle accidents. *Journal of the American Veterinary Medical Association*. 2004; **225**(8): 1198-1204.

36. Evans JA, van Wessem KJP, McDougall D, et al. Epidemiology of Traumatic Deaths: Comprehensive Population-Based Assessment. *World Journal of Surgery*. 2010; **34**(1): 158-163.