TITLE: Mortality resulting from undesirable behaviours in dogs aged under three years attending primary-care veterinary practices in England

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JOURNAL: Animal Welfare

PUBLISHER: Universities Federation for Animal Welfare

PUBLICATION DATE: 1 August 2018

DOI: 10.7120/09627286.27.3.251

Mortality resulting from undesirable behaviours in dogs aged under three years attending primary-care veterinary practices in England

Running title: Dog deaths related to undesirable behaviour

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Conflict of interest: Dan O'Neill is supported at the RVC by an award from the Kennel Club Charitable Trust. The remaining authors have no conflicts of interest to declare.

Acknowledgments: Thanks to Noel Kennedy (RVC) for VetCompass software and programming development. We acknowledge the Medivet Veterinary Partnership, Vets4Pets/Companion Care, 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.

Abstract

Undesirable behaviours (UBs) are common in dogs and can jeopardise animal and human health, leading to dog abandonment and euthanasia. Dogs exhibiting UBs may have compromised welfare from underlying emotional motivations for the behaviour (e.g. anxiety) or from how owners might seek resolution (e.g. aversive techniques). The objective of this study was to estimate proportional mortality due to UBs and risk factors for death due to UBs, including death from road traffic accidents, in dogs under three years of age attending primary-care veterinary practices in England from 2009-2014. Cases were identified by searching de-identified electronic patient records from primary-care veterinary practices participating in the VetCompass Programme. The findings highlight that dogs under three years of age are at a proportionately high risk of death due to UBs (33.7%) compared with other specific causes of death (e.g. Gastrointestinal issues:14.5%). Male dogs had 1.40 times the odds of death from UB compared with females. The proportional mortality from UB for male dogs where information on the cause of death was available was 0.41. Neutered dogs had 1.94 times the odds of death due to an UB compared with entire dogs. Aggression was the most prevalent UB overall. Veterinarians had recommended referral in 10.3% of cases where dogs died due to exhibiting an UB and had dispensed nutraceutical, pheromone or pharmacological treatment to 3.0% of the UB cases that died. This study shows that undesirable behaviours require better preventive measures and treatment,

through further research and education of veterinarians, other professionals within the dog industry and owners.

Keywords: animal welfare, behaviour, canine, epidemiology, euthanasia, VetCompass

Introduction

Dogs are the most common mammalian companion animal in the UK, with an estimated 24% of households owning a dog (Westgarth et al., 2007; Pet Food Manufacturers Association, 2014). Often dubbed 'man's best friend', dogs offer health and companionship benefits to their human carers but, for many human households, the reality of dog-owner co-existence is not always as harmonious as expected (McGreevy and Bennett, 2010; McGreevy and Calnon, 2010). Many dogs behave in ways that owners find unwelcome, with 40-87% of dogs reported to exhibit undesirable behaviours (UBs) (Voith, 1985; Campbell, 1986; O'Farrell, 1992; Martínez et al., 2011). UBs can be either a normal behaviour such as vocalisation, a behavioural pathology such as tail-chasing or can arise due to physiological dysfunction or medical conditions e.g., inappropriate elimination may result from a urinary tract infection (Overall, 1997; Landsberg et al., 2012) . Human opinions about the undesirability of a behaviour are subjective and are heavily dependent on context and the human's expectations of how a dog should behave (Jagoe and Serpell, 1996). This underlines the importance of veterinary and behaviourist input for dogs suspected of UBs. Some owners find certain UBs, such as tail-chasing, amusing and only consider these activities as a problem when the dog hurts itself or spends excessively long periods carrying out the behaviour (Burns, 2011). The purpose for which the dog was acquired can also affect the perceived desirability by the owner for any given behaviour. For example, vocalisation may be welcomed in a dog acquired for protection of property but unwelcome in a dog acquired as a child's pet (Lund et al., 1996). In contrast to experienced dog owners, first-time owners report a higher prevalence of UBs in their dogs, which could reflect their limited understanding of how normal behaviour manifests in dogs (Jagoe and Serpell, 1996) and how to respond to early signs of UBs.

78 Specific behavioural patterns can be typically associated with individual breeds. For example,
79 chase behaviour may be normal and common in certain dog breeds such as Border Collies and varying
80 levels of this behaviour may be expressed across other breeds (Udell et al., 2014). Similarly, individual
81 breeds may be associated with typical pathological behaviours e.g. flank-sucking in Doberman
82 Pinschers (Moon-Fanelli et al., 2007; Dodman et al., 2010). The causes of UBs are manifold and include
83 various combinations and interactions between owner-related management (McBride, 1995) and
84 multiple genetic, phenotypic, learning and environmental factors (McCune et al., 1995). It is important
85 to note that the emotional motivation of anxiety may be needed in certain situations and can contribute
86 positively to survival (Livesey, 1986). Many UBs show a negative correlation between the size of the
87 dog and the prevalence of the behaviours (Martínez et al., 2011; McGreevy et al., 2013; Stone et al.,
88 2016). For example, it has been reported that as dog size decreased, human-directed aggression
89 increased (Martínez et al., 2011). McGreevy et al. (2013) stated that, for behaviours reported through
90 the Canine Behaviour Assessment and Research Questionnaire (C-BARQ), the frequency of 33
91 undesirable behaviours had at least one significant morphological predictor e.g. height alone (n= 14)
92 and bodyweight alone (n= 5) (McGreevy et al., 2013).
93 Small breeds may have been unintentionally selected for traits linked with UBs. For example
94 the small size of the dogs may have led to the perception that UBs are less problematic than for larger
95 dogs (McGreevy et al., 2013). Associations between behaviour and size could also be environmentally
96 driven because owners tend to treat small dogs differently to large dogs. Small dogs may be managed
97 and handled in ways that inadvertently increase fear and elicit aggression, e.g. being picked-up without
98 much warning. The lack of autonomy and the likely discomfort associated with being lifted-off the
99 ground at speed, may contribute to small dogs becoming fearful of humans. In addition, small dogs may
100 receive less training than large dogs (Martínez et al., 2011).
101 There are many response options for owners of dogs that exhibit UBs. The most extreme of the
102 available approaches would be to euthanise or relinquish the dog. It is worth noting that many of the
103 behaviours captured by the C-BARQ would not be likely triggers for euthanasia. Indeed, there is some

104 evidence that, overall, only 5.5% of dogs with UBs are recommended for, or are actually, euthanised
105 (Lund et al., 1996). However, for most UBs, there is not a 'quick-fix' solution because altering a learnt
106 behaviour and emotional response takes time and often requires the owners to make lifestyle changes
107 (Reisner, 2003). Therefore, owners must be willing to invest time and effort into implementing a
108 remedial training program and, where human health is at risk, then euthanasia might be considered the
109 best option (Reisner et al., 1994). If the UB is driven by an abnormal emotional response such as
110 maladaptive anxiety, it can deny the dog the opportunity to exhibit normal biological functions (Ohl et
111 al., 2008), for example dogs that suffer from anxiety might have a reduced appetite or show an
112 unwillingness to go outside which can affect housetraining. Under these circumstances, the dog's
113 welfare is compromised and this needs to be considered when deciding on how to manage or treat the
114 UB.

115 A recent study of dogs presented to veterinary clinics in the South-East of England reported
116 that the three most common causes of death among dogs under the age of three years of age were
117 behavioural abnormality (14.7%); gastrointestinal disorder (14.5%) and road traffic accident (RTA)
118 (12.7%) (O'Neill et al., 2013). RTAs may result from straying, poor recall, or limited traffic training,
119 all of which have associated behavioural components (McGreevy, 2009). Therefore, the combined
120 proportional mortality from RTA and undesirable behaviours may account for up to 27.40% of deaths
121 in dogs under the age of three years (O'Neill et al., 2013).

122 The current study aimed to determine the proportional mortality due to a UB and risk factors
123 for mortality due to UBs (including RTAs) in dogs aged under three years of age attending primary-
124 care veterinary practices in the UK. The primary focus was to identify dog breeds or type (notably size)
125 associated with increased mortality due to UBs, to characterise the UBs recorded and describe their
126 clinical management. As discussed previously, many UBs show a negative correlation between the size
127 of the dog and the prevalence of the behaviours (Martínez et al., 2011; McGreevy et al., 2013; Stone et
128 al., 2016). Therefore, this study wanted to evaluate if this transcribed into smaller breeds and dogs in

the lighter weight categories, regardless of breed, having a higher proportional mortality from UBs compared with larger breeds and dogs in heavier weight categories.

Materials and methods

VetCompass

The VetCompass companion animal surveillance programme (VetCompass, 2016) collates de-identified electronic patient record (EPR) data from primary-care veterinary practices in the UK for epidemiological research (O Neill et al., 2014). Collaborating practices were selected by their willingness to participate, and their recording of clinical data within an appropriately configured practice management system (PMS). Practitioners could record summary diagnosis terms from an embedded VeNom Code list (The VeNom Coding Group, 2015) during episodes of care. Information collected related mainly to the owned dog population and included data on patient demography (species, breed, date of birth, sex, neuter status, insurance status and bodyweight) and clinical information data fields (free-form text clinical notes, summary diagnosis terms, treatment and de-activated status with relevant dates). Dogs recorded as de-activated may either have died or were no longer registered at the practice for some other reason, such as relocation. EPR data were extracted from PMSs using integrated clinical queries (O'Neill et al., 2014) and uploaded to a secure VetCompass relational database.

A cross-sectional study design using cohort clinical data was used to estimate the proportional mortality and risk factors for mortality from undesirable behaviours in dogs that died aged under three years (Pearce, 2012). Sample size calculations estimated that 421 dogs weighing under 10 kg and 106 dogs weighing 30-40 kg would be required to detect a 2 fold increase in the odds of death from UBs among all deaths (80% power, assuming that 25% of deaths in the group aged under 10 kg were ascribed to UBs, 95% confidence level, Epi Info 7 CDC, 2012) . Ethical approval was granted by the Veterinary Ethical Review Committee from The Royal (Dick) School of Veterinary Studies (reference number 25/15).

155 ***Selection criteria and definitions***

156 The sampling frame for the current study included all dogs recorded as de-activated within the
157 VetCompass database from September 1st, 2009 to August 31st, 2014. The age at de-activation was
158 calculated for each dog as the difference between the dates of birth and de-activation. The subset that
159 were aged under three years at de-activation was selected and randomised using the *RAND* function in
160 Microsoft Excel (Microsoft Office Excel 2007, Microsoft Corp). The full EPR of each dog was
161 manually reviewed to identify those dogs that had truly died and to identify the date of death, the method
162 of death and whether the cause of death was ascribed to an UB. UBs were defined in Appendix Table
163 1. Additional data were extracted on deaths ascribed to UBs to determine whether pharmacological
164 therapy had been tried, whether a referral had been offered, whether neutering was due to UB, whether
165 the owners tried to resolve the UB and whether rehoming had been attempted before euthanasia
166 (Appendix Table 2).

167 An undesirable behaviour was defined as any behavioural attribute that was recorded in the clinical
168 notes and which the owner and/or other people deemed to be unwelcome. Other people included
169 veterinarians and nurses, groomers, trainers, anyone in the dog profession, and family, friends or
170 strangers that interacted with the dog. Additionally, for the purposes of the current study, RTA was
171 included as an UB. The case definition for UB mortality required that the stated cause of death included
172 either: 1) a stated cause of death from a UB or 2) death resulting from RTA.

173

174 ***Variables***

175 A *purebred* variable grouped all dogs recorded as a recognisable breed (Irion et al., 2003) as
176 'purebred' and all other dogs as 'crossbred'. A *breed* variable included any individual breeds with 15
177 or more dogs in the study, a grouping of all remaining breeds (i.e. breeds with less than 15 study dogs)
178 and a grouping of all crossbred dogs. A *KC breed group* variable classified breeds recognised by the
179 Kennel Club (KC) into their relevant KC breed groups (Gundog, Hound, Pastoral, Terrier, Toy, Utility,
180 Working) and all remaining dogs were classified as non-KC recognised. *Neuter* described the status of

the dog (entire or neutered) as 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 death (years) and was categorised into three groups (< 1.0, 1.0-1.9, 2.0-<3.0). *Bodyweight* described the maximum bodyweight recorded during the study period 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).

Data Analysis

Data checking and cleaning to evaluate for internal data consistency, missing values and outlier data were performed in Excel (Microsoft Office Excel 2007, Microsoft Corp.). All analyses were conducted using Stata Version 13 (Stata Corporation).

The proportional mortality with 95% confidence intervals (CI) described the probability of dogs dying with a cause ascribed to a UB from all dogs that died aged under three years of age with an ascribed cause of death. The CI estimates were derived from standard errors, based on approximation to the normal distribution (Kirkwood and Sterne, 2003). Descriptive statistics characterised the breed, sex, neuter status, insurance status, bodyweight and age at death separately for all dogs, the dogs that died from a cause ascribed to a UB and the dogs that died from a cause other than a UB. The chi-square test was used to compare categorical variables (Kirkwood and Sterne, 2003). All specific and grouped UB disorder terms recorded as causes of death were extracted and ranked according to frequency of deaths from that UB.

Binary logistic regression modelling was used to evaluate univariable associations between risk factors (*purebred, breed, KC breed group, bodyweight, sex, neuter, insurance and age at death*) and an outcome of death from a UB. Risk factors with liberal associations in univariable modelling ($P < 0.2$) were taken forward for multivariable evaluation. With breed being a factor of primary interest for the study, *purebred*, *KC breed group* and *bodyweight* (highly associated with breed) were not simultaneously considered in multivariable modelling but instead were each individually used to replace the *breed* variable in the final breed multivariable model developed from *breed, age at death, sex and*

neuter status. Model development used manual backwards stepwise elimination. Clinic attended was evaluated as a random effect and pair-wise interaction effects were evaluated in the final model (Dohoo et al., 2009). The quality of the model fit was assessed using the area under the ROC curve and the Hosmer-Lemeshow test statistic for the main final multivariable model (Dohoo et al., 2009; Hosmer et al., 2013). Statistical significance was set at $P < 0.05$.

Results

There are an estimated 5 thousand clinics in the UK (O'Neill et al., 2013). The overall sampling frame comprised 264,259 dogs attending 127 clinics in England. The 127 clinics in this study comprises 2.5% of these 5 thousand clinics. Of these 264,259 dogs, 41,280 dogs were recorded as deactivated overall with 7,882 of these recorded as deactivated before three years of age. Manual EPR evaluation of all of these 7,882 records confirmed that 1,574 were records for a single dog that had died aged under three years of age and these 1,574 dogs were therefore included in the current analysis. Reasons for deactivation of the dogs that were not confirmed deaths included dogs that were rehomed, or belonging to owners who moved away, switched practices or were bad debtors.

Of the 1,574 records of death relating to dogs that died before three years of age, 933 (59.3%) were not ascribed to UBs, 474 (30.1%) were ascribed to UBs (including RTAs) and 167 (10.6%) did not have a cause ascribed. The estimated prevalence of deaths ascribed to UBs among deaths with a cause ascribed (n=1,407) was 33.7% (95% confidence interval [CI] 31.2-36.2). There are an estimated 8 million dogs in the UK and they live on average 12 years so there are an estimated 666 667 deaths per year (O'Neill et al., 2013). Of these, 9.6% die before 3 years of age (489/5095) equalling 63,984 dogs under 3 years dying annually (O'Neill et al., 2013). Therefore, it can be estimated that 33.7% (21,562 dogs) of these were from UB.

Of the 1,574 deaths, the mechanism of death was not recorded for 109 (6.9%) of deaths. Of the remaining deaths, 984 (76.2%) were by euthanasia and 481 (32.8%) were unassisted. Of the unassisted

deaths, 143 were associated with RTAs (not all dogs involved in an RTA died unassisted), 17 were dogs killed by other dogs and the remaining 321 died from other reasons.

Demographic data

Of the dogs that died from UBs, the median age at which an UB was first recorded was 1.4 years (interquartile range [IQR] 0.8-2.0, range 0.0-<3.0), the median bodyweight was 14.5 kg (IQR: 6.8-25.3, range: 1.6-54.0) and the median age at death was 1.5 years (IQR: 1.0-2.1, range: 0.0-<3.0). Table 1 displays additional descriptive and univariable logistic regression results for the categorical risk factors: body weight, age at death, sex, neuter status and insurance status.

The clinical notes recorded that neutering had been undertaken during the available clinical records in 91/474 (19.2%) dogs during the study period. Of the 91 dogs with a recorded reason for the neutering decision, 7/91 (7.7%) neutering decisions were made at least in part to address the UB. The median age at neutering was 0.9 years (interquartile range [IQR] 0.6-1.2, range 0.3-2.6). The acquisition source of the dog was not recorded for 409 (86.3%) dogs that were deceased due to an UB. For the remaining 65 dogs for which the sources of acquisition were recorded, these were breeder (n = 24, 36.9%), rescue centre (21, 32.2%), previous owner (11, 16.9%), family/friend (4, 6.2%), pet shop (2, 3.1%), bred themselves (2, 3.1%) and puppy farm (1, 1.5%).

Table 2 displays the descriptive and univariable logistic regression results for categorical risk factors of purebred versus crossbred, individual purebred breeds and for Kennel Club (KC) Breed Groups. Breed was recorded for 473 of the 474 dogs that died from causes related to UB and, of these, 347/473 (73.4%) were purebred. The most common breeds that died from UBs were the Staffordshire Bull Terrier (n = 92, 19.5%) Jack Russell Terrier (n = 34, 7.2%) and Cocker Spaniel (n = 20, 4.2%), along with crossbreds (n = 126, 26.6%).). The KC Terrier group was the KC group that covered the highest count of dogs that died of UB 9n = 109, 23.0%). Sex was recorded for 473 of the 474 dogs that died from causes related to UB and 171/473 (36.2%) with sex status recorded were female. Neuter status

was recorded for 153/474 (32.3%) of dogs that died from causes related to UB and 117/153 (76.5%) of these were neutered. Insurance status was recorded for 304/474 (64.1%) dogs that died from causes related to UB and of these 93/304 (30.6%) were insured.

Treatment

Among the 474 dogs that died from UBs, the clinical notes indicated that owners had sought behavioural advice for 61 (12.9%) dogs and behavioural referral was recommended for 49 (10.3%) dogs. It was not always clear from the records if the owners attended the behavioural resource that the veterinarian recommended or if these were independently identified by the owners. For the dogs whose owners did seek help (n = 61), the source of this assistance was recorded as animal behaviourist (n = 21, 34.4%), veterinary surgeon (21, 34.4%), dog trainer (5, 8.2%) and unspecified (14, 23.0%). Of the 474 dogs that died due to an UB, prior use of pharmacological management for the UB was recorded in 14/474 (3.0%) dogs. Rehoming had been attempted but had proved unsuccessful in 58/474 (12.2%) dogs and one (0.2%) dog had been rehomed to a rescue centre before being euthanised due to aggression. For the remaining 415 (87.6%) dogs, there was no indication of rehoming attempts.

Non-behavioural deaths

Of the dogs that died from causes other than UBs (not including those animals with missing data), 734 (78.8%) were purebred, 422 (46.2%) were female, 111 (48.5%) were neutered and 148 (29.6%) were insured. The median bodyweight was 8.9 kg (IQR: 2.9-21.6, range: 0.1-73.0) and the median age at death was 0.6 years (IQR: 0.2-1.6, range: 0.0-3.0) years. The most common breeds that died from causes other than UBs were the Staffordshire Bull Terrier (n = 75, 8.1%), Jack Russell Terrier (n = 49, 5.3%), Chihuahua (n = 44, 4.7%), along with crossbreds (n = 198, 21.2%) (Table 2).

Undesirable behaviours exhibited

Of the 474 dogs that died from UBs, 364 (76.8%) had a single UB reported as a contributory cause of death, 83 (17.5%) had two UBs, 19 (4.0%) had three UBs, 6 (1.3%) had four UBs and 2 (0.4%) had five UBs. There were 36 specific UB terms recorded as causes of death in dogs aged under three years. Of these, the most common specific UBs recorded were road traffic accident (RTA) (n = 185, 39.0% of deaths ascribed to UBs, 95% CI 34.6-43.6), inter-pet conflict (n = 31, 6.5%, 95% CI 4.5-9.2) and dog attack (n = 28, 5.9%, 95% CI 4.0-8.4). After grouping the UBs into 14 groups, the most common UB groups were aggression (n = 256, 54.0%, 95% CI 49.4-58.6) and RTA (n = 185, 39.0%, 95% CI 34.6-43.6) (Table 3). The most common UB group, aggression, was cited as a contributory cause of death for 100.0% (11/11) Rottweilers, 100% (4/4) Bulldogs, 88.9% (8/9) Border Collies, 87.5% (7/8) American Pit Bull Terriers, 71.4% (10/14) German Shepherd Dogs, 73.9% (68/92) Staffordshire Bull Terriers and 53.2% (67/126) crossbreds that died of UB.

Risk factor analysis

Univariable logistic regression modelling identified 8 variables with liberally significant ($P < 0.20$) association with death from UB: *purebred, breed, KC breed group, bodyweight, age at death, sex, neuter and insured* (Tables 1 and 2). As explained above, *purebred, breed, KC breed group* and *bodyweight* were not considered simultaneously in multivariable modelling. Following evaluation using multivariable logistic regression, the final breed model comprised 4 risk factors: *breed, age at death, sex and neuter status*. No biologically significant interactions were identified. The final model was not improved by inclusion of the clinic attended as a random effect ($P = 0.209$). The final model showed adequate fit (Hosmer-Lemeshow test: $P = 0.641$) and good discrimination (area under the ROC curve: 0.762). *Purebred*, *KC breed group* and *bodyweight* each replaced the *breed* variable in the final breed multivariable model and these multivariable results are reported for these three variables.

Crossbred dogs had 1.39 times the odds (95% CI 1.05-1.83; $P = 0.023$) of death from an UB compared with purebred dogs. Dogs from the KC Utility, Toy, Working, Pastoral and Terrier groups had lower odds of death from an UB compared with breed types not recognised by the KC. Dogs of

bodyweight ≥ 40.0 kg had 0.44 times the odds (95% CI 0.20-0.97; $P = 0.041$) of death from an UB compared with dogs weighing < 10.0 kg (Table 4).

After accounting for the effects of the other variables evaluated, Cocker Spaniel (8.04 OR, 95% CI 2.99-21.56, P < 0.001), West Highland White Terrier (5.71 OR, 95% CI 1.44-22.67, P = 0.013), Staffordshire Bull Terrier (4.50 OR, 95% CI 2.10-9.64, P < 0.001), Jack Russell Terrier (2.69 OR, 95% CI 1.16-6.21, P = 0.021), and crossbreeds (2.62 OR, 95% CI 1.26-5.42, P = 0.010) showed higher odds of death from UBs compared with Labrador Retrievers. Compared with dogs aged under one year, dogs aged 1.0 to < 2.0 years showed 5.42 times the odds (95% CI 3.96-7.43; $P < 0.001$) and dogs aged 2.0 to < 3.0 years showed 4.21 times the odds (95% CI 3.03-5.86; $P < 0.001$) of death from an UB. Male dogs, had 1.40 times the odds (95% CI 1.09-1.81; $P = 0.009$) of death from an UB compared with female dogs. Neutered animals had 1.94 (95% CI 1.17-3.22, P = 0.010) times the odds of death from an UB compared with entire animals (Table 5).

Discussion

UBs are one of the most common reasons to euthanise owned companion dogs, (Hsu and Serpell, 2003) most notably dogs under three years of age (O'Neill et al., 2013). The current study reports that the prevalence of dogs under the age of three in the primary-care caseload dying due to UBs is 33.7%. This is higher than the prevalence reported in an earlier comparable study (O'Neill et al., 2013) of dogs under the age of three, that assigned behavioural abnormalities and RTAs a combined percentage of 27.40% (O'Neill et al., 2013). The relatively high proportion of deaths due to UBs in the current study, could reflect owners' focusing on the detrimental effects that the dogs' UBs have on their own human quality of life and the prospect that dogs displaying UBs, such as anxious behaviours or self-trauma, could have reduced welfare and compromised dog quality of life (Hiby et al., 2004). Dying due to an UB is an increased risk compared with death from other causes for dogs under the age of three. For example, in dogs under the age of three the prevalence of death due to Gastrointestinal issues is 14.5% or the prevalence of death due to neurological issues is 7.4 % (O'Neill et al., 2013).

This study wanted to evaluate if smaller breeds and dogs in the lighter weight categories, regardless of breed, have a higher proportional mortality from UBs compared with larger breeds and dogs in heavier weight categories, as previous research has shown a negative correlation between the size of the dog and the prevalence of the behaviours (Martínez et al., 2011; McGreevy et al., 2013; Stone et al., 2016) . For dogs in all the weight categories (other than '≥ 40.0') there was no significant finding. For the population of dogs less than three years of age in the weight category '≥ 40.0', the risk of death ascribed to an UB decreases with body weight. This finding could be due to larger breeds posing a greater perceived risk of injury and therefore owners of larger dogs invest more time training appropriate behaviours to prevent UBs from occurring (Martínez et al., 2011). It is possible that the C-BARQ reports preferentially describe behaviours of dogs that are not in immediate danger of being euthanised; i.e. behaviours that can be tolerated, or that deaths attributed to UBs in larger dogs may be observed after the age of three.

Age was also a risk factor with dogs aged 1.0 to < 2.0 years and dogs aged 2.0 to < 3.0 years having an increased risk of death due to an UB compared with dogs under the age of one. Although the rationale behind this finding is not completely clear, it is possible that owners may be more willing to tolerate UBs in a puppy, if they view the UB as a puppy behaviour. A dog's personality is not stable in puppies under 9 months of age so a puppy's personality is not necessarily a predicator of what they will be like as an adult (Goddard and Beilharz, 1986). Puppies have also been shown to exhibit fewer UBs compared with juvenile and adult dogs (Wells and Hepper, 2000), though aggression can be exhibited within the first year (Guy et al., 2001). It is important to note that early life experiences can impact a dog and the UBs that they later exhibit. Previous research has shown that suboptimal learning opportunities before eight weeks of age are a risk factor for behavioural issues later in life (Appleby et al. 2002). The quality of socialisation is also important, as puppies that are exposed to negative incidents are more likely to show aggression later in life (Wormald et al., 2016). Owners who have received advice regarding their puppy from a veterinary behaviourist report fewer UBs thus illustrating the importance for owners to receive good behavioural advice when their dog is young to prevent UBs from

361 arising or to prevent them from worsening as that is when owners may seek to resolve the problems
362 (Gazzano et al., 2008). Though only 25% of veterinarians enquire about behaviour on a regular basis
363 (Hetts et al., 2004). Behavioural referral recommendation was recorded in 10.3% of the UB death cases
364 and nutraceutical, pheromone or pharmacological treatment were used in only 3.0% of the UB death
365 cases. These low percentages could be due to many reasons such as it might not have been recorded in
366 the EPR if the veterinarian offered referral or nutraceutical, pheromone or pharmacological treatment
367 and the owner did not accept. This current study revealed that a record of owners trying to solve the UB
368 was present in only 12.9% of behavioural death cases and only 34.4% of these 12.9% had previously
369 consulted their veterinarian about their dogs' behaviour. There are many potential reasons for this
370 relatively low percentage. For example, the owner may have viewed the UB as too severe to resolve or
371 been unaware of the veterinary and other options available to them. If they did consult their veterinarian,
372 it is possible that they did not tell them about any interventions that they had already tried or the
373 veterinarian did not record information about previous attempts to resolve the behaviour in the EPR.
374 Sex was also identified in the current study as a risk factor, with male dogs having 1.40 times
375 the odds of death due to an UB compared with females. This finding agrees with previous research that
376 has shown that male dogs are more likely to exhibit an UB compared with female dogs (Wright and
377 Nesselrote,1987; Landsberg, 1991; Hsu and Serpell, 2003). Therefore, increased prevalence of
378 exhibiting an UB could explain the statistical difference as to why males are at higher risk of death due
379 to an UB compared with female dogs. Neutered dogs also have a higher risk of death due to an UB
380 compared with entire dogs. This difference could be due to owners using neutering as a solution to the
381 UB however, of the neutered dogs in this study only 7.7% were recorded as being neutered as a bid to
382 address the UB. Many scientific papers that have assessed whether neuter status affects behaviour have
383 reported contradictory results. Older studies suggested that neutering aggressive dogs could help reduce
384 aggression (Wright and Nesselrote,1987; Blackshaw, 1991) but a more recent study reported that
385 neutered male and female dogs were more likely to show aggression compared with entire male and
386 female dogs (Guy et al., 2001).

Breed was also identified as a risk factor in the current study. Labrador Retrievers were chosen as the base line as they have a reputation for being a friendly family dog and are regularly used as service dogs (The Guide Dogs for the Blind Association, 2017). The most popular breed types in the UK by percentage are: Crossbreeds (21.1%), Labrador Retriever (9.0%), Staffordshire Bull Terrier (8.2%), Jack Russel Terrier (6.7%), Cocker Spaniel (3.8%), German Shepard dog (3.6%), Yorkshire Terrier (3.3%) and Border Collie (2.7%) (O'Neill et al., 2014). The current study found that the Cocker Spaniel, West Highland White Terrier, Staffordshire Bull Terrier, Jack Russell Terrier, and crossbreeds showed higher odds of death from UB compared to Labrador Retrievers. All of these breeds, other than the West Highland White Terrier, are in the list of most popular breeds in the UK and emphasises that popularity does not preclude high proportional probability of death from UB. The West Highland White Terrier has previously been reported to exhibit aggression to unfamiliar dogs which could be a factor in the owner's decision to euthanise them due to an UB (Duffy et al. 2008).

Previous literature has examined whether breed has an impact on behaviour with conflicting results. Breeds in the UK that have previously been identified with aggression include: German Shepard Dog, Rottweiler, American Pit Bull Terrier, Bull Terrier, Great Dane, Dobermann, Border Collie, Wolfhound (Podbersecek, 1994) and Cocker Spaniel (Podberscek & Serpell, 1996 and Podberscek & Serpell, 1997). Only the Cocker Spaniel is in both lists. Previous research has reported that aggression is prevalent in Cocker Spaniels and it has been described as 'rage syndrome' or 'low threshold aggression' (Podberscek & Serpell 1996). Though Martinez et al. 2011, found no difference between breeds and the prevalence of aggression. Our findings did not assess whether the Cocker Spaniels in it would be classified as having 'rage syndrome' but it is known that there is a genetic component to this UB (Podberscek & Serpell 1996). It has also been shown that Cocker Spaniels are one of the breeds that most represents attacks on humans, along with terrier breeds (Amat et al. 2009). Though science has shown correlations between individual breeds and certain behaviours, a lot of information, especially with regards to aggression, has come from reports based on bite statistics which could be

biased due to increased risk of injury from larger dogs (Duffy et al. 2008) and therefore it is important to remember that every dog is an individual.

The most common UB group was aggression. This aligns with previous reports that the most common behaviour concern reported to veterinarians is aggression and that this is the behaviour that poses the most risk to humans (Beaver, 1994; Reisner, 2003). Aggression in dogs is a public health and welfare concern (Duffy et al. 2008), however, reporting that a dog is 'aggressive' does not explain the context in which the dog exhibited aggression and therefore does not identify the motivation or explain whether the aggression was abnormal or 'appropriate' given the circumstances. Fear, anxiety and frustration are emotional motivations for which aggression can be an appropriate behavioural response (McGreevy and Calnon, 2010).

The current study ascribed 5.9% of deaths from UB before 3 years of age to dog attack but the available study data did not include the absolute context for each altercation. The roles of aggressor and aggressee within any dog-on-dog altercation are complex and may often be fluid: an initial submissive response may swiftly change to an aggressive one. In addition, pre-existing UBs in either party plus extrinsic factors such as the presence of owners or food/toys may promote the possibility, severity or duration of any event. This is an area of research that warrants greater exploration and could be the subject of a prospective study based on primary-care veterinary clinical records.

Implications for the dog owning public

The data from this study highlight the importance of education for owners about acceptable and unacceptable behaviour in dogs. Human perception is also an important factor in the classification of behaviours in dogs as being undesirable. Owner expectations are related to their understandings about the normal behavioural responses of domestic dogs and of the underlying emotional motivations for those responses. Improved education to enable owners to recognise 'normal' canine behaviour and identify emotional states such as fear and anxiety, is necessary to improve early reporting of behavioural concerns. Combining this with improved education of the veterinary profession offers opportunity for

owners to find appropriate information on sourcing and raising a puppy and guidance concerning the management and potential resolution of UBs. Technology is a rapidly expanding market in the pet world and encouraging owners to monitor the behaviour of their pet may be beneficial; technologies such as smartphone apps can assist them in recording management, socialisation and current behaviours (Paldanius et al. 2011). There has been much discussion regarding influences from the early rearing environment on subsequent behaviour of domestic dogs (Appleby et al 2002, Pluijmakers et al 2010). It is advised that young puppies are exposed to a complex environment in a controlled way in order to ensure that the puppy is in a positive emotional state (Howell et al., 2015). Research has identified additional factors, which can affect the presence of UBs. For example rearing environment, dogs sourced from pet shops exhibit increased aggression towards familiar people (Pirrone et al., 2016) and dogs that are from more stressful environments such as the breeding stock from puppy farms have been reported to have more problems with training and show more anxiety and fear related behaviours (McMillan et al. 2011). Dogs whose owners had previous dog owning experience and spent more time with their dog and attended training classes were more likely to respond to verbal cues (Kobelt et al., 2003). This literature suggests that it is important for puppies and adult dogs to be appropriately socialised, habituated and trained. However, only 24% of dog owners are reported to attend training classes (Coren, 1999) Coren, 1999 is almost 20 years old and it is possible that more people attend training classes now as there is more information available about the importance of training a dog and there are more repercussions if your dog is a nuisance or dangerous to other people but a more recent study found that people would rather seek help that is free than pay for services (Shore et al. 2008). Owners who engage in training with their dogs report that their dogs are less ‘disobedient’, less nervous and more friendly (Bennett and Rohlf, 2007).

Animal Welfare Implications

As previously discussed, animals that exhibit UBs are at risk of compromised welfare, either because of their own underlying emotional motivations for the behaviour (e.g. anxiety or fear) or

because of the ways in which their owners might seek to resolve the problem (e.g. the use of aversive techniques such as electric shock collars (Schilder & Van Der Borg, 2004)). The high level of reporting of behavioural concerns by owners, and the implications of UB in terms of mortality risk as well as animal welfare in those that do not die, would suggest that behavioural medicine should be considered a day one 'core competence' skill for veterinary graduates and afforded appropriate time and importance within the veterinary curriculum.

Conclusion

This study has reported UB as a substantial risk factor of death for dogs under the age of three years of age. The odds of death ascribed to an UB increases with age (up to three years), for males, for cross breeds and certain breeds: The Cocker Spaniel, West Highland White Terrier, Staffordshire Bull Terrier, Jack Russell Terrier. Aggression is the most prevalent UB group and of the dogs that died due to an UB, 100% of Rottweilers, 100% of Bulldogs, 88.9% of Border Collies, 87.5% of American Pit Bull Terriers, 71.4% of German Shepherd Dogs, 73.9% of Staffordshire Bull Terriers and 53.2% of crossbreeds in the study died due to aggression. Further studies are needed to investigate the context in which UBs are exhibited, to establish the efficacy of treatments and to determine the effects of owner education (specifically about socialisation and training) in reducing the prevalence of UBs.

In most cases in this study, veterinarians did not record offers of advice on how to solve the UB or where to find a behavioural professional for further help. Furthermore, in most cases, there was no record of the owners having actively pursued resolution of the UB. In the interests of improving welfare of domestic dogs, the authors suggest that it would be beneficial to investigate whether targeted education of veterinarians can increase their effectiveness in the management of UBs and in recognising the triggers for referral of these dogs so that they can receive appropriate help.

Abbreviations

CI; confidence interval

EPR; electronic patient record

KC; Kennel Club

OR; odds ratio

PMS; practice management system

SQL; structured query language

UB; undesirable behaviour

RTA; road traffic accident

499 **Tables**

500 Table 1: Descriptive and univariable logistic regression results for risk factor (bodyweight, age at death,
501 sex, neuter status and insurance status) associations with deaths that were or were not ascribed to
502 undesirable behaviour (UB) among dogs attending primary-care veterinary practices in England that
503 died before three years of age (n = 1,574).

Variable	Category	UB No. (%)	Non-UB No. (%)	Odds ratio	95% CI*	*P*-value
Bodyweight (kg)	< 10.0	107 (22.6)	307 (32.9)	Base		
	10.0-19.9	60 (12.7)	115 (12.3)	1.50	1.02-2.19	0.038
	20.0-29.9	55 (11.6)	84 (9.0)	1.88	1.25-2.82	0.002
	30.0-39.9	34 (7.2)	49 (5.3)	1.99	1.22-3.25	0.006
	≥ 40.0	10 (2.1)	29 (3.1)	0.99	0.47-2.10	0.978
	Not recorded	208 (43.9)	349 (37.4)	1.71	1.29-2.26	< 0.001
Age at death (years)	< 1.0	112 (23.9)	559 (60.4)	Base		
	1.0 - < 2.0	190 (40.6)	189 (20.4)	5.02	3.77-6.68	< 0.001
	2.0 - < 3.0	166 (35.5)	178 (19.2)	4.65	3.47-6.24	< 0.001
Sex	Female	171 (36.2)	422 (46.2)	Base		
	Male	302 (63.9)	491 (53.8)	1.52	1.21-1.91	< 0 .001
Neuter	Entire	36 (7.6)	118 (12.7)	Base		
	Neutered	117 (24.7)	111 (11.9)	3.45	2.19-5.44	< 0.001

	Not recorded	321 (67.7)	704 (75.5)	1.49	1.01-2.22	0.047
Insured	Non-insured	211 (44.5)	372 (39.9)	Base		
	Insured	93 (19.6)	148 (15.9)	1.11	0.81-1.51	0.517
	Not recorded	170 (35.9)	413 (44.3)	0.73	0.57-0.93	0.011

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512 Table 2: Descriptive and univariable logistic regression results for risk factor (purebred status, breed
513 and Kennel Club (KC) Breed Group) associations with deaths that were or were not ascribed to
514 undesirable behaviour (UB) among dogs attending primary-care veterinary practices in England that
515 died before three years of age (n = 1,574).

Variable	**Category**	**UB No. (%)**	**Non-UB No. (%)**	**Odds ratio**	**95% CI***	***P*-value**
Purebred status	Purebred	347 (73.4)	734 (78.8)	Base		
	Crossbred	126 (26.6)	198 (21.2)	1.35	1.04-1.74	0.024
Breed	Labrador Retriever	12 (2.5)	39 (4.2)	Base		
	Boxer	0 (0.0)	20 (2.2)	~	~	~
	Staffordshire Bull Terrier	92 (19.5)	75 (8.1)	3.99	1.95-8.15	< 0.001
	Cocker Spaniel	20 (4.2)	19 (2.0)	3.42	1.39-8.43	0.008
	West Highland White Terrier	6 (1.3)	7 (0.8)	2.79	0.78-9.90	0.113
	Jack Russell Terrier	34 (7.2)	49 (5.3)	2.26	1.03-4.92	0.041
	Crossbreed	126 (26.6)	198 (21.2)	2.07	1.04-4.10	0.037
	Husky	6 (1.3)	11 (1.2)	1.77	0.54-5.81	0.344
	Rottweiler	11 (2.3)	21 (2.3)	1.7	0.64-4.51	0.285
	Cavalier King Charles Spaniel	8 (1.7)	17 (1.8)	1.53	0.53-4.42	0.432
	English Springer Spaniel	5 (1.1)	11 (1.2)	1.48	0.43-5.10	0.537

	American Pit Bull Terrier	8 (1.7)	19 (2.0)	1.37	0.48-3.91	0.558
	Border Collie	9 (1.9)	22 (2.4)	1.33	0.48-3.65	0.58
	Other purebreds	78 (16.5)	201 (21.6)	1.26	0.63-2.53	0.515
	German Shepherd Dog	14 (3.0)	36 (3.9)	1.26	0.52-3.09	0.608
	Shih-tzu	10 (2.1)	27 (2.9)	1.2	0.46-3.18	0.709
	Yorkshire Terrier	13 (2.8)	39 (4.2)	1.08	0.44-2.67	0.862
	Chihuahua	11 (2.3)	44 (4.7)	0.81	0.32-2.05	0.66
	Bulldog	4 (0.9)	22 (2.4)	0.59	0.17-2.06	0.408
	Dogue de Bordeaux	3 (0.6)	17 (1.8)	0.57	0.14-2.30	0.432
	French Bulldog	2 (0.4)	19 (2.0)	0.34	0.07-1.68	0.187
	Pug	1 (0.2)	19 (2.0)	0.17	0.02-1.41	0.101
Kennel Club (KC) Breed Group	Not KC-Recognised	178 (37.6)	279 (29.9)	Base		
	Terrier	109 (23.0)	104 (11.2)	1.64	1.18-2.28	0.003
	Hound	13 (2.8)	24 (2.6)	0.85	0.42-1.71	0.647
	Gundog	40 (8.5)	94 (10.1)	0.67	0.44-1.01	0.056
	Pastoral	27 (5.7)	71 (7.6)	0.60	0.37-0.96	0.035
	Working	35 (7.4)	100 (10.7)	0.55	0.36-0.84	0.006
	Toy	43 (9.1)	155 (16.6)	0.43	0.30-0.64	< 0.001
	Utility	28 (5.9)	105 (11.3)	0.42	0.26-0.66	0.006

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Table 3: Prevalence of the most common groups of undesirable behaviours (UBs) recorded as contributing to deaths from a UB among dogs attending primary-care veterinary practices in England that died before three years of age with an ascribed cause (n = 474). [Note that some deaths had multiple contributory UBs ascribed]

Undesirable behaviour	**No.**	**Percent**	**95% CI***
Aggression	256	54.0	49.4-58.6
Road Traffic Accident (RTA)	185	39.0	34.6-43.6
Inter-pet conflict	31	6.5	4.5-9.2
Dog Attack	28	5.9	4.0-8.4
Anxious/Nervous	25	5.3	3.4-7.7
Restraint required for veterinary examination	24	5.1	3.3-7.4
Hyper-excitability	9	1.9	0.9-3.6
Limited training	9	1.9	0.8-3.4
Destructive	7	1.5	0.6-3.0
Excessive Vocalisation	5	1.1	0.3-2.4
Hyper-sexuality	4	0.8	0.2-2.1
Inappropriate elimination	4	0.8	0.2-2.0
Owner can't cope	1	0.2	0.0-1.2
Other or undiagnosed behaviours	20	4.2	2.6-6.4

528 Table 4: Final multivariable logistic regression model results for *purebred, Kennel Club (KC) breed*
529 *group and bodyweight as* risk factors associated with deaths ascribed to UBs among dogs attending
530 primary-care veterinary practices in England that died before three years of age with an ascribed cause.
531 These variables were used individually to replace the *breed* variable in the original multivariable
532 modelling.

Variable	**Category**	**Odds ratio**	**95% CI***	***P*-value**
Purebred status	Purebred	Base		
	Crossbred	1.39	1.05-1.83	0.023
KC Breed Group	Not KC-Recognised	Base		
	Terrier	1.52	1.07-2.17	0.020
	Gundog	0.76	0.48-1.19	0.230
	Hound	0.80	0.38-1.67	0.545
	Toy	0.55	0.36-0.82	0.004
	Pastoral	0.54	0.33-0.90	0.019
	Working	0.51	0.32-0.81	0.004
	Utility	0.47	0.29-0.78	0.003
Bodyweight (kg)	< 10.0	Base		
	10.0-19.9	0.95	0.62-1.44	0.794
	20.0-29.9	0.89	0.57-1.39	0.599
	30.0-39.9	0.77	0.45-1.30	0.328
	≥ 40.0	0.44	0.20-0.97	0.041
	Not recorded	1.46	1.07-1.99	0.016

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535 Table 5: Final multivariable logistic regression model for risk factors associated with deaths ascribed
536 to undesirable behaviour (UB) among dogs attending primary-care veterinary practices in England that
537 died before three years of age with an ascribed cause. (Note: Odds ratio was not calculable for Boxer
538 because of zero deaths from UB)

Variable	Category	Odds ratio	95% CI*	*P*-value
Breed	Labrador Retriever	Base		
	Boxer	~	~	~
	Cocker Spaniel	8.04	2.99-21.56	< 0.001
	West Highland White Terrier	5.71	1.44-22.67	0.013
	Staffordshire Bull Terrier	4.5	2.10-9.64	< 0.001
	Jack Russell Terrier	2.69	1.16-6.21	0.021
	Crossbreed	2.62	1.26-5.42	0.01
	Husky	2.29	0.63-8.31	0.208
	English Springer Spaniel	2.21	0.58-8.48	0.247
	Shih-tzu	2.08	0.73-5.97	0.173
	Cavalier King Charles Spaniel	1.97	0.63-6.13	0.24
	Yorkshire Terrier	1.9	0.72-5.01	0.197
	Rottweiler	1.83	0.64-5.18	0.258
	German Shepherd Dog	1.73	0.67-4.49	0.261
	Other purebreds	1.42	0.68-2.98	0.349
	Chihuahua	1.17	0.44-3.11	0.758
	Border Collie	1.12	0.39-3.21	0.836
	American Pit Bull Terrier	0.97	0.33-2.89	0.956
	Bulldog	0.75	0.20-2.76	0.666
	Dogue de Bordeaux	0.62	0.15-2.61	0.514

	French Bulldog	0.55	0.10-2.89	0.477
	Pug	0.36	0.04-3.14	0.355
Age at death (years)	< 1.0	Base		
	1.0 - < 2.0	5.42	3.96-7.43	< 0.001
	2.0 - < 3.0	4.21	3.03-5.86	< 0.001
Sex	Female	Base		
	Male	1.40	1.09-1.81	0.009
Neuter	Entire	Base		
	Neutered	1.94	1.17-3.22	0.010
	Not recorded	1.50	0.97-2.32	0.067

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