

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

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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 (eg anxiety) or from the methods used by owners to resolve the problem (eg 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 (eg gastrointestinal issues: 14.5%). Male dogs had 1.40× 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× the odds of death due to a 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 a 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 & Bennett 2010; McGreevy & 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, eg 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 heavily dependent on context

and the human’s expectations of how a dog should behave (Jagoe & 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 & Serpell 1996) and how to respond to early signs of UBs. Specific behavioural patterns can be associated with individual breeds. For example, chase behaviour may be normal and common in certain dog breeds such as Border Collies

and varying levels of this behaviour may be expressed across other breeds (Udell *et al* 2014). Similarly, individual breeds may be associated with certain pathological behaviours, eg flank-sucking in Doberman Pinschers (Moon-Fanelli *et al* 2007; Dodman *et al* 2010). The causes of UBs are manifold and include various combinations and interactions between owner-related management (McBride 1995) and multiple genetic, phenotypic, learning and environmental factors (McCune *et al* 1995). It is important to note that the emotional motivation of anxiety may be needed in certain situations and can contribute positively to survival (Livesey 1986). Many UBs show 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 example, it has been reported that as dog size decreased, human-directed aggression increased (Martínez *et al* 2011). McGreevy *et al* (2013) stated that, for behaviours reported through the Canine Behaviour Assessment and Research Questionnaire (C-BARQ), the frequency of 33 undesirable behaviours had at least one significant morphological predictor, eg height alone ($n = 14$) and body-weight alone ($n = 5$) (McGreevy *et al* 2013).

Small breeds may have been unintentionally selected for traits linked with UBs. For example, the small size of the dogs may have led to the perception that UBs are less problematic than for larger dogs (McGreevy *et al* 2013). Associations between behaviour and size could also be environmentally driven because owners tend to treat small dogs differently to larger dogs. Small dogs may be managed and handled in ways that inadvertently increase fear and elicit aggression, eg being picked up without much warning. The lack of autonomy and the likely discomfort associated with being lifted off the ground at speed, may contribute to small dogs becoming fearful of humans. In addition, small dogs may receive less training than large dogs (Martínez *et al* 2011).

There are many response options for owners of dogs that exhibit UBs. The most extreme of the available approaches would be to euthanase or relinquish the dog. It is worth noting that many of the behaviours captured by the C-BARQ would not be likely triggers for euthanasia. Indeed, there is some evidence that only 5.5% of dogs with UBs are or are actually euthanased (Lund *et al* 1996). For most UBs, there is not a 'quick fix' solution because altering a learnt behaviour and emotional response takes time and often requires the owners to make lifestyle changes (Reisner 2003). Therefore, owners must be willing to invest time and effort into implementing a remedial training programme and, where human health is at risk, then euthanasia might be considered the best option (Reisner *et al* 1994). If the UB is driven by an abnormal emotional response, such as maladaptive anxiety, it can deny the dog the opportunity to exhibit normal biological functions (Ohl *et al* 2008). For example, dogs that suffer from anxiety might have a reduced appetite or show an unwillingness to go outside which can affect house-training. Under these circumstances, the dog's welfare is compromised and this needs to be considered when deciding on how to manage or treat the UB.

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

The current study aimed to determine the proportional mortality due to a UB and risk factors for mortality due to UBs (including RTAs) in dogs aged under three years of age attending primary-care veterinary practices in England. The primary focus was to identify dog breeds or type (notably size) associated with increased mortality due to UBs, to characterise the UBs recorded and describe their clinical management. As discussed previously, many UBs display 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). Therefore, we sought to evaluate whether this transcribed into smaller breeds and dogs in the lighter weight categories, irrespective of breed, having a higher proportional mortality from UBs than larger breeds and dogs in heavier weight categories, respectively.

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 two-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).

Selection criteria and definitions

The sampling frame for the current study included all dogs recorded as de-activated within the VetCompass database from 1st September 2009 to 31st August 2014. The age at de-activation was calculated for each dog as the difference between the dates of birth and de-activation. The subset that were aged under three years at de-activation was selected and randomised using the RAND function in Microsoft Excel® (Microsoft Office Excel® 2007). The full EPR of each dog was manually reviewed to identify those dogs that had truly died and to identify the date of death, the method of death and whether the cause of death was ascribed to a UB. UBs were defined in Appendix Table 1 (see the supplementary material to papers published in *Animal Welfare* section on the UFAW website; <https://www.ufaw.org.uk/the-ufaw-journal/supplementary-material>). Additional data were extracted on deaths ascribed to UBs to determine whether pharmacological therapy had been tried, whether a referral had been offered, whether neutering was due to UB, whether the owners tried to resolve the UB and whether re-homing had been attempted before euthanasia (Appendix Table 2; <https://www.ufaw.org.uk/the-ufaw-journal/supplementary-material>).

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

Variables

A 'purebred' variable grouped all dogs recorded as a recognisable breed (Irion *et al* 2003) as 'purebred' and all other dogs as 'crossbred'. A 'breed' variable included any individual breeds with 15 or more dogs in the study, a grouping of all remaining breeds (ie breeds with less than 15 study dogs) and a grouping of all crossbred dogs. A KC 'breed group' variable classified breeds recognised by the Kennel Club (KC) into their relevant KC breed groups (Gundog, Hound, Pastoral, Terrier, Toy, Utility, 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). 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 & 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-squared test was used to compare categorical variables (Kirkwood & 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 5,000 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 5,000 clinics. Of these 264,259 dogs, 41,280 were recorded as deactivated overall with 7,882 of these recorded as deactivated prior to three years of age. Manual EPR evaluation of all of these 7,882 records confirmed that 1,574 were records for single dogs 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 re-homed, 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

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

Variable	Category	UB number (%)	Non-UB number (%)	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

estimated prevalence of deaths ascribed to UBs among deaths with a cause ascribed (n = 1,407) was 33.7% (95% 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 three years of age (489/5095) equalling 63,984 dogs under three 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 a 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 provides additional descriptive and univariable logistic regression results for the categorical risk factors: bodyweight, age at death, sex, neuter status and insurance status. 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.

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 (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 a 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 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

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

Variable	Category	UB number (%)	Non-UB number (%)	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
	Crossbred	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)	1.70	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	0.580
	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)	1.20	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	0.660
	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	

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).

Undesirable behaviour	N (%)	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 vet 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
Hypersexuality	4 (0.8)	0.2–2.1
Inappropriate elimination	4 (0.8)	0.2–2.0
Owner unable to cope	1 (0.2)	0.0–1.2
Other or undiagnosed behaviours	20 (4.2)	2.6–6.4

Note that some deaths had multiple contributory UBs ascribed.

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 crossbreeds (n = 126; 26.6%). The KC Terrier group was the KC group that covered the highest count of dogs that died of UB (n = 109; 23.0%).

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 a UB, prior use of pharmacological management for the UB was recorded in 14/474 (3.0%) dogs. Re-homing 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 euthanased due to aggression. For the remaining 415 (87.6%) dogs, there was no indication of re-homing 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 crossbreeds (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, six (1.3%) had four UBs and two (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 RTAs (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% (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) crossbreeds that died of UB.

Risk factor analysis

Univariable logistic regression modelling identified eight 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 four 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 a UB compared with purebred dogs. Dogs from the KC Utility, Toy, Working, Pastoral and Terrier groups had lower odds of death from a UB compared

Table 4 Final multivariable logistic regression model results for purebred, Kennel Club (KC) breed group and bodyweight as risk factors associated with deaths ascribed to UBs among dogs attending primary-care veterinary practices in England that died before three years of age with an ascribed cause. These variables were used individually to replace the breed variable in the original multivariable 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-registered	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
Bodyweight (kg)	Utility	0.47	0.29–0.78	0.003
	< 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	0.44	0.20–0.97	0.041
	Not recorded	1.46	1.07–1.99	0.016

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 a 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 a UB. Male dogs, had 1.40 \times the odds (95% CI: 1.09–1.81; $P = 0.009$) of death from a UB compared with female dogs. Neutered animals had 1.94 \times (95% CI: 1.17–3.22; $P = 0.010$) the odds of death from a UB compared with entire animals (Table 5).

Discussion

UBs are one of the most common reasons to euthanase owned companion dogs (Hsu & 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%. 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 anxiety or self-trauma, could have reduced welfare and compromised quality of life (Hiby *et al* 2004). Dying due to a 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 aimed to evaluate whether smaller breeds and dogs in the lighter weight categories, irrespective 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 these 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 a UB decreases with bodyweight. 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 euthanased; ie 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 a 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 nine months of age, so therefore a puppy's personality is not necessarily a predictor of what they will be like as an adult (Goddard & Beilharz 1986). Puppies have also been shown to exhibit fewer UBs compared with juvenile and adult dogs (Wells & 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

Table 5 Final multivariable logistic regression model for risk factors associated with deaths ascribed to undesirable behaviour (UB) among dogs attending primary-care veterinary practices in England that died before three years of age with an ascribed cause.

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	4.50	2.10–9.64	< 0.001
	Jack Russell Terrier	2.69	1.16–6.21	0.021
	Crossbreed	2.62	1.26–5.42	0.010
	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	0.240
	Yorkshire Terrier	1.90	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

Note: Odds ratio was not calculable for Boxer because of zero deaths from UB.

they later exhibit. Previous research has shown that sub-optimal learning opportunities before eight weeks of age are a risk factor for behavioural issues later in life (Appleby *et al* 2002). 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). 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. These findings illustrate the importance of owners receiving good behavioural advice when their dog is young to prevent UBs from arising or worsening (Gazzano *et al* 2008), however, only 25% of veterinarians enquire about behaviour on a regular basis (Hetts *et al* 2004). In the current study, behavioural referral recommendation was recorded in 10.3% of the UB death cases and nutraceutical, pheromone or pharmacological treatment were used in only 3.0% of the UB death cases. The current study also revealed that a record of owners trying to solve the UB was present in only 12.9% of behavioural death cases and only 34.4% of that 12.9% had previously consulted their veterinarian about their dogs' behaviour. The reasons for this relatively low percentage are unknown, but possibilities include that the owner may have viewed the UB as too severe to resolve or was unaware of the available options, including veterinary intervention, or that the information was simply not recorded.

Sex was also identified in the current study as a risk factor, with male dogs having 1.40× the odds of death due to a UB compared with females. This finding is in accordance with previous research showing that male dogs are more likely to exhibit a UB compared with female dogs (Wright & Nesselrote 1987; Landsberg 1991; Hsu & Serpell 2003). Therefore, increased prevalence of exhibiting a UB could explain the statistical difference as to why males are at higher risk of death due to a UB compared with female dogs. Neutered dogs also have a higher risk of death due to a UB compared with entire dogs. This difference could, however, be due to owners using neutering as a solution to the UB: of the neutered dogs in this study, only 7.7% were recorded as being neutered as a bid to address the UB. Many scientific papers seeking to assess whether neuter status affects behaviour have reported contradictory results. Older studies suggested that neutering aggressive dogs could help reduce aggression (Wright & Nesselrote 1987; Blackshaw 1991) but a more recent study reported that neutered male and female dogs were more likely to show aggression compared with entire male and female dogs (Guy *et al* 2001).

Breed was also identified as a risk factor in the current study. Labrador Retrievers were chosen as the baseline 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 Russell Terrier (6.7%), Cocker Spaniel (3.8%), German Shepherd dog (3.6%), Yorkshire Terrier (3.3%) and Border Collie (2.7%) (O'Neill *et al* 2014). Our 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 so 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 euthanase them due to a 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 Shepherd Dog, Rottweiler, American Pit Bull Terrier, Bull Terrier, Great Dane, Doberman, Border Collie, Wolfhound (Podbersecsek 1994) and Cocker Spaniel (Podbersecsek & Serpell 1996, 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' (Podbersecsek & Serpell 1996), although Martinez *et al* (2011) found no difference between breeds and the prevalence of aggression. Our findings did not assess whether the Cocker Spaniels in the study were classified as having 'rage syndrome' but it is known that there is a genetic component to this UB (Podbersecsek & Serpell 1996). It has also been shown that Cocker Spaniels are one of the breeds that are most represented in attacks on humans, along with terrier breeds (Amat *et al* 2009). Although science has shown correlations between individual breeds and certain behaviours, much of the information, especially regarding 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 (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 & Calnon 2010).

The current study ascribed 5.9% of deaths from UB before three years of age to dog attack but the data did not

include the context for each altercation. This is a slightly lower percentage than Shamir *et al* (2002), who found the mortality rate to be 7%. The roles of aggressor and target within any dog-on-dog altercation are complex and may often be fluid: an initial appeasement or inhibited response may swiftly change to an aggressive one. Context and other factors may influence aggression. For example, pre-existing UBs in either party, extrinsic factors such as the presence of owners, training style of the owner, location or food/toys may promote the possibility, severity or duration of any event (Roll & Unshelm 1997). This is an area that warrants further research.

Implications for the dog-owning public

Our results highlight the importance of owner education regarding 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 manner in order to ensure that the puppy is in a positive emotional state (Howell *et al* 2015). Other factors can also affect the presence of UBs. For example, dogs whose owners had previous dog-owning experience and spent more time with their dog and who attended training classes were more likely to respond to verbal cues (Kobelt *et al* 2003). Owners who engage in training with their dogs report that their dogs are less 'disobedient', less nervous and more friendly (Bennett & Rohlf 2007) but Coren (1999) reported that only 24% of dog owners attended training classes. It is possible that more people attend training classes now as there is more information available about the importance of training a dog and repercussions are greater if a dog is a nuisance or dangerous to other people. However, people would rather seek free help than pay for services (Shore *et al* 2008).

Animal welfare implications

Animals that exhibit UBs are at risk of compromised welfare, either because of their own underlying emotional motivations for the behaviour (eg anxiety or fear) or because of the ways in which their owners might seek to resolve the problem (eg 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 UBs in terms of mortality risk as well as animal welfare in those that do not die, suggests 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 that UBs are a substantial risk factor of death for dogs under the age of three years. The odds of death ascribed to a UB increases with age (up to three years), for males, for crossbreeds 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 a 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 regarding 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.

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