

Analysis of 2,570 responses to Dog Aging Project End of Life Survey demonstrates that euthanasia is associated with cause of death but not age

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OBJECTIVE

The Dog Aging Project End of Life Survey was used to evaluate factors associated with manner of death (euthanasia vs unassisted death), including cause of death (CoD), reason for euthanasia (RFE) if performed, medical symptoms, old age characteristics, and perimortem quality of life (QoL).

SAMPLE

Responses collected between the End of Life Survey launch (January 20, 2021) through December 31, 2021, from 2,570 participants whose dogs died.

METHODS

Response frequencies were described. Associations between manner of death and medical symptoms or old age characteristics were evaluated using logistic regression. Factors associated with RFE were evaluated using multinomial regression. The effects of CoD, age at death, and QoL on the frequency of euthanasia as the manner of death were evaluated using multivariate logistic regression.

RESULTS

2,195 (85.4%) dogs were euthanized, and 375 (14.6%) experienced unassisted death. The most frequent owner-reported CoD was illness/disease ($n = 1,495$ [58.1%]). The most frequently reported RFE was pain/suffering ($n = 1,080$ [49.2% of those euthanized]). As age increased, RFE was more likely to be "poor QoL" than any other response. In a multivariate regression including CoD, chronologic age, and QoL, euthanasia as the manner of death was not significantly associated with age.

CLINICAL RELEVANCE

Euthanasia was a common manner of death for dogs in the US. Compared with unassisted death, euthanasia was associated with CoD illness/disease, lower QoL scores, and the presence and number of medical symptoms and old age characteristics. Understanding factors associated with manner of death is important to veterinarians who care for dogs at the end of life.

Keywords: death, euthanasia, age, quality of life, end of life

As of 2020, there were an estimated 86 million owned pet dogs, living in approximately 45% of US households.¹ Recent studies have estimated that the annual mortality rate for owned US dogs is 7.3%² to 7.9%.³ Extrapolating from those mortality rates, we estimate that 6.2 to 6.8 million pet dogs died in the US in 2020. In a

study⁴ in the UK, it was found that of dogs that died, 86% were euthanized. An initial report from the Dog Aging Project (DAP)⁵ found a euthanasia proportion of 83%; to the authors' knowledge, no other large-scale report of the proportion of deceased pet dogs that were euthanized is available for dogs in the US.

The social and emotional bonds that US dog owners share with their dogs are steadily growing and deepening. Among respondents to surveys reported in the AVMA Pet Ownership and Demographics Sourcebooks, the description of dogs as family members (rather than pets or property) rose from 67.2% in 2012 to 85% in 2018.^{6,7} In the Golden Retriever Lifetime Study, 73.8% of dogs were reported to sleep in the owner's bedroom, with 20.9% of those sleeping in the owner's bed.⁸ In the 2022 AVMA Pet Ownership and Demographics Sourcebook,¹ over 80% of the most attentive group of owners ("pampered pets") reported celebrating their pets' birthdays and over 60% reported celebrating other holidays with their pets.¹

Unsurprisingly, dog owners can experience stress associated with illness and death of their dogs⁹ and many owners experience substantial grief with the loss of their companions.¹⁰ Research shows that 70% of owners experience emotional impacts from the loss of their pets, with up to 30% reporting severe grief around the time of their pets' death.¹¹⁻¹⁴

The death of pet dogs takes a toll on veterinarians as well.¹⁴⁻¹⁸ Veterinarians are estimated to be present at the death of their patients 5 times more often than human general practitioners are present at their patients' deaths.¹⁹ Veterinarians often become very involved, whether by providing guidance on at-home care of a terminally ill pet, conversations around quality of life (QoL) and choosing a time to euthanize, or performing the act of euthanasia itself.¹⁴ QoL is a nuanced and complex concept that may incorporate enjoyment, energy, and/or the ability to perform routine activities.²⁰⁻²² Veterinarians generally seek to help owners maximize the length of time with a perceived high QoL and minimize suffering for their pets.¹⁵ Better understanding of the factors that influence owners' experiences surrounding their dogs' death, including decision-making about euthanasia, would enable veterinarians to better support owners as they navigate these experiences.

The DAP^{23,24} is a long-term, longitudinal study of aging, age-related disease, and end-of-life events in US companion dogs.²³ To gather comprehensive information about death among participating dogs, the DAP created the owner-reported End of Life Survey (EOLS),^{5,25} which includes items addressing cause of death (CoD), primary reason for euthanasia (RFE) if performed, and perimortem QoL among participating dogs. The study reported here used responses to the EOLS to evaluate factors related to the manner of death (euthanasia or unassisted death) and reasons for euthanasia when it occurred. We hypothesized that manner of death would be associated with CoD and with the presence of characteristics of old age and medical symptoms but not with a dog's chronological age at death. For dogs that were euthanized, we further hypothesized that the primary RFE would be associated with CoD and perimortem QoL. Additionally, we sought to identify factors most likely to contribute to an owner's decision to euthanize.

Methods

The DAP²⁴ is a long-term, longitudinal, community science, open-data project among US companion dogs and their owners.²³ Dog owners nationwide are recruited directly through conventional and social media as well as targeted recruitment campaigns. Owners volunteer to participate as community scientists, and no incentive to enroll is provided. Each owner who nominates a dog through the DAP website is invited to create a personal password-protected online portal through which they interact with the study to provide survey data and responses to other research tasks that are assigned to specific nested cohorts.

This custom-built DAP platform uses Research Electronic Data Capture^{26,27} tools hosted at the University of Washington for data management. All participants complete an initial comprehensive questionnaire, the Health and Life Experience Survey (HLES),²⁸ to provide information about their dog's current and historical husbandry, physical and social environment, and health. Owners are asked to update this information annually. All dogs whose owners complete the HLES become members of the study population called the DAP Pack. Owners who report the death of a DAP Pack member are invited to complete the previously validated EOLS^{5,25} and given a 40-day window in which to do so. The University of Washington Institutional Review Board deemed that recruitment of dog owners for the DAP and the administration and content of the DAP questionnaires are human subjects research that qualifies for Category 2 exempt status (No. 5988, effective October 30, 2018). No interactions between researchers and privately owned dogs occurred during recruitment of dogs to the project or completion of surveys; therefore, IACUC oversight was not required.

The DAP is an open-data project that provides cumulative, curated annual data releases to the public.²⁹ These data are housed on the Terra platform at the Broad Institute of the Massachusetts Institute of Technology and Harvard University and are available to the general public through the DAP.²⁴ The 2021 Curated Data Release was used for the project reported here. All EOLS responses contained in the dataset were included, and select information from the HLES was used for analysis of EOLS respondents.

To promote uniformity in demographic descriptions of dogs in the study and comparability between studies, the DAP has adopted several demographic descriptive conventions (**Supplementary Table S1**) for sex, age, weight, breed, size class, and life stage using HLES data at enrollment, briefly summarized as follows. In the analysis presented here, age at death and weight were analyzed as continuous variables. Weight was used in place of size class as a more powerful variable. Because age and life stage can be confounded, only one was used; the continuous variable age was used to preserve power.

Age at enrollment is calculated from the date of birth (DoB) if known. For owners who do not know their dog's actual DoB, survey logic is used to collect

the information they do have (eg, year \pm month of birth or current estimated age) to generate an estimated DoB. Descriptive age bins generally span 2 years; for immature dogs (< 3 years of age), bins contain 1-year intervals.

Owners of purebred dogs select their dog's breed from a list of American Kennel Club (AKC) affiliated breeds or can select "My dog is a non-AKC purebred" and report the breed as free text.

Owner-reported weight is described in 5- or 10-kg-interval bins. For dogs that are < 1 year old at the time of enrollment, owners are asked to select the expected adult weight in 10-kg intervals.

Dogs are assigned to size classes for demographic reporting. Dogs from AKC-affiliated breeds (ie, Recognized Breeds, Foundation Stock Service, and Miscellaneous Class) at the time of the DAP's online platform construction in January 2019, are categorized on the basis of breed standard adult weight. For the Poodle, only Toy and Standard options are offered, and data inspection revealed consistent inaccuracy when size options were compared to owner-reported weights; thus, all Poodles were combined for this analysis. Mixed-breed dogs and dogs from non-AKC-affiliated breeds are categorized on the basis of owner-reported weight; those < 1 year of age at enrollment are categorized on the basis of owner-reported expected adult weight (Supplementary Table S1).

Categorization by life stage provides a means to appropriately compare the aging trajectory among dogs of different sizes.^{3,4,30} The DAP's life stage categories (Supplementary Table S1) were developed by combining the median survival time data of Urfer et al² for dogs attending primary care practices, using median survival time in 10-kg weight bins, with the American Animal Hospital Association description of life stages.³¹

The EOLS was designed by the DAP team to acquire information regarding date, location, and manner of death (ie, euthanasia or unassisted death); perimortem old age characteristics, medical symptoms, veterinary care, and QoL assessment; reason(s) for euthanasia if performed; and owner-perceived cause(s) of death.⁵ Items in the EOLS are forced choice and contain discrete, categorical, and Likert-type items; some items offer "other, please describe" as a response variable with an associated free-text box. Within the EOLS, respondents are asked to provide a precise date of death (DoD) and are advised to select the 15th day of the month of death if the date is not known. Using the estimated DoB and the reported DoD, age at death and corresponding life stage at death were generated for all dogs. DoD was compared against the date of HLES completion and DoB to ensure that the DoD entry was plausible. Erroneous DoDs were corrected using veterinary records, when possible, or those dogs were excluded from the analysis.

Within the EOLS, respondents provide a QoL assessment for the final 2 weeks of their dogs' lives on a 7-point Likert-type scale, with anchors at "always bad days" (1) and "always good days" (7). Additionally, "poor QoL" is offered as a categorical response option as an RFE for the subset of dogs that were euthanized.

Due to infrequent selection of some answer choices, response variables for 2 items were collapsed for analytical purposes. The CoD item offers 8 response variables. The RFE item offers 8 response variables. Both items offer a free-text option "Other, please describe" and allow only 1 response to be chosen. For CoD, "old age" and "illness/disease" comprised 89.0% of the responses, and the remaining response variables were collapsed into "other CoD" for analysis. For RFE, "poor QoL," "pain/suffering," and "poor prognosis" comprised 91.9% of the responses. The remaining response variables were collapsed into "other RFE" for analysis.

Statistical analyses

All statistical analyses were completed in the programming language R.³² For all models described below, assumptions were met. To identify factors associated with specific reasons for euthanasia, we used only those dogs that were marked as euthanized. RFEs were grouped into 4 categories: poor QoL, pain/suffering, poor prognosis, and other RFE. These categories were used as the dependent variable in a multinomial regression using the *nnet* package.³³ QoL was coded as a factor with 7 (always good days) as the reference. Continuous age at death, QoL score, and CoD were explanatory variables in the regression. CoD had 3 categories: old age, illness/disease, and other CoD, with old age as the reference.

To examine whether individual medical symptoms were associated with manner of death (ie, euthanasia vs unassisted death), a logistic regression was performed with euthanized (true/false) as the dependent variable and individual medical symptoms as the explanatory variable. The same analysis was repeated with individual characteristics of old age as the explanatory variable. For both, a Bonferroni correction was applied to determine statistical significance. The significance level after Bonferroni correction for individual medical symptoms was $\alpha = 0.0028$ and for individual characteristics of old age was $\alpha = 0.0025$. Individual models evaluated both the number of medical symptoms or characteristics of old age on risk of being euthanized, as well as the presence of any specific medical symptom or old age characteristic. For these individual exploratory models, significance was set at $P < .05$.

In the subset of dogs that had a specific CoD, we explored whether the manner of death within that group was associated with the number of medical symptoms or characteristics of old age recorded. For dogs with illness/disease as the CoD, we determined whether the number of medical symptoms differed between dogs that experienced euthanasia versus unassisted death. Similarly, for dogs with old age as the CoD, we determined whether the number of characteristics of old age differed between dogs that experienced euthanasia versus unassisted death. Finally, we ran a univariate logistic regression to determine the association of age and euthanasia as the manner of death; we then followed this up with a multivariate logistic regression to test whether any association with age remained when also controlling

for CoD and QoL. As above, old age and QoL of 7 were set as the references. Dogs with missing data for any variable were removed from the analysis. Odds ratios and 95% CIs are available for each model (**Supplementary Tables S2–S4**).

Results

The 2021 curated data release²⁹ contained data from 33,172 dogs. Of those dogs, owners of 2,885 (8.7%) reported to the DAP that their dogs were deceased and 2,570 of those 2,885 (89.1%) owners completed the EOLS. A total of 58 EOLS entries that generated an implausible date of death were corrected (n = 56) or excluded from analysis (2), as described.

Demographic characteristics of the study population, divided into those that were euthanized and those that experienced unassisted death, as well as the entire DAP Pack, are provided (**Table 1**).

Among the 2,570 responses, 2,195 (85.4%) dogs were euthanized and 375 (14.6%) experienced unassisted death. While the most frequent owner-reported CoD was illness/disease (n = 1,495; 58.1% of EOLS respondents), old age was also a very common response (793 [30.9%]; **Figure 1**). Among all respondents, the most frequently reported QoL was 3 (more bad days than good days; n = 660 [25.7%]). QoL 1 (always bad days; n = 49 [1.9%]) was very infrequently reported compared to the remaining responses (QoL 2, n = 225 [87.5%]; QoL 4, 413 [16.1%]; QoL 5, 534 [20.8%]; QoL 6, 447 [17.4%]; QoL 7, 242 [9.4%]). Among dogs whose manner of death was euthanasia, the most frequently reported primary RFE was pain/suffering (n = 1,080 [49.2% of those euthanized]), with substantial numbers also reporting poor QoL (566 [25.7%]) and poor prognosis (363 [16.5%]). Each remaining RFE was selected for < 5% of respondents.

Table 1—Owner-reported demographics for dogs in the Dog Aging Project Pack that, at the time of the release of these data, were either alive (n = 33,168) or reported in an owner-completed End of Life Survey as having been euthanized (2,195) or having had unassisted death (375). In each demographic category, groups of dogs are reported as number (percent within that column for that category).

Characteristic	Euthanized (n = 2,195)	Unassisted death (n = 375)	All dogs (n = 33,168)
	No. of dogs (% of euthanized dogs)	No. of dogs (% of dogs with unassisted death)	No. of dogs (% of total dogs)
Age at death			
< 1 y	0 (0.0%)	0 (0.0%)	—
1-< 2 y	3 (0.1%)	4 (1.1%)	—
2-< 3 y	8 (0.4%)	6 (1.6%)	—
3-< 5 y	24 (1.1%)	10 (2.7%)	—
6-< 7 y	45 (2.1%)	7 (1.9%)	—
8-< 9 y	92 (4.2%)	23 (6.1%)	—
10-< 11 y	244 (11.1%)	50 (13.3%)	—
11-< 13 y	508 (23.1%)	79 (21.1%)	—
13-< 15 y	662 (30.2%)	112 (21.9%)	—
15-< 17 y	467 (21.3%)	65 (17.3%)	—
≥ 17 years	141 (6.4%)	18 (4.8%)	—
N/A	1 (< 0.1%)	1 (0.3%)	—
Life stage at death			
Puppy	2 (0.1%)	1 (0.3%)	—
Juvenile	11 (0.5%)	9 (2.4%)	—
Adult	415 (18.9%)	95 (25.3%)	—
Senior	1,766 (80.5%)	269 (71.7%)	—
Sex			
Male, neutered	1,063 (48.4%)	174 (46.4%)	14,808 (44.6%)
Male, intact	53 (2.4%)	21 (5.6%)	1,906 (5.7%)
Female, spayed	1,069 (48.7%)	168 (44.8%)	15,310 (46.2%)
Female, intact	10 (0.5%)	12 (3.2%)	1,148 (3.5%)
Breed classification			
AKC-recognized purebred	1,166 (53.1%)	228 (60.8%)	16,619 (50.1%)
Non-AKC-recognized purebred, F1 hybrid, or mixed breed	1,029 (46.9%)	147 (39.2%)	16,553 (49.9%)
Dog weight class			
0–4.9 kg	117 (5.3%)	29 (7.7%)	2,457 (7.4%)
5–9.9 kg	335 (15.3%)	87 (23.2%)	5,316 (16.0%)
10–14.9 kg	203 (9.2%)	34 (9.1%)	3,228 (9.8%)
15–19.9 kg	200 (9.1%)	26 (6.9%)	3,332 (10.0%)
20–24.9 kg	343 (15.6%)	34 (9.1%)	5,009 (15.1%)
25–29.9 kg	307 (14.0%)	56 (14.9%)	4,669 (14.1%)
30–34.9 kg	306 (13.9%)	40 (10.7%)	3,885 (11.6%)
35–39.9 kg	187 (8.5%)	32 (8.5%)	2,329 (7.0%)
40–44.9 kg	84 (3.8%)	16 (4.3%)	1,329 (4.0%)
≥ 45 kg	113 (5.1%)	21 (5.6%)	1,638 (4.9%)

AKC = American Kennel Club.

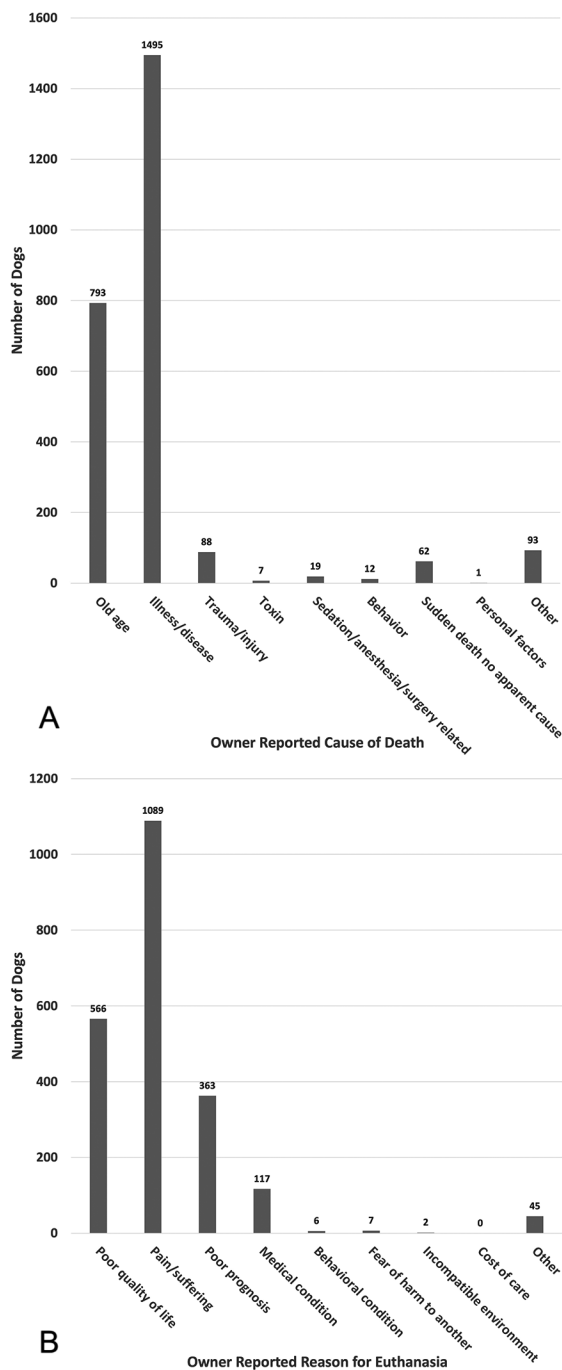


Figure 1—A—Owner-reported cause of death (CoD) selected from 9 possible choices for the 2,570 dogs from the Dog Aging Project Pack whose owners completed the End of Life Survey (EOLS). Response categories are on the x-axis; number of dogs are on the y-axis. The precise number of responses are reported on the top of each column. B—Owner-reported reason for euthanasia (RFE) selected from 9 possible choices for 2,195 dogs whose manner of death was euthanasia among the 2,570 dogs from the Dog Aging Project Pack whose owners completed the EOLS. Response categories are on the x-axis, with number of dogs on the y-axis. The precise number of responses are reported on the top of each column.

Using our multinomial regression, we found that with increasing age, the RFE was increasingly more likely to be poor QoL than pain/suffering ($P = .017$), poor prognosis ($P < .001$), or combined other RFE ($P = .003$). Owner-reported CoD was more likely to be illness/disease or combined other CoD than old age if the RFE was poor prognosis ($P < .001$ for both), pain/suffering ($P < .001$ for both), or combined other RFE ($P < .001$ for both; **Figure 2**). Additionally, compared to dogs whose primary RFE was poor QoL, dogs whose primary RFE was pain/suffering, poor prognosis, or combined other RFE were likely to have higher QoL scores ($P < .001$ for all).

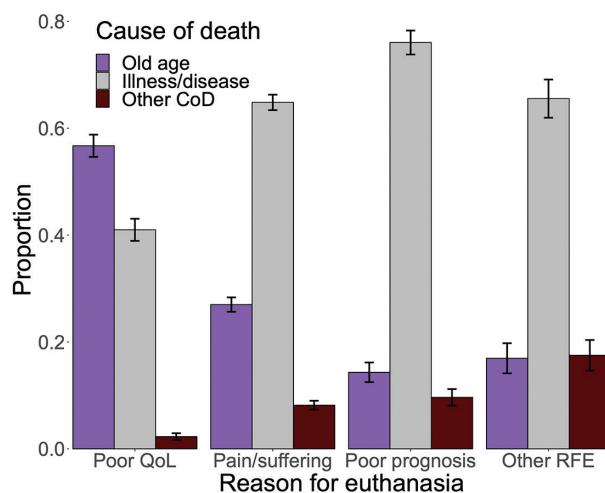
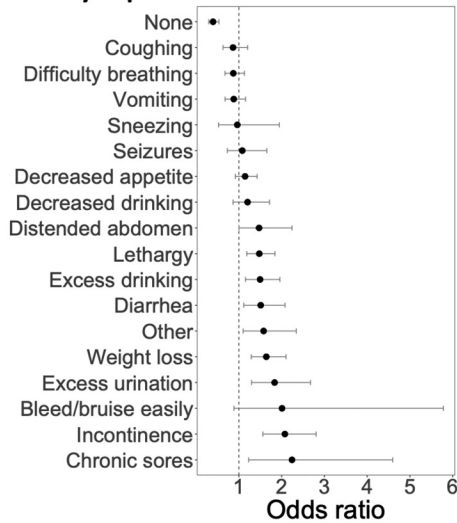


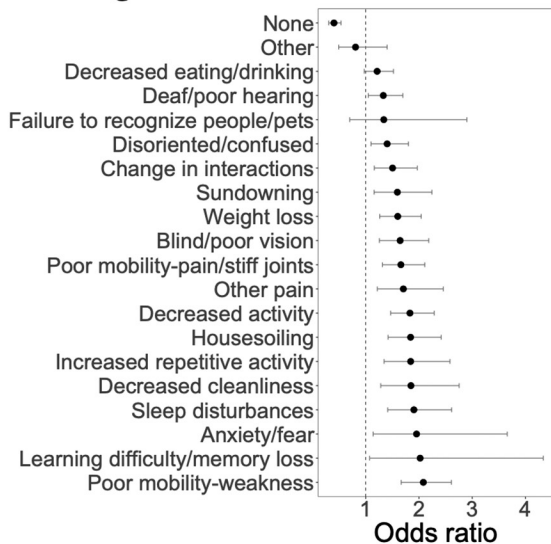
Figure 2—Associations between CoD and RFE responses by owners of 2,195 dogs whose manner of death was euthanasia, as in Figure 1B. RFE categories are on the x-axis, with proportion of responses on the y-axis. Column colors represent CoD responses (old age, purple; illness/disease, gray; and other CoD, maroon). Vertical bars display the proportion of each CoD within an individual RFE. The top and bottom brackets demonstrate SE range. Within each cluster of columns, responses sum to 100% for each RFE.

The average number of medical symptoms reported for those that experienced unassisted death was 2.76 (SD, 2.24), whereas the average number for those that were euthanized was 3.41 (SD, 2.20). Using logistic regression, we found that dogs that were euthanized had significantly more medical symptoms than those that experienced unassisted death ($z = 5.13$; degrees of freedom [df] = 2,569; $P < .001$; **Figure 3; Supplementary Table S5**) and that dogs whose owners reported no medical symptoms were less likely to experience euthanasia than dogs whose owners reported at least 1 medical symptom ($z = 6.99$; df = 2,569; $P < .001$). Individual medical symptoms that were significantly associated with euthanasia after multiple-comparison correction included “lethargy (very low energy)” ($z = 3.45$; df = 2,569; $P < .001$), weight loss ($z = 3.98$; df = 2,569; $P < .001$), urinating a lot ($z = 3.29$; df = 2,569; $P = .001$), and “incontinence (urine or stool)” ($z = 4.88$;

A. Medical Symptoms



B. Old Age Characteristics



df = 2,569; $P < .001$). When considering only the subset of dogs whose reported CoD was illness/disease, presence of any medical symptom ($P = .961$) and number of symptoms ($P = .282$) were not significantly associated with euthanasia as the manner of death.

The average number of characteristics of old age reported for those that experienced an unassisted death was 3.62 (SD, 3.24), whereas the average number for those that were euthanized was 5.08 (SD, 3.46; Figure 3; **Supplementary Table S6**). Using logistic regression, we found that the number of characteristics of old age reported was significantly positively associated with euthanasia ($z = 7.29$; df = 2,569; $P < .001$). Dogs whose owners did not report any characteristics of old age were less likely to experience euthanasia than dogs whose owners reported at least 1 old age characteristic ($z = 6.35$; df = 2,569; $P < .001$). Individual characteristics of old age that were significantly associated with

Figure 3—A—Solid circles represent the OR for euthanasia over unassisted death for each of the displayed medical symptoms, with bands representing the 95% CI. The number and percent of respondents who reported a medical symptom within the EOLS is listed below, with the P value for each symptom. The adjusted significance level after Bonferroni correction is $\alpha = 0.0027$. Significantly associated factors are displayed in bold type. **None** ($n = 264$ [10%]; $P = 6.79E-10$), coughing (307 [12%]; $P = .3703$), difficulty breathing (569 [22%]; $P = .2834$), vomiting (509 [20%]; $P = .3457$), sneezing (73 [3%]; $P = .9068$), seizures (211 [8%]; $P = .7160$), decreased appetite (1,238 [48%]; $P = .2342$), very little drinking (331 [13%]; $P = .2941$), swollen abdomen (belly) (270 [11%]; $P = .0595$), **lethargic (very low energy)** (1,316 [51%]; $P = .0006$), drinking a lot (705 [27%]; $P = .0029$), diarrhea (481 [19%]; $P = .0096$), other not listed here (323 [13%]; $P = .0181$), **weight loss** (928 [36%]; $P = 7.04E-05$), **urinating a lot** (394 [15%]; $P = .0010$), bleeding/bruising easily (63 [2%]; $P = .1372$), **incontinence (urine or stool)** (672 [26%]; $P = 1.06E-06$), and chronic wounds/sores (137 [5%]; $P = .0155$). B—The OR for characteristics of old age reported in the EOLS is displayed as described in panel A. The adjusted significance level after Bonferroni correction is $\alpha = 0.0025$. Significantly associated factors are displayed in bold type. **None** ($n = 309$ [12%]; $P = 2.18E-10$), other not listed here (104 [4%]; $P = .4239$), decreased eating/drinking (1,111 [43%]; $P = .0886$), deaf/poor hearing (876 [34%]; $P = .0197$), difficulty recognizing (79 [3%]; $P = .4149$), disoriented/confused (826 [32%]; $P = .0072$), **change in interactions** (716 [28%]; $P = .0024$), sundowning (437 [17%]; $P = .0056$), **weight loss** (963 [37%]; $P = .0001$), **blind/poor vision** (672 [26%]; $P = .0004$), **poor mobility-pain/stiff joints** (1,029 [40%]; $P = 2.60E-05$), other pain (402 [16%]; $P = .0028$), **decreased activity** (1,419 [55%]; $P = 8.86E-08$), **house soiling** (785 [31%]; $P = 6.70E-06$), **increased repetitive activity** (496 [19%]; $P = .0002$), **decreased cleanliness** (355 [14%]; $P = .0016$), **sleep disturbances** (577 [22%]; $P = 3.78E-05$), anxiety/fear (157 [6%]; $P = .0231$), learning/memory difficulty (113 [4%]; $P = .0453$), and **poor mobility-weakness** (1,398 [54%]; $P = 1.41E-10$).

euthanasia after multiple-comparison correction included poor mobility due to weakness/collapse ($z = 6.42$; df = 2,569; $P < .001$) or pain/stiffness ($z = 4.21$; df = 2,569; $P < .001$), decreased ability to keep clean ($z = 3.16$; df = 2,569; $P = .0016$), house soiling ($z = 4.50$; df = 2,569; $P < .001$), sleep disturbances ($z = 4.12$; df = 2,569; $P < .001$), and decreased time spent active ($z = 5.35$; df = 2,569; $P < .001$). When considering only the subset of dogs whose reported CoD was old age, the presence ($z = 2.44$; df = 792; $P = .0147$) and number ($z = 3.53$; df = 792; $P = .0004$) of characteristics of old age remained associated with euthanasia as the manner of death.

As dogs' age increased, they were more likely to experience euthanasia ($z = 3.92$; df = 2,567; $P < .001$); however, in a multivariate regression including CoD, age, and QoL, age was not significantly associated with euthanasia. Dogs with illness/disease as their CoD were more likely to be euthanized than old age CoD dogs ($z = 2.27$; $P = .024$), while other CoD dogs were less likely to be euthanized ($z = -5.69$; $P < .001$). Dogs with lower QoL scores were more likely to be euthanized ($z = -8.57$; $P < .001$; **Figure 4**).

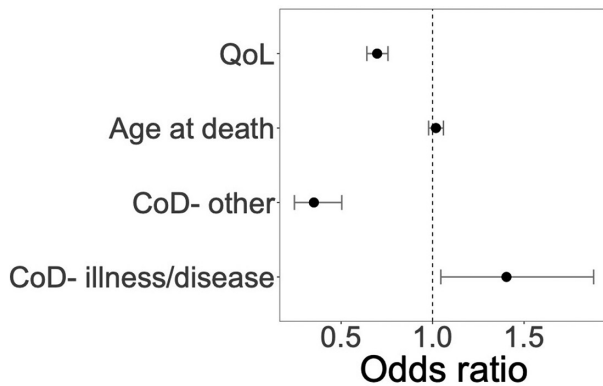


Figure 4—Solid circles represent the OR for euthanasia over unassisted death for each of the displayed medical symptoms included in a multivariate logistic regression model. Bands represent 95% CIs. Illness/disease as a CoD was positively associated with euthanasia over unassisted death, while other CoD was negatively associated. QoL score was also negatively associated with euthanasia, meaning that a higher QoL (closer to baseline, “all good days”) results in decreased risk of euthanasia versus unassisted death. When adjusting for QoL scores and CoD, age was not significantly associated with euthanasia versus unassisted death.

Discussion

This study utilized the owner-directed EOLS developed by the DAP to evaluate factors related to the manner of death (euthanasia or unassisted death) and reasons for euthanasia (if performed). We hypothesized that the manner of death would be associated with CoD and the presence and number of medical symptoms and characteristics of old age but not with the dog’s numeric age at death. We additionally sought to identify factors that were most likely to contribute to an owner’s decision to euthanize, and we hypothesized that the primary RFE would be associated with the reported CoD and the dog’s perimortem QoL.

QoL assessments in humans are generally self-reported or can be provided by a person who knows the subject well when needed (eg, infants).³⁴ To adapt this idea for nonhuman animals,^{34,35} various QoL scores have been formulated to make this complex idea more understandable to owners, using simple approaches,^{36,37} as well as more sophisticated tools designed for specific scenarios like cancer,³⁸ congestive heart failure,³⁷ and orthopedic disease.³⁷ Despite these attempts, a single, broadly recognized definition of QoL does not exist in veterinary medicine. The DAP EOLS utilized a simple Likert-type scale for perimortem QoL and did not attempt to standardize the criteria by which owners interpreted this observation about their dogs.

Age was significantly associated with euthanasia versus unassisted death in univariate analysis. However, in a multivariate model when other factors were controlled, age lost significance, supporting our hypothesis that age by itself is not a primary RFE. By contrast, each QoL score below the baseline value

(7 = all good days) was increasingly associated with euthanasia over unassisted death and CoD illness/disease was associated with increased odds of euthanasia (Figure 4). This suggests that chronological age may become a factor in euthanasia decision-making only when numeric age is associated with declining QoL and/or the development of medical illnesses. Thus, as a dog’s age increases, declining QoL and development of medical comorbidities, regardless of the cause of that decline in QoL, appears to have more impact on euthanasia decision-making than numeric age itself.

Regarding the manner of death and CoD, as hypothesized, we found that dogs whose CoD was illness/disease were more likely to experience euthanasia and dogs whose CoD was the combined “other CoD” (which included trauma, toxin, and sudden death, among others) were less likely to experience euthanasia than dogs whose CoD was old age. Euthanasia of dogs in the US is most commonly a decision made by owners in collaboration with their veterinarians.³⁹ As such, it is understandable that such a decision may be reached when a dog is known or suspected to have an illness or disease. This is compatible with our finding that the most common RFEs were pain/suffering, poor QoL, and poor prognosis, all of which reflect the deterioration of health status. By contrast, several of the causes of death in our other CoD grouping are those often considered “extrinsic” causes of death, such as traumatic events or toxin exposure.⁴⁰ It is likely that such events occurred unexpectedly, rapidly, or both, and there may not have been an opportunity for owners to elect euthanasia before the dog’s death occurred.

We found that, as age increased, dogs were more likely to have poor QoL as the primary RFE compared to pain/suffering, poor prognosis, or other RFE. Pain/suffering, poor prognosis, and other RFE may be tied to a discrete injury, illness, or change in status, rather than a general deterioration. By contrast, poor QoL likely reflects a composite assessment that may encompass pain/suffering and prognosis, as well as other things. The RFE poor QoL may also be selected for a dog with no specific, definable medical problems or concerns when that dog’s owner perceives it is losing vitality, vigor, ability, or enjoyment.

Our hypothesis that there would be relationships among primary RFE, CoD, and QoL was also confirmed. Dogs with RFEs poor prognosis and pain/suffering were more likely to have CoD illness/disease than CoD old age. A prognosis is often associated with a diagnosis, so the fact that owners often indicated a primary RFE of poor prognosis with a CoD of illness/disease seems reasonable. Similarly, many illnesses that are common among aging dogs (eg, neoplasia and osteoarthritis), can cause pain and/or suffering^{35,37,38,41}; thus, it makes sense that owners often indicated pain/suffering as the RFE for dogs with illness/disease CoDs. Numeric age was not associated with euthanasia in our multivariate model. However, among dogs that did experience euthanasia, increasing age was associated with higher likelihood that

the RFE was poor QoL. This is compatible with previous work identifying that poor QoL is an important component of euthanasia decisions, in ways that are sometimes entangled with old age.^{42,43} It is interesting that QoL 1 (always bad days) was reported far less frequently than any other QoL response. This may suggest that owners elect euthanasia before the QoL becomes this poor. Owners may also be reluctant to acknowledge or report QoL 1.

Additionally, owners were asked to provide QoL on a Likert-type scale independent from the item in which they provided RFE. Dogs whose owners identified poor QoL as the primary RFE had lower QoL scores on the Likert-type item, which confirms consistency in their responses (ie, if the QoL was poor, poor QoL was often the primary RFE).

The QoL of dogs whose primary RFE was poor prognosis was significantly better than those whose primary RFE was poor QoL. This suggests that owners differentiate the current QoL from anticipated future experiences inherent to a poor prognosis. Further, it suggests that owners who expect QoL to deteriorate due to a disease process with a reportedly poor prognosis might choose euthanasia before QoL declines. This highlights the significant impact a veterinarian can have on an owner's reaction to their dog's medical diagnosis and importance of providing clear, evidence-based prognostic information to owners considering euthanasia decisions.

The QoL of dogs whose primary RFE was pain/suffering was also better than those whose primary RFE was poor QoL. This suggests that pain and/or suffering might be severe enough to prompt a euthanasia decision whether or not it has impacted global QoL, as could possibly occur in the setting of traumatic injury or sudden illness. These findings highlight the value of distinguishing the RFE from the apparent CoD, as the EOLS is designed to do.

Regarding relationships between the number and presence of medical symptoms and specific characteristics of old age with the manner of death, our hypothesis was partially confirmed. The presence and number of characteristics of old age among dogs in all CoD categories were significantly associated with euthanasia over unassisted death, as were the presence and number of medical symptoms. The relationship between euthanasia and characteristics of old age persisted for the subset of dogs whose CoD was old age. Interestingly, the relationship between euthanasia and the presence and number of medical symptoms did not persist for the subset of dogs whose CoD was illness/disease. It is likely that many dogs whose CoD was illness/disease had a diagnosis of that illness or disease prior to death. The fact that presence and number of medical symptoms are not associated with euthanasia in that CoD group suggests that owners may perceive that medical symptoms can be treated or managed, or can at least be understood, in relation to the dogs' known health problems. By contrast, owners elect euthanasia for dogs with greater numbers of old age symptoms in all CoD categories, perhaps because they do not expect to be able to reverse or mitigate those old age changes.

While our study was one of the largest to attempt to understand the factors that influence owner choices to euthanize their dogs, it also had limitations. First, the DAP seeks broad nationwide enrollment, but as participants are self-selected, the study population was likely skewed toward owners with flexible free time and a strong interest in dog health and longevity. Responses provided in the EOLS by such individuals may or may not reflect the experiences of all US dogs and owners. Second, the concepts of QoL, prognosis, and even pain and/or suffering central to this work are not objectively quantifiable. Their recognition and reporting may be influenced by owner factors (eg, frequency or intensity of observation, prior experience, etc), dog factors (eg, temperament, behavior, comorbidity, etc), and external sources of information (eg, prognosis as communicated by the veterinarian or as discovered online by the owner, etc).^{37,38,44} Specifically, owners' perception of the central role of QoL in end-of-life decision-making may be driven by veterinarians' increasing emphasis on QoL in end-of-life discussions with owners.^{45,46} Similarly, there is overlap in observations that may be most appropriately called "medical symptoms" or "characteristics of old age." Third, while the EOLS was carefully designed and validated to ensure clarity,⁵ it is possible that respondents interpreted similar observations differently; for instance, a given respondent may have reported the medical symptom of incontinence, the old age characteristic of house soiling, or both for the same observation. Similarly, because dogs of different sizes have different aging trajectories, "old age" was intentionally offered as a CoD without a specific definition of the meaning of "old." Therefore, it is probable that there was some confounding between respondent selection of old age as the CoD and the dog's numeric age. Despite this possibility, numeric age dropped out of the multivariate model as a predictor of euthanasia, suggesting that the concept of old age as a CoD has a different meaning to respondents than simple numeric age, even though the two cannot be completely disentangled. The EOLS is subject to potential inaccuracies inherent to all questionnaire-based research, including recall bias, social desirability bias, and lack of a full medical understanding of each dog's health. However, given that there is no standardized medical or legal system for documenting companion dogs' deaths, some dogs die at home without veterinary involvement, and owners elect euthanasia for a variety of complex and overlapping reasons, dog owners represent the most consistent, and sometimes only, source of end-of-life information about their dogs.

This work built upon a preliminary report⁵ from the DAP and was the first large-scale report on the frequency of euthanasia versus unassisted death among companion dogs in the US, describing factors associated with manner of death and relationships among CoD, RFE, and QoL. A better understanding of factors associated with euthanasia of companion dogs creates opportunities to improve communication between veterinarians and owners. Awareness

of the relationships between medical symptoms, characteristics of old age, and poorer QoL with the choice of euthanasia can inform medical history taking and problem prioritization in older dogs. Continued analysis of these data may make it possible to identify some factors associated with euthanasia and/or declining QoL that could be mitigated.

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Supplementary Materials

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