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

3 **Running title: Dog deaths related to undesirable behaviour**

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34

35 **Abstract**

36 Undesirable behaviours (UBs) are common in dogs and can jeopardise animal and human
37 health, leading to dog abandonment and euthanasia. Dogs exhibiting UBs may have compromised
38 welfare from underlying emotional motivations for the behaviour (e.g. anxiety) or from how owners
39 might seek resolution (e.g. aversive techniques). The objective of this study was to estimate proportional
40 mortality due to UBs and risk factors for death due to UBs, including death from road traffic accidents,
41 in dogs under three years of age attending primary-care veterinary practices in England from 2009-
42 2014. Cases were identified by searching de-identified electronic patient records from primary-care
43 veterinary practices participating in the VetCompass Programme. The findings highlight that dogs
44 under three years of age are at a proportionately high risk of death due to UBs (33.7%) compared with
45 other specific causes of death (e.g. Gastrointestinal issues:14.5%). Male dogs had 1.40 times the odds
46 of death from UB compared with females. The proportional mortality from UB for male dogs where
47 information on the cause of death was available was 0.41. Neutered dogs had 1.94 times the odds of
48 death due to an UB compared with entire dogs. Aggression was the most prevalent UB overall.
49 Veterinarians had recommended referral in 10.3% of cases where dogs died due to exhibiting an UB
50 and had dispensed nutraceutical, pheromone or pharmacological treatment to 3.0% of the UB cases that
51 died. This study shows that undesirable behaviours require better preventive measures and treatment,

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

54

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

56

57 **Introduction**

58 Dogs are the most common mammalian companion animal in the UK, with an estimated 24%
59 of households owning a dog (Westgarth et al., 2007; Pet Food Manufacturers Association, 2014). Often
60 dubbed ‘man’s best friend’, dogs offer health and companionship benefits to their human carers but, for
61 many human households, the reality of dog-owner co-existence is not always as harmonious as expected
62 (McGreevy and Bennett, 2010; McGreevy and Calnon, 2010). Many dogs behave in ways that owners
63 find unwelcome, with 40-87% of dogs reported to exhibit undesirable behaviours (UBs) (Voith, 1985;
64 Campbell, 1986; O’Farrell, 1992; Martínez et al., 2011). UBs can be either a normal behaviour such as
65 vocalisation, a behavioural pathology such as tail-chasing or can arise due to physiological dysfunction
66 or medical conditions e.g., inappropriate elimination may result from a urinary tract infection (Overall,
67 1997; Landsberg et al., 2012) . Human opinions about the undesirability of a behaviour are subjective
68 and are heavily dependent on context and the human’s expectations of how a dog should behave (Jagoe
69 and Serpell, 1996). This underlines the importance of veterinary and behaviourist input for dogs
70 suspected of UBs. Some owners find certain UBs, such as tail-chasing, amusing and only consider these
71 activities as a problem when the dog hurts itself or spends excessively long periods carrying out the
72 behaviour (Burns, 2011). The purpose for which the dog was acquired can also affect the perceived
73 desirability by the owner for any given behaviour. For example, vocalisation may be welcomed in a
74 dog acquired for protection of property but unwelcome in a dog acquired as a child’s pet (Lund et al.,
75 1996). In contrast to experienced dog owners, first-time owners report a higher prevalence of UBs in
76 their dogs, which could reflect their limited understanding of how normal behaviour manifests in dogs
77 (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

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

131

132 **Materials and methods**

133 *VetCompass*

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

146 A cross-sectional study design using cohort clinical data was used to estimate the proportional
147 mortality and risk factors for mortality from undesirable behaviours in dogs that died aged under three
148 years (Pearce, 2012). Sample size calculations estimated that 421 dogs weighing under 10 kg and 106
149 dogs weighing 30-40 kg would be required to detect a 2 fold increase in the odds of death from UBs
150 among all deaths (80% power, assuming that 25% of deaths in the group aged under 10 kg were ascribed
151 to UBs, 95% confidence level, Epi Info 7 CDC, 2012). Ethical approval was granted by the Veterinary
152 Ethical Review Committee from The Royal (Dick) School of Veterinary Studies (reference number
153 25/15).

154

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

181 the dog (entire or neutered) as recorded at the final EPR. *Insurance* described whether a dog was insured
182 at any point during the study period. The age value described the age at death (years) and was
183 categorised into three groups (< 1.0, 1.0-1.9, 2.0-<3.0). *Bodyweight* described the maximum
184 bodyweight recorded during the study period and was categorised into six groups (0.0-9.9 kg, 10.0-19.9
185 kg, 20.0-29.9 kg, 30.0-39.9 kg, \geq 40.0 kg, not recorded).

186

187 ***Data Analysis***

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

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

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

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

212

213 **Results**

214 There are an estimated 5 thousand clinics in the UK (O'Neill et al., 2013). The overall sampling
215 frame comprised 264,259 dogs attending 127 clinics in England. The 127 clinics in this study comprises
216 2.5% of these 5 thousand clinics. Of these 264,259 dogs, 41,280 dogs were recorded as deactivated
217 overall with 7,882 of these recorded as deactivated before three years of age. Manual EPR evaluation
218 of all of these 7,882 records confirmed that 1,574 were records for a single dog that had died aged under
219 three years of age and these 1,574 dogs were therefore included in the current analysis. Reasons for
220 deactivation of the dogs that were not confirmed deaths included dogs that were rehomed, or belonging
221 to owners who moved away, switched practices or were bad debtors.

222 Of the 1,574 records of death relating to dogs that died before three years of age, 933 (59.3%)
223 were not ascribed to UBs, 474 (30.1%) were ascribed to UBs (including RTAs) and 167 (10.6%) did
224 not have a cause ascribed. The estimated prevalence of deaths ascribed to UBs among deaths with a
225 cause ascribed ($n=1,407$) was 33.7% (95% confidence interval [CI] 31.2-36.2). There are an estimated
226 8 million dogs in the UK and they live on average 12 years so there are an estimated 666 667 deaths
227 per year (O'Neill et al., 2013). Of these, 9.6% die before 3 years of age (489/5095) equalling 63,984
228 dogs under 3 years dying annually (O'Neill et al., 2013). Therefore, it can be estimated that 33.7%
229 (21,562 dogs) of these were from UB.

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

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

234

235 *Demographic data*

236 Of the dogs that died from UBs, the median age at which an UB was first recorded was 1.4
237 years (interquartile range [IQR] 0.8-2.0, range 0.0-<3.0), the median bodyweight was 14.5 kg (IQR:
238 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).
239 Table 1 displays additional descriptive and univariable logistic regression results for the categorical risk
240 factors: body weight, age at death, sex, neuter status and insurance status.

241 The clinical notes recorded that neutering had been undertaken during the available clinical
242 records in 91/474 (19.2%) dogs during the study period. Of the 91 dogs with a recorded reason for the
243 neutering decision, 7/91 (7.7%) neutering decisions were made at least in part to address the UB. The
244 median age at neutering was 0.9 years (interquartile range [IQR] 0.6-1.2, range 0.3-2.6). The acquisition
245 source of the dog was not recorded for 409 (86.3%) dogs that were deceased due to an UB. For the
246 remaining 65 dogs for which the sources of acquisition were recorded, these were breeder (n = 24,
247 36.9%), rescue centre (21, 32.2%), previous owner (11, 16.9%), family/friend (4, 6.2%), pet shop (2,
248 3.1%), bred themselves (2, 3.1%) and puppy farm (1, 1.5%).

249

250 Table 2 displays the descriptive and univariable logistic regression results for categorical risk
251 factors of purebred versus crossbred, individual purebred breeds and for Kennel Club (KC) Breed
252 Groups. Breed was recorded for 473 of the 474 dogs that died from causes related to UB and, of these,
253 347/473 (73.4%) were purebred. The most common breeds that died from UBs were the Staffordshire
254 Bull Terrier (n = 92, 19.5%) Jack Russell Terrier (n = 34, 7.2%) and Cocker Spaniel (n = 20, 4.2%),
255 along with crossbreds (n = 126, 26.6%). The KC Terrier group was the KC group that covered the
256 highest count of dogs that died of UB n = 109, 23.0%). Sex was recorded for 473 of the 474 dogs that
257 died from causes related to UB and 171/473 (36.2%) with sex status recorded were female. Neuter status

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

261

262 ***Treatment***

263 Among the 474 dogs that died from UBs, the clinical notes indicated that owners had sought
264 behavioural advice for 61 (12.9%) dogs and behavioural referral was recommended for 49 (10.3%)
265 dogs. It was not always clear from the records if the owners attended the behavioural resource that the
266 veterinarian recommended or if these were independently identified by the owners. For the dogs whose
267 owners did seek help (n = 61), the source of this assistance was recorded as animal behaviourist (n =
268 21, 34.4%), veterinary surgeon (21, 34.4%), dog trainer (5, 8.2%) and unspecified (14, 23.0%). Of the
269 474 dogs that died due to an UB, prior use of pharmacological management for the UB was recorded
270 in 14/474 (3.0%) dogs. Rehoming had been attempted but had proved unsuccessful in 58/474 (12.2%)
271 dogs and one (0.2%) dog had been rehomed to a rescue centre before being euthanised due to
272 aggression. For the remaining 415 (87.6%) dogs, there was no indication of rehoming attempts.

273

274 ***Non-behavioural deaths***

275 Of the dogs that died from causes other than UBs (not including those animals with missing
276 data), 734 (78.8%) were purebred, 422 (46.2%) were female, 111 (48.5%) were neutered and 148
277 (29.6%) were insured. The median bodyweight was 8.9 kg (IQR: 2.9-21.6, range: 0.1-73.0) and the
278 median age at death was 0.6 years (IQR: 0.2-1.6, range: 0.0-3.0) years. The most common breeds that
279 died from causes other than UBs were the Staffordshire Bull Terrier (n = 75, 8.1%), Jack Russell Terrier
280 (n = 49, 5.3%), Chihuahua (n = 44, 4.7%), along with crossbreds (n = 198, 21.2%) (Table 2).

281

282 ***Undesirable behaviours exhibited***

283 Of the 474 dogs that died from UBs, 364 (76.8%) had a single UB reported as a contributory
284 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%)
285 had five UBs. There were 36 specific UB terms recorded as causes of death in dogs aged under three
286 years. Of these, the most common specific UBs recorded were road traffic accident (RTA) (n = 185,
287 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)
288 and dog attack (n = 28, 5.9%, 95% CI 4.0-8.4). After grouping the UBs into 14 groups, the most
289 common UB groups were aggression (n = 256, 54.0%, 95% CI 49.4-58.6) and RTA (n = 185, 39.0%,
290 95% CI 34.6-43.6) (Table 3). The most common UB group, aggression, was cited as a contributory
291 cause of death for 100.0% (11/11) Rottweilers, 100% (4/4) Bulldogs, 88.9% (8/9) Border Collies, 87.5%
292 (7/8) American Pit Bull Terriers, 71.4% (10/14) German Shepherd Dogs, 73.9% (68/92) Staffordshire
293 Bull Terriers and 53.2% (67/126) crossbreeds that died of UB.

294

295 ***Risk factor analysis***

296 Univariable logistic regression modelling identified 8 variables with liberally significant ($P <$
297 0.20) association with death from UB: *purebred*, *breed*, *KC breed group*, *bodyweight*, *age at death*, *sex*,
298 *neuter and insured* (Tables 1 and 2). As explained above, *purebred*, *breed*, *KC breed group* and
299 *bodyweight* were not considered simultaneously in multivariable modelling. Following evaluation using
300 multivariable logistic regression, the final breed model comprised 4 risk factors: *breed*, *age at death*,
301 *sex and neuter status*. No biologically significant interactions were identified. The final model was not
302 improved by inclusion of the clinic attended as a random effect ($P = 0.209$). The final model showed
303 adequate fit (Hosmer-Lemeshow test: $P = 0.641$) and good discrimination (area under the ROC curve:
304 0.762). *Purebred*, *KC breed group* and *bodyweight* each replaced the *breed* variable in the final breed
305 multivariable model and these multivariable results are reported for these three variables.

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

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

311 After accounting for the effects of the other variables evaluated, Cocker Spaniel (8.04 OR, 95%
312 CI 2.99-21.56, $P < 0.001$), West Highland White Terrier (5.71 OR, 95% CI 1.44-22.67, $P = 0.013$),
313 Staffordshire Bull Terrier (4.50 OR, 95% CI 2.10-9.64, $P < 0.001$), Jack Russell Terrier (2.69 OR, 95%
314 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
315 of death from UBs compared with Labrador Retrievers. Compared with dogs aged under one year, dogs
316 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
317 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
318 dogs, had 1.40 times the odds (95% CI 1.09-1.81; $P = 0.009$) of death from an UB compared with
319 female dogs. Neutered animals had 1.94 (95% CI 1.17-3.22, $P = 0.010$) times the odds of death from
320 an UB compared with entire animals (Table 5).

321

322 **Discussion**

323 UBs are one of the most common reasons to euthanise owned companion dogs, (Hsu and
324 Serpell, 2003) most notably dogs under three years of age (O'Neill et al., 2013). The current study
325 reports that the prevalence of dogs under the age of three in the primary-care caseload dying due to UBs
326 is 33.7%. This is higher than the prevalence reported in an earlier comparable study (O'Neill et al.,
327 2013) of dogs under the age of three, that assigned behavioural abnormalities and RTAs a combined
328 percentage of 27.40% (O'Neill et al., 2013). The relatively high proportion of deaths due to UBs in the
329 current study, could reflect owners' focusing on the detrimental effects that the dogs' UBs have on their
330 own human quality of life and the prospect that dogs displaying UBs, such as anxious behaviours or
331 self-trauma, could have reduced welfare and compromised dog quality of life (Hiby et al., 2004). Dying
332 due to an UB is an increased risk compared with death from other causes for dogs under the age of
333 three. For example, in dogs under the age of three the prevalence of death due to Gastrointestinal issues
334 is 14.5% or the prevalence of death due to neurological issues is 7.4 % (O'Neill et al., 2013).

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

347 Age was also a risk factor with dogs aged 1.0 to < 2.0 years and dogs aged 2.0 to < 3.0 years
348 having an increased risk of death due to an UB compared with dogs under the age of one. Although the
349 rationale behind this finding is not completely clear, it is possible that owners may be more willing to
350 tolerate UBs in a puppy, if they view the UB as a puppy behaviour. A dog's personality is not stable in
351 puppies under 9 months of age so a puppy's personality is not necessarily a predictor of what they will
352 be like as an adult (Goddard and Beilharz, 1986). Puppies have also been shown to exhibit fewer UBs
353 compared with juvenile and adult dogs (Wells and Hepper, 2000), though aggression can be exhibited
354 within the first year (Guy et al., 2001). It is important to note that early life experiences can impact a
355 dog and the UBs that they later exhibit. Previous research has shown that suboptimal learning
356 opportunities before eight weeks of age are a risk factor for behavioural issues later in life (Appleby et
357 al. 2002). The quality of socialisation is also important, as puppies that are exposed to negative incidents
358 are more likely to show aggression later in life (Wormald et al., 2016). Owners who have received
359 advice regarding their puppy from a veterinary behaviourist report fewer UBs thus illustrating the
360 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).

387 Breed was also identified as a risk factor in the current study. Labrador Retrievers were chosen
388 as the base line as they have a reputation for being a friendly family dog and are regularly used as
389 service dogs (The Guide Dogs for the Blind Association, 2017). The most popular breed types in the
390 UK by percentage are: Crossbreeds (21.1%), Labrador Retriever (9.0%), Staffordshire Bull Terrier
391 (8.2%), Jack Russel Terrier (6.7%), Cocker Spaniel (3.8%), German Shepard dog (3.6%), Yorkshire
392 Terrier (3.3%) and Border Collie (2.7%) (O'Neill et al., 2014). The current study found that the Cocker
393 Spaniel, West Highland White Terrier, Staffordshire Bull Terrier, Jack Russell Terrier, and crossbreeds
394 showed higher odds of death from UB compared to Labrador Retrievers. All of these breeds, other than
395 the West Highland White Terrier, are in the list of most popular breeds in the UK and emphasises that
396 popularity does not preclude high proportional probability of death from UB. The West Highland White
397 Terrier has previously been reported to exhibit aggression to unfamiliar dogs which could be a factor in
398 the owner's decision to euthanise them due to an UB (Duffy et al. 2008).

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

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

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

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

429

430 ***Implications for the dog owning public***

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

438 owners to find appropriate information on sourcing and raising a puppy and guidance concerning the
439 management and potential resolution of UBs. Technology is a rapidly expanding market in the pet world
440 and encouraging owners to monitor the behaviour of their pet may be beneficial; technologies such as
441 smartphone apps can assist them in recording management, socialisation and current behaviours
442 (Paldanius et al. 2011). There has been much discussion regarding influences from the early rearing
443 environment on subsequent behaviour of domestic dogs (Appleby et al 2002, Pluijmakers et al 2010).
444 It is advised that young puppies are exposed to a complex environment in a controlled way in order to
445 ensure that the puppy is in a positive emotional state (Howell et al., 2015). Research has identified
446 additional factors, which can affect the presence of UBs. For example rearing environment, dogs
447 sourced from pet shops exhibit increased aggression towards familiar people (Pirrone et al., 2016) and
448 dogs that are from more stressful environments such as the breeding stock from puppy farms have been
449 reported to have more problems with training and show more anxiety and fear related behaviours
450 (McMillan et al. 2011). Dogs whose owners had previous dog owning experience and spent more time
451 with their dog and attended training classes were more likely to respond to verbal cues (Kobelt et al.,
452 2003). This literature suggests that it is important for puppies and adult dogs to be appropriately
453 socialised, habituated and trained. However, only 24% of dog owners are reported to attend training
454 classes (Coren, 1999) Coren, 1999 is almost 20 years old and it is possible that more people attend
455 training classes now as there is more information available about the importance of training a dog and
456 there are more repercussions if your dog is a nuisance or dangerous to other people but a more recent
457 study found that people would rather seek help that is free than pay for services (Shore et al. 2008).
458 Owners who engage in training with their dogs report that their dogs are less ‘disobedient’, less nervous
459 and more friendly (Bennett and Rohlf, 2007).

460

461 *Animal Welfare Implications*

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

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

470

471 **Conclusion**

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

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

487

488 **Abbreviations**

489 CI; confidence interval

- 490 EPR; electronic patient record
- 491 KC; Kennel Club
- 492 OR; odds ratio
- 493 PMS; practice management system
- 494 SQL; structured query language
- 495 UB; undesirable behaviour
- 496 RTA; road traffic accident
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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

517 Table 3: Prevalence of the most common groups of undesirable behaviours (UBs) recorded as
 518 contributing to deaths from a UB among dogs attending primary-care veterinary practices in England
 519 that died before three years of age with an ascribed cause (n = 474). [Note that some deaths had multiple
 520 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

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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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