Companion Animal Health and Genetics

RESEARCH

Open Access

Beagles kept as companion animals in the UK – demography, disorders and mortality

Dan G. O'Neill[1*], Morgan R. Schiksnis[1], Dave C. Brodbelt[1], David B. Church[2], Samantha Goldberg[1] and Karolina S. Engdahl[3]

Abstract

Background Beagles are a popular companion animal dog breed and are generally stated to be a healthy breed. This VetCompass study aimed to report the demography, common disorders and mortality of Beagles under primary veterinary care in the UK. Anonymised clinical records within VetCompass were followed over time to extract disorder and mortality data during 2019 on Beagles under primary veterinary care in the UK.

Results Beagles comprised 19,906 (0.88%) of the 2,250,417 dogs in the study population. Annual proportional birth rates showed an increasing breed popularity from 0.41% of all dogs born in 2005 and peaking at 1.06% in 2012, followed by a decrease to 0.90% in 2019. The median adult bodyweight was 18.19 kg (IQR 15.68–21.07). From a random sample of Beagles (3,729/19,906, 18.73%), the most diagnosed disorders were obesity (24.27%, 95% CI: 22.89–25.65), periodontal disease (17.78%, 95% CI: 16.55–19.01), overgrown nail(s) (11.61%, 95% CI: 10.58–12.64), otitis externa (11.18%, 95% CI: 10.17–12.19) and anal sac impaction (10.59%, 95% CI 9.60-11.58). Once disorders were grouped by pathology, the most common group-level disorders were obesity (24.27%, 95% CI: 22.89–25.65), dental disorders (21.48%, 95% CI: 20.16–22.80), ear disorders (13.62%, 95% CI: 12.52–14.72), claw/nail disorders (13.14%, 95% CI: 12.06–14.22) and anal sac disorders (11.10%, 95% CI: 10.09–12.11). The median age at death was 11.28 years (IQR 9.32–13.08) for 322 deaths recorded during the study period. The most common causes of death at group level were neoplasia (19.26%, 95% CI: 14.76–23.75), mass (13.18%, 95% CI: 9.32–17.03), poor quality of life (12.84%, 95% CI: 9.03–16.65), and brain disorders (6.76%, 95% CI: 3.90–9.62).

Conclusions Their disorder profile suggests the Beagle breed should not be considered to have an extreme conformation. Owners and veterinary teams should put special emphasis on care related to bodyweight control and dental hygiene in Beagles. Their median age at death of 11.70 years suggests reasonable overall health but neoplasia is a common biomedical cause of death in Beagles.

Plain English summary

The Beagle is a scenthound originally created to hunt hare but that is now more commonly kept as a companion dog breed. The Beagle is promoted as a generally healthy dog but there is limited published evidence of the health of the subset of the breed that is owned outside of laboratory research. This VetCompass study aimed to report on the demography, common disorders and mortality of Beagles under primary veterinary care in the UK.

*Correspondence:
Dan G. O'Neill
doneill@rvc.ac.uk

Full list of author information is available at the end of the article

VetCompass collects anonymised veterinary clinical records for research on canine health. Beagles comprised 0.88% of the 2,250,417 dogs in the current study under veterinary care during 2019 in the UK. The average adult bodyweight of Beagles was 18.19 kg. Male Beagles were on average over 3 kg heavier than female Beagles (19.70 kg vs. 16.59 kg). From a random sample of 3,729 Beagles whose clinical records were examined in more detail, the most common disorders diagnosed were obesity (24.27% of all Beagles affected in 2019), dental disease (17.78%), overgrown nail(s) (11.61%), ear infection (11.18%) and anal sac impaction (10.59%). From 322 dogs that died during the study, the average age at death was 11.28 years. Females outlived males by almost a year (11.70 years vs. 10.75 years). The most common general causes of death were cancer (19.26%,), lumps (13.18%), poor quality of life (12.84%) and brain disorders (6.76%).

These results confirm the Beagle as a generally healthy breed, with a lifespan and disorder profile similar to dogs overall. However, owners and veterinary teams should put special emphasis on care related to bodyweight control and dental hygiene in Beagles.

Keywords VetCompass, Electronic health record, EHR, Breed, Dog, Epidemiology, Primary-care, Veterinary, Pedigree, Purebred

Background

The Beagle is a scenthound originally created to hunt hare, with the breed name believed to originate from the French word *begueule* meaning "gaped throat", depicting the characteristic vocalisation of these types of dogs while hunting [1]. Originating in England during the 15th century, the earliest dog types classified as Beagles stood at eight to nine inches tall and were termed "Pocket Beagles" as they could fit in a hunter's coat pocket [2]. As hunting bigger prey species such as fox and deer became popularised in the 1800s, Pocket Beagles were crossbred with larger, faster dogs (i.e., Foxhounds, Greyhounds) to create a bigger type of dog standing five to six inches taller and more closely resembling today's modern Beagle [1]. The Beagle was formally recognised in 1885 as a specific breed by the UK Kennel Club (KC), signaling a growing shift towards keeping these dogs for showing and companion animal purposes [2]. The modern Beagle is now a popular companion animal dog, ranked as the 20th most commonly registered breed from the 222 breeds registered by the KC in 2023 [3]. Among the pedigree subset of dogs, Beagle popularity has decreased in the UK in recent years, with KC annual registration dropping from 2,364 Beagles (1.06% of all registrations) in 2013 to 1,581 in 2022 (0.57% of all registrations) [3]. However, there is limited evidence on the demography and ownership of Beagles in the wider UK general population of dogs, despite such information being seen as critical to better understand the breed at a national level [4].

The Beagle is described by the KC as a generally healthy breed and holds no points of physical or behavioural concern on its Breed Watch system for special attention by judges [5]. However, until its discontinuation in 2024, breeders within the KC Assured Breeders Scheme were required to genetically test all breeding Beagles for two inherited disorders, Musladin-Leuke syndrome (autosomal-recessive condition linked to abnormal development of connective tissue) and Lafora's disease (autosomal-recessive condition linked to epilepsy) [6–8]. Despite this apparently good health, a review of breed predispositions in dogs in 2018 identified evidence for predispositions to 32 different disorders in Beagles, suggesting that some wider health issues do exist in the breed, although the authors of that book did flag that the extensive use of Beagles in research may have led to reporting of some relatively uncommon disorders in the breed that are linked to human genetic disorders [9]. That said, there is strong evidence of predisposition to some common disorders among the wider population of Beagles kept as companion animals, including periodontal disease [10], obesity [11] and otitis externa [12]. A study of the overall disorder burden and mortality in Beagles kept as companion animals had yet to be published. This would help owners and breeders put the prevalence of these common disorders into context against dogs overall and assist to prioritise health care and disorder prevention strategies in their Beagle dogs.

Dogs as an overall species are widely used in medical research [13, 14]. Genetic studies using dogs as research models are enhanced by the closed breed registers, frequent use of common sires and limited founder members of the pedigree subsets of many dog breeds that had led to limited locus and disease heterogeneity in many breeds [15]. Dogs offer a spontaneous model for many heritable human diseases, particularly cancer loci [16]. Following marketing in the 1950s as being genetically healthy, cheap to breed and highly tractable to handle, the Beagle became and still is the dominant dog breed used as a laboratory organism specifically in the area of toxicological research [17]. Greater understanding of the overall typical disorder burdens of Beagles could help to appreciate the implications of disorder and age at death changes recorded in laboratory experiments [18]. There is also growing social demand to rehome laboratory dogs once they are no longer needed for experimental use, so

an enhanced health evidence base on the breed could contribute towards optimising outcomes for the later lives of these ex-laboratory dogs [19].

With this broad background, the current study aimed to report the demography, common disorders and mortality of privately owned Beagles under primary veterinary care in the UK. This information could assist veterinary teams to optimise diagnostics and treatment of the most common diseases and assist the wider dog-owning public to understand the potential strengths and weaknesses of taking on a Beagle as a domestic pet. Specific focus was placed on exploring associations between sex and disorder risk.

Materials and methods

The study population included all dogs under primary veterinary care at clinics participating in the VetCompass Programme during 2019. Dogs under veterinary care were defined as having at least one electronic health record [EHR] (free-text clinical note, treatment or bodyweight) recorded during 2019. VetCompass data fields available for the current study included fixed variables of unique animal identifier, species, breed, date of birth, sex and neuter status along with time-varying variables of bodyweight, free-form text clinical notes and treatment with relevant dates [20–22].

Dogs recorded as Beagle were categorised as Beagle while all remaining dogs were categorised as non-Beagle. The bodyweight, sex, neuter status and age for Beagles under veterinary care during 2019 were described. *All-age Bodyweight* (kg) described all available bodyweight and date combinations. *Adult Bodyweight* (kg) described the mean bodyweight recorded from all bodyweight data for dogs aged over 18 months and was categorised into 6 groups (< 14, 14 to < 17, 17 to < 20, 20 to < 23, 23 to < 26, ≥ 26). *Neuter* described the status of the dog (entire or neutered) at the final EHR. *Age* (years) described the age at the final date under veterinary care during 2019 (December 31st, 2019) and was categorised into 6 groups (≤ 3.0, 3.0 to < 6.0, 6.0 to < 9.0, 9.0 to < 12.0 and ≥ 12.0).

A retrospective cohort study design followed the EHRs over 2019 and used a cross-sectional analysis to estimate the one-year period prevalence of the most diagnosed disorders of Beagle dogs from a population of 2,250,417 dogs across all breeds under primary veterinary care during 2019 at VetCompass participating practices. Sample size calculation estimated that disorder burden would need to be extracted on at least 3,012 dogs to reliably report the prevalence for a disorder with an expected prevalence of 2% or higher with a 95% confidence level and to a 0.50% margin of error [23]. Ethical approval was given by the RVC Social Science Research Ethical Review Board (SSRERB) (reference number SR2018-1652).

The EHRs of a random sample from all available Beagles were manually reviewed by one of the authors (MRS) in detail to extract the most definitive diagnoses recorded for all disorders recorded as existing during 2019 and to link these to the most appropriate VeNom term as previously described [21]. The extracted diagnosis terms were mapped to a dual hierarchy of precision for analysis: fine-level precision and grouped-level precision [21]. Fine-level precision terms described the original extracted terms at the maximal diagnostic precision recorded within the clinical notes (e.g. *inflammatory bowel disease* remained as *inflammatory bowel disease*). Grouped-level precision terms mapped the original diagnosis terms to a general level of diagnostic precision (e.g. *inflammatory bowel disease* mapped to *enteropathy)*. Disorders described within the clinical notes using presenting sign terms (e.g. 'vomiting' or 'vomiting and diarrhoea') without a formal clinical diagnostic term were included using the first sign listed (e.g. vomiting). Elective (e.g. neutering) or prophylactic (e.g. vaccination) clinical events were excluded. No distinction was made between pre-existing and incident disorder presentations. Neoplasia described clinical conditions recorded in the clinical notes as having a neoplastic pathology whereas the term 'mass' was applied to clinical conditions where a lump was described but without the notes confirming an underlying neoplastic pathology. Mortality data (recorded cause, date and method of death) were extracted on all deaths at any date during the available EHRs.

Following data checking for internal validity and cleaning in Excel (Microsoft Office Excel 2013, Microsoft Corp.), analyses were conducted using R version 4.2.1 [24]. Annual proportional birth rates described the relative proportion of Beagles compared with all dogs from the cohort under veterinary care in 2019 born in each year from 2005 to 2019. The figure illustrating annual proportional birth rates was generated with the R package ggplot2 [25]. All bodyweight data with their associated dates at any dog age were used to generate individual bodyweight growth curves for male and female Beagle by plotting age-specific bodyweights overlaid with a cross medians line using the R package ggplot2 [25].

One-year (2019) period prevalence values were reported along with 95% confidence intervals (CI) that described the probability of diagnosis at least once during 2019. The CI estimates were derived from standard errors based on approximation to the normal distribution (Wald CI) for disorders with ten or more events [26] or the Wilson approximation method for disorders with fewer than ten events [27], using the binom.approx() and binom.wilson() functions from the R package epitools [28]. Prevalence values were reported overall and separately for males and females. Median age (years) as defined above was reported for each of the most common

diagnoses at fine-level and group-level. The 10 most common disorders at group-level precision in each of three age bands (<3 years, 3–7 years, and >7 years) were identified and the prevalence of each these disorders through life up to the age of 14 is presented using loess curves in a figure generated with the R packages ggplot2, cowplot, and ggpubr [25, 29, 30]. A combination of the Shapiro-Wilk test and visual assessment of histograms was used to assess normality of continuous variables. The two-proportion z-test was used to compare proportions, chi-square test to compare categorical variables, and the Mann-Whitney U test to compare continuous variables that deviated from normality [26]. Statistical significance was set at the 5% level.

Results

Demography

The study population of 2,250,417 dogs under veterinary care during 2019 in the UK included 19,906 (0.88%) Beagles. Of the Beagles with information available, 9,381 (47.13%) were females and 13,222 (66.42%) were neutered (Table 1).

Proportionally more females than males were neutered; 68.98% of the females and 64.52% of the males were neutered (chi-square test: $P<0.001$). The overall median age was 4.86 years (interquartile range (IQR) 2.18–7.99, range 0.03–22.01). Annual proportional birth rates showed an increasing breed popularity from 2005 to 2012, starting at 0.41% of all dogs born in 2005 and peaking at 1.06% in 2012, followed by a decrease to 0.90% in 2019 (Fig. 1).

The median adult bodyweight overall was 18.19 kg (IQR 15.68–21.07, range 6.46–46.25). Males (19.70 kg, IQR 17.26–22.44, range 8.11–46.25) were heavier than females (16.59 kg, IQR 14.48–18.97, range 6.46–44.7) (Mann-Whitney U test: $P<0.001$). The median bodyweight across all ages was also higher in males (17.70, IQR 14.50-20.85, range 0.51–44.21) than in females (14.99, IQR 12.30-17.65, range 0.89–36.40) (Mann-Whitney U test: $P<0.001$). Bodyweight curves based on 107,614 bodyweight values in 9,704 males and 96,367 bodyweight values in 8,657 females showed that Beagles grow rapidly during their first year and continue to gain weight until around three to four years of age (Fig. 2). Proportional completeness for each variable was sex 99.58%, neuter 100.00%, mean adult bodyweight 82.26%, and age 99.68%.

Disorder prevalence

The EHRs from a random sample of Beagles (3,729/19,906, 18.73%) were manually reviewed and information was extracted on all disorders recorded as existing during 2019. Of these 3,729 Beagles, there were 3,072 (82.38%) that had at least one disorder recorded during 2019, while the remainder received only prophylactic care or no active veterinary care during 2019. There were 7,889 unique disorder events reported during 2019. The median annual disorder count per Beagle was 2 (IQR 1–3, range 0–17) disorders. The distribution of annual disorder counts did not differ significantly between females (median count 2, IQR 1–3, range 0–17) and males (median count 2, IQR 1–3, range 0–16) (Mann-Whitney U test, $P=0.928$).

The 7,889 disorder events were spread across 435 fine-level disorder terms. The most diagnosed disorders were obesity ($n=905$, prevalence 24.27%, 95% CI: 22.89–25.65), periodontal disease (663, 17.78%, 95% CI: 16.55–19.01), overgrown nail(s) (433, 11.61%, 95% CI: 10.58–12.64), otitis externa (417, 11.18%, 95% CI: 10.17–12.19) and anal sac impaction (395, 10.59%, 95% CI 9.60-11.58). Among the 36 most common fine-level disorders, females had higher probability of periodontal disease, anal sac impaction, postoperative wound complications, and urinary tract infection, while males had higher probability of postoperative complications and seizure disorders (two-proportion z-test: $P<0.05$). The median age of dogs with the 36 most common fine-level diagnoses

Table 1 Demography of 19,906 Beagles under primary veterinary care at practices participating in the VetCompass Programme in the UK from January 1st to December 31st, 2019. *Counts cover dogs with available data

Variable	Category	Overall No. (%)*	Female No. (%)*	Male No. (%)*
Neuter status	Neutered	13,222 (66.42)	6,471 (68.98)	6,737 (64.52)
Adult bodyweight (kg)	< 14	1,966 (12.05)	1,563 (20.26)	401 (4.68)
	14 to < 17	4,204 (25.76)	2,671 (34.62)	1,521 (17.75)
	17 to < 20	4,750 (29.11)	2,128 (27.58)	2,615 (30.51)
	20 to < 23	3,164 (19.39)	940 (12.18)	2,218 (25.88)
	23 to < 26	1,516 (9.29)	301 (3.90)	1,211 (14.13)
	> 26	717 (4.39)	112 (1.45)	604 (7.05)
Age (years)	< 3	6,629 (33.41)	3,044 (32.57)	3,549 (34.06)
	3 to < 6	5,155 (25.98)	2,472 (26.45)	2,666 (25.59)
	6 to < 9	4,399 (22.17)	2,056 (22.00)	2,341 (22.47)
	9 to < 12	2,593 (13.07)	1,230 (13.16)	1,348 (12.94)
	≥ 12	1,066 (5.37)	544 (5.82)	516 (4.95)

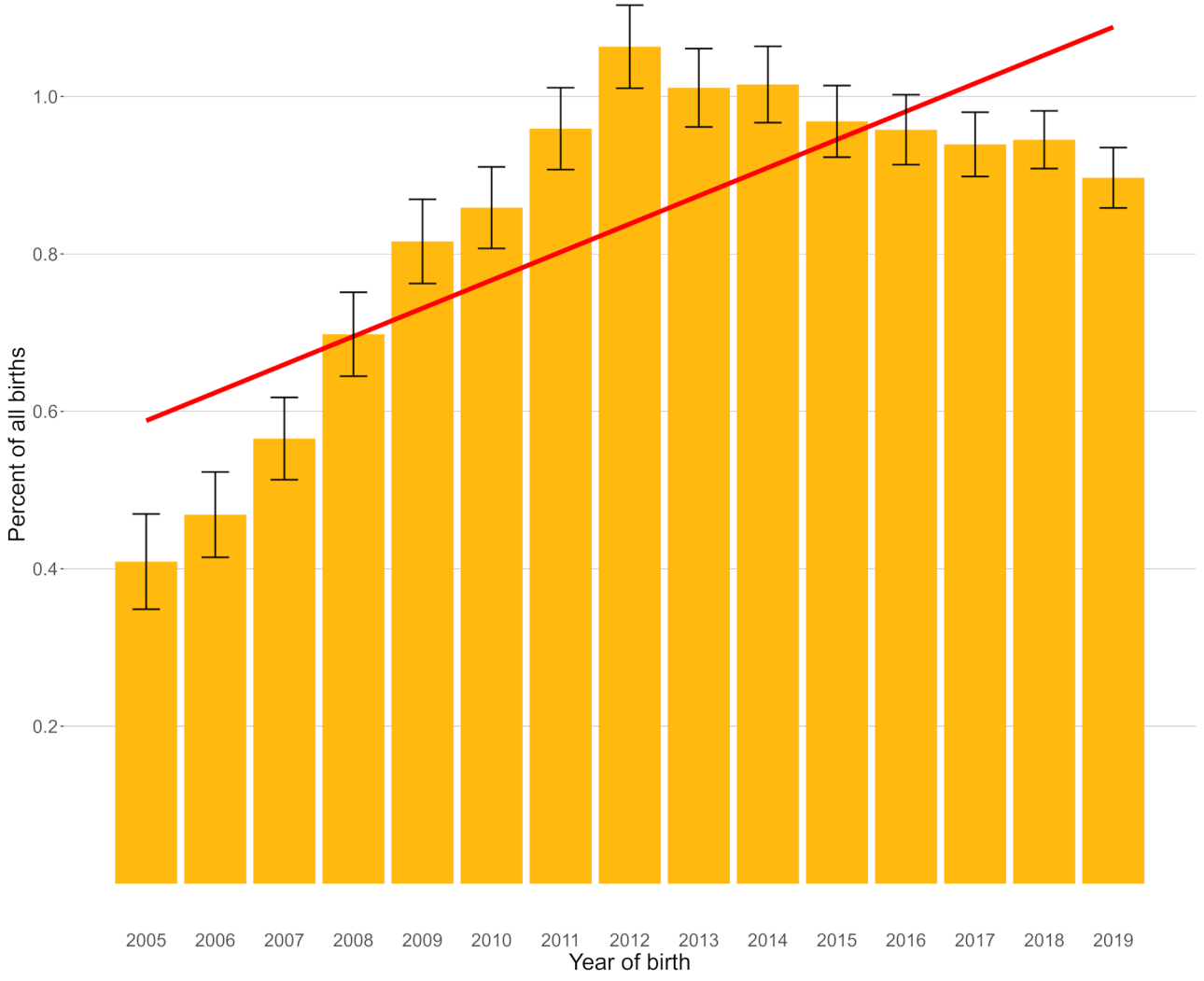

Fig. 1 Annual proportional birth rates (2005–2019) with linear trend and 95% confidence intervals for Beagles ($n = 19{,}906$) among all dogs ($n = 2{,}250{,}417$) under UK primary veterinary care from January 1st 2019 to December 31st, 2019 at practices participating in the VetCompass Programme

varied from 1.58 years for diarrhoea to 10.40 years for multiple masses (Table 2).

The fine-level disorder terms were condensed into 63 group-level disorder terms. The most common group-level disorders were obesity ($n = 905$, prevalence 24.27%, 95% CI: 22.89–25.65), dental disorders (801, 21.48%, 95% CI: 20.16–22.80), ear disorders (508, 13.62%, 95% CI: 12.52–14.72), claw/nail disorders (490, 13.14%, 95% CI: 12.06–14.22) and anal sac disorders (414, 11.10%, 95% CI: 10.09–12.11). Among the 20 most common group-level disorders, females had higher probability of dental disorders and anal sac disorders while males had higher probability of intoxication, skin and brain disorders ($P < 0.05$, two-proportion z-test). The median age of dogs with the 20 most common group-level disorders ranged from 1.85 years for parasite infestation to 9.42 years for heart disorders (Table 3).

The prevalence of the top 10 most common group-level disorders in three age bands: < 3 years, 3–7 years, and >7 years is presented in Fig. 3. There were 1,274 dogs aged under 3 years, 1,276 dogs aged from 3 to 7 years, and 1,168 dogs aged over 7 years. The prevalence of all disorders in Fig. 3 except for behavioural and ophthalmological (12/14 of the disorders, 85.71%) varied significantly between the age groups (chi-square test, $P < 0.05$).

Mortality

During the study period, deaths were recorded in 322/3,729 (8.64%) Beagles. The median age at death was 11.28 years (IQR 9.32–13.08, range 0.03–19.51). Longevity was significantly higher in females (median age at death 11.70 years, IQR 9.82–13.43, range 0.03–19.51, $n = 151$) than in males (10.75 years, IQR 8.88–12.65, range 0.15–16.89, $n = 169$) (Mann-Whitney U test, $P = 0.035$). Of the 313/322 (97.20%) deaths with a recorded method

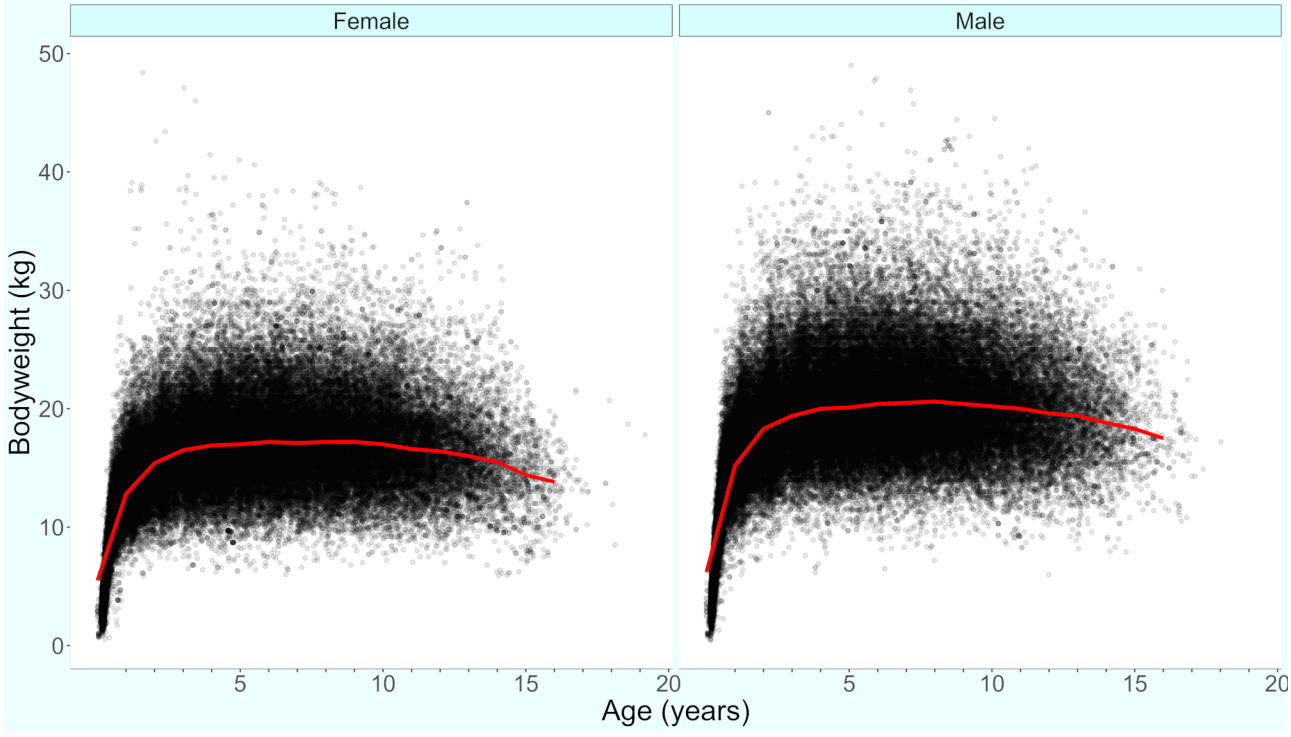

Fig. 2 Bodyweight at different life stages with a cross medians line plot for female ($n=8,657$) and male ($n=9,704$) Beagles under UK primary veterinary care from January 1st 2019 to December 31st, 2019 at practices participating in the VetCompass Programme

of death, 290 (92.65%) were euthanised and 23 (7.35%) died unassisted.

Among the 296/322 (91.93%) deaths with a reported biomedical cause, the most common causes of death at group level precision were neoplasia ($n=57$, 19.26%, 95% CI: 14.76–23.75), mass (39, 13.18%, 95% CI: 9.32–17.03), poor quality of life (38, 12.84%, 95% CI: 9.03–16.65), and brain disorders (20, 6.76%, 95% CI: 3.90–9.62) (Table 4).

Discussion

The current paper represents the largest epidemiological study to report the demography, disorder burden and mortality of Beagles under primary veterinary care in the UK. Beagles are shown to be a relatively common companion dog breed in the UK with highly consistent ownership levels over the past decade. The breed is shown to be commonly diagnosed with dental disease and obesity. However, the median age at death of 11.70 years suggests reasonable overall health. These results suggests that Beagle owners could substantially improve the welfare of their dogs by greater attention to good dental hygiene and bodyweight control.

Despite evidence that annual UK KC registrations of Beagles dropped from 1.06% of all registrations 2013 to 0.57% of all registrations in 2022 [3], the current study shows a different picture among the wider UK dog population where annual births of Beagles have been relatively static over the past decade at around 0.9% of all dogs. Given there are an estimated 10 million dogs in the UK, this suggests an overall UK Beagle population of around 90,000 and highlights the welfare value from greater understanding of the demography and health of this breed [31–34]. In the face of the twin phenomena of rising UK and worldwide popularity of both dog breeds with extreme conformation such as the French Bulldog and also of newly invented designer crossbred breeds such as Cockapoo and Cavapoo based on perceptions of hybrid vigour health, it is interesting that the Beagle has maintained its ownership levels among the wider public [35–37]. This enduring popularity may be linked to the Beagle being seen largely as just a reasonably natural type of dog without extreme conformation or major social media hype by celebrity influencers [38].

The current study reports a median adult bodyweight of 18.19 kg for the wider population of Beagles owned in the UK, with male Beagles at 19.70 kg weighing over 3 kg heavier than females at 16.59 kg. Although not giving a target bodyweight in its Beagle breed standard, the UK KC does specify a range of 33–40 cm for height to withers which is similar to the US AKC breed standard that specifies 33–38 cm height with a weight range of 9.1–13.6 kg [2, 39]. This suggests that the general public prefer to own a larger version of the Beagle than is generally desired for the show ring and could partially explain the diminishing KC registrations in the UK despite resilient wider Beagle ownership.

Table 2 Prevalence of the most diagnosed disorders at *fine-level* diagnostic precision in Beagles ($n = 3,729$) under primary veterinary care at practices participating in the VetCompass Programme in the UK from January 1st to December 31st, 2019

Fine-level disorder	No.	Prevalence % (95% CI*)	Female % prevalence	Male % prevalence	*P*-value**	Median age (years) of affected dogs
Obesity	905	24.27 (22.89–25.65)	25.26	23.44	0.211	5.44 (0.40-15.54)
Periodontal disease	663	17.78 (16.55–19.01)	19.66	16.18	**0.007**	7.53 (1.02–18.63)
Overgrown nail(s)	433	11.61 (10.58–12.64)	12.17	11.16	0.364	5.08 (0.34–17.26)
Otitis externa	417	11.18 (10.17–12.19)	10.29	11.97	0.114	5.67 (0.37–15.54)
Anal sac impaction	395	10.59 (9.60-11.58)	12.40	9.03	**0.001**	6.01 (0.49–17.26)
Lipoma	205	5.50 (4.77–6.23)	4.80	6.14	0.086	9.53 (1.68–16.61)
Anxiety/distressed	183	4.91 (4.21–5.60)	4.69	5.07	0.637	5.29 (0.42–15.39)
Conjunctivitis	149	4.00 (3.37–4.62)	3.89	4.11	0.792	4.46 (0.63–16.09)
Dental disorder	122	3.27 (2.70–3.84)	3.66	2.94	0.259	6.44 (0.87–16.42)
Heart murmur	122	3.27 (2.70–3.84)	3.26	3.30	> 0.999	9.40 (0.40-16.61)
Foreign body	107	2.87 (2.33–3.41)	2.34	3.35	0.083	4.12 (0.31–14.73)
Aural discharge	91	2.44 (1.95–2.94)	2.63	2.23	0.498	3.78 (0.27–13.03)
Diarrhoea	90	2.41 (1.92–2.91)	2.17	2.64	0.413	1.58 (0.25–15.46)
Allergic skin disorder	83	2.23 (1.75–2.70)	1.71	2.69	0.058	6.39 (0.74–13.78)
Postoperative complication (not wound-related)	81	2.17 (1.70–2.64)	1.20	2.99	**< 0.001**	2.35 (0.46–13.43)
Intoxication/poisoning (food item)	79	2.12 (1.66–2.58)	1.89	2.33	0.405	5.68 (0.42–13.34)
Postoperative wound complication	78	2.09 (1.63–2.55)	3.20	1.12	**< 0.001**	4.03 (0.58–15.13)
Seizure disorder	76	2.04 (1.58–2.49)	1.09	2.84	**< 0.001**	7.45 (1.00-15.08)
Skin mass	76	2.04 (1.58–2.49)	1.71	2.33	0.223	8.28 (0.72–16.35)
Anal sac infection	72	1.93 (1.49–2.37)	2.11	1.78	0.529	7.50 (1.56–13.89)
Gastroenteritis	71	1.90 (1.47–2.34)	1.83	1.98	0.831	3.20 (0.27–14.86)
Osteoarthritis	71	1.90 (1.47–2.34)	2.00	1.83	0.790	9.68 (2.17–18.63)
Papilloma	70	1.88 (1.44–2.31)	1.77	1.93	0.817	8.36 (0.75–15.41)
Aggression	69	1.85 (1.42–2.28)	1.20	2.44	0.008	5.16 (0.64–13.56)
Skin cyst	67	1.80 (1.37–2.22)	2.17	1.42	0.108	7.88 (1.37–16.35)
Wound	66	1.77 (1.35–2.19)	1.37	2.13	0.104	4.21 (0.76–13.05)
Cruciate ligament disease	63	1.69 (1.28–2.10)	1.66	1.73	0.974	7.27 (1.49–15.64)
Musculoskeletal pain	60	1.61 (1.21–2.01)	1.43	1.78	0.478	6.08 (0.39–13.91)
Vomiting	60	1.61 (1.21–2.01)	1.60	1.62	> 0.999	3.35 (0.40-15.38)
Multiple masses	58	1.56 (1.16–1.95)	1.43	1.67	0.637	10.40 (3.09–16.42)
Claw injury	55	1.47 (1.09–1.86)	1.31	1.57	0.602	5.76 (0.99–15.46)
Allergy	53	1.42 (1.04–1.80)	1.14	1.67	0.220	5.54 (0.70-12.52)
Urinary tract infection	53	1.42 (1.04–1.80)	2.23	0.71	**< 0.001**	6.14 (0.22–16.42)
Soft tissue injury	51	1.37 (0.99–1.74)	1.54	1.22	0.477	5.06 (0.33–11.78)
Dermatitis	47	1.26 (0.90–1.62)	1.26	1.22	> 0.999	5.82 (0.40-11.52)
Ear disorder	47	1.26 (0.90–1.62)	1.09	1.42	0.444	8.54 (2.00-15.13)

**95% CI* 95% confidence interval. ** two-proportion z-test comparing female and male prevalence with *P*-values < 0.05 shown in bold

High levels of obesity could offer another explanation for the heavier bodyweights in the wider population of Beagles compared to the ideal targets for sizes of Beagles presented in the show ring as suggested in pedigree breed standards. The current study identified obesity as the most commonly diagnosed disorder in Beagles, with 24.27% of Beagles diagnosed annually. This prevalence is substantially higher than the 7.1% annual prevalence of obesity previously reported across all dogs in the UK using a similar methodology to the current study [11]. That previous study also identified the Beagle with 2.67 times odds of obesity compared to crossbred dogs as having the second highest breed predisposition for obesity, surpassed only by the Pug with 3.12 times the odds despite active selection pressure for several decades on the Pug to be 'never lean nor leggy' until the breed standard was recently updated [40]. A tendency towards normalisation of being overweight has been reported in Beagles presented for dog showing. The Beagle was ranked with the ninth highest mean body condition score (BCS) (9-point scale) among 63 breeds assessed at a major dog show in the Netherlands, with the 5.45 BCS of

Table 3 Prevalence of the most common disorders at *group-level* diagnostic precision in Beagles ($n = 3,729$) under primary veterinary care at practices participating in the VetCompass Programme in the UK from January 1st to December 31st, 2019

Group-level disorder	No.	Prevalence % (95% CI*)	Female % prevalence	Male % prevalence	*P*-value**	Median age (years) of affected dogs
Obesity	905	24.27 (22.89–25.65)	25.26	23.44	0.211	5.44 (0.40-15.54)
Dental disorder	801	21.48 (20.16–22.80)	23.71	19.58	**0.003**	7.21 (0.22–18.63)
Ear disorder	508	13.62 (12.52–14.72)	13.03	14.16	0.341	5.48 (0.27 15.54)
Claw/nail disorder	490	13.14 (12.06–14.22)	13.43	12.89	0.660	5.18 (0.34 17.26)
Anal sac disorder	414	11.10 (10.09–12.11)	12.86	9.59	**0.002**	6.15 (0.49–17.26)
Skin disorder	408	10.94 (9.94–11.94)	9.83	11.92	**0.047**	6.15 (0.40-18.63)
Neoplasia	407	10.91 (9.91–11.92)	10.34	11.36	0.344	9.00 (0.75–16.61)
Enteropathy	378	10.14 (9.17–11.11)	10.11	10.15	> 0.999	3.12 (0.22–16.42)
Mass	318	8.53 (7.63–9.42)	8.11	8.88	0.438	8.71 (0.67–16.42)
Behavioural disorder	311	8.34 (7.45–9.23)	7.37	9.18	0.053	5.05 (0.29–16.61)
Musculoskeletal disorder	311	8.34 (7.45–9.23)	8.34	8.37	> 0.999	7.31 (0.25–18.63)
Ophthalmological disorder	270	7.24 (6.41–8.07)	7.54	6.95	0.527	5.06 (0.29–17.26)
Traumatic injury	165	4.42 (3.76–5.08)	3.71	5.07	0.054	4.17 (0.20-13.46)
Heart disorder	155	4.16 (3.52–4.80)	4.17	4.16	> 0.999	9.42 (0.31–16.61)
Complication associated with clinical care	151	4.05 (3.42–4.68)	4.17	3.91	0.744	2.57 (0.46–15.13)
Brain disorder	140	3.75 (3.14–4.36)	2.40	4.92	**< 0.001**	6.96 (0.34–16.42)
Respiratory tract disorder	136	3.65 (3.05–4.25)	3.43	3.86	0.545	3.08 (0.22–15.54)
Parasite infestation	122	3.27 (2.70–3.84)	3.20	3.35	0.871	1.85 (0.22–17.26)
Foreign body	107	2.87 (2.33–3.41)	2.34	3.35	0.083	4.12 (0.31–14.73)
Intoxication	106	2.84 (2.31–3.38)	2.23	3.40	**0.041**	4.98 (0.42–15.54)

**95% CI* 95% confidence interval. ** two-proportion z-test comparing female and male prevalence with *P*-values < 0.05 shown in bold

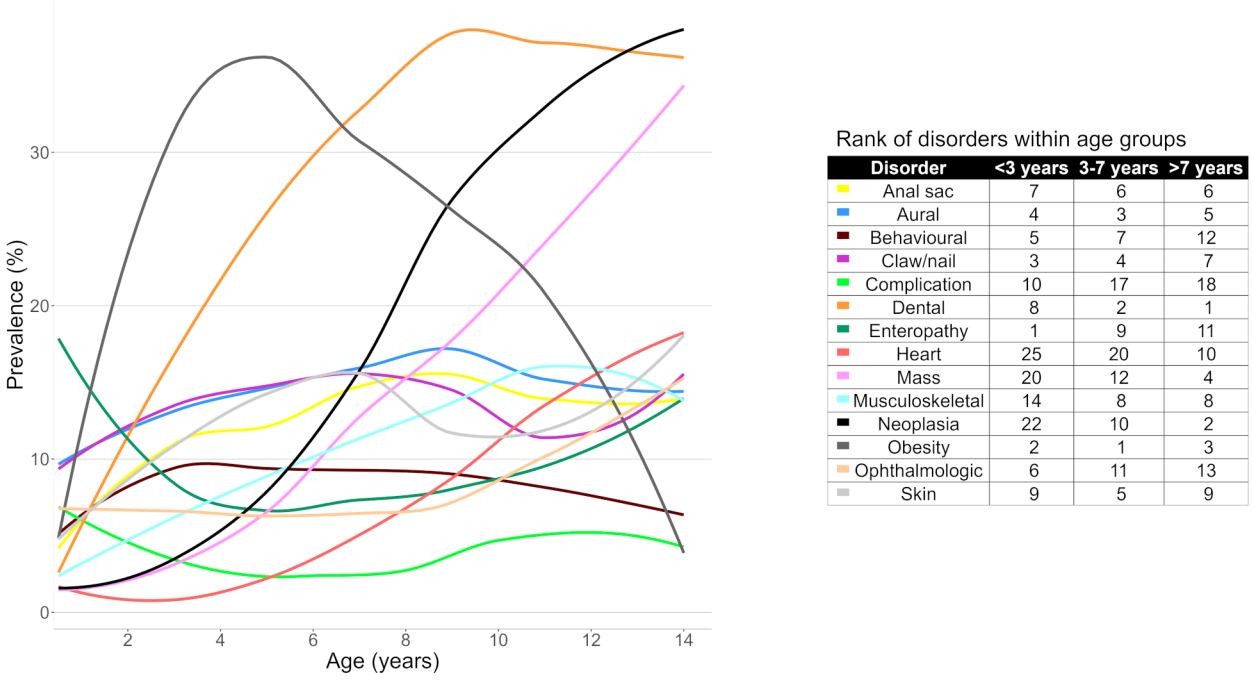

Fig. 3 Prevalence of the 10 most common group-level disorders within each of three age bands (under 3 years $n = 1,274$, 3–7 years $n = 1,276$, over 7 years $n = 1,168$) in Beagles under primary veterinary care at UK practices participating in the VetCompass Programme from January 1st to December 31st, 2019. *Complication* refers to complication associated with clinical care

Table 4 Mortality in Beagles with a recorded cause of death under primary veterinary care at UK practices participating in the VetCompass Programme from January 1st to December 31st, 2019. *N* = 296

Group-level disorder	Count	Percent (95% CI*)
Neoplasia	57	19.26 (14.76–23.75)
Mass	39	13.18 (9.32–17.03)
Poor quality of life	38	12.84 (9.03–16.65)
Brain disorder	20	6.76 (3.90–9.62)
Kidney disorder	20	6.76 (3.90–9.62)
Liver disorder	16	5.41 (2.83–7.98)
Heart disorder	13	4.39 (2.06–6.73)
Behavioural disorder	12	4.05 (1.81–6.30)
Endocrine disorder	9	3.04 (1.61–5.68)
Collapsed	8	2.70 (1.38–5.24)
Haematopoietic disorder	6	2.03 (0.93–4.35)
Respiratory tract disorder	6	2.03 (0.93–4.35)
Spinal cord disorder	6	2.03 (0.93–4.35)
Skin disorder	5	1.69 (0.72–3.89)
Abdominal disorder	4	1.35 (0.53–3.42)
Incontinence	4	1.35 (0.53–3.42)
Traumatic injury	4	1.35 (0.53–3.42)
Lethargy	3	1.01 (0.35–2.94)
Spinal arthropathy	3	1.01 (0.35–2.94)
Other	23	7.77 (4.72–10.82)

**CI* confidence interval **Separate categories are presented for group-level disorders with ≥ 3 affected dogs

the Beagle statistically significantly higher ($P<0.05$) than the 4.67 BCS for the dogs overall [41]. Analysis of data gathered on dogs visiting private veterinary clinics in Japan reported the Beagle with the fourth highest prevalence of overweight or obesity from 103 breeds assessed, with their prevalence of 26.2% being very similar to the 24.27% current result [42]. There is substantial evidence that neutering is a strong predisposing factor for obesity in dogs, and especially for males [43–45]. The 66.42% proportional neutering in Beagles at the end of the current study was substantially higher than the 43.74% previously reported for dogs overall during 2019 from the same underlying data source [35]. This suggests that the high levels of obesity recorded in the current population of Beagles may in part reflect high levels of neutering and that greater consideration should be given to obesity awareness and prevention when deciding on neutering of Beagles. However, given that neuter status was recorded at the end of the study period after which all of the disorders recorded in study has already occurred, the current data did not lend themselves to deeper analysis to explore neutering as a causal factor for these disorders. The twin factors of a strong breed predisposition as well as high prevalence suggest that obesity should be considered as a major breed welfare issue for the Beagle and should be prioritised for attention by Beagle breed clubs and owners [46]. The current study did not capture clinical data on the duration and severity of obesity that would be needed to fully evaluate the overall welfare impact of obesity in Beagles [47]. However, a previous study that did extract prevalence, duration and severity data on common disorders in dogs from veterinary clinical records reported obesity as having the third highest overall welfare impact on dogs, surpassed only by dental disease and osteoarthritis [48]. Paradoxically, predisposition to obesity has contributed to greater emphasis on using Beagles as a laboratory model for human obesity research to better understand obesogenic genetics and pathophysiology [49–51]. Obesity has been reported to shorten life span [52], reduce quality of life [53] and lead to higher frequency of important comorbid disorders including osteoarthritis, diabetes mellitus and certain types of neoplasia [54–56]. Despite these high rates of obesity, many dog owners understand that regular physical exercise benefits their own health and may opt to own a Beagle because, as a breed originally invented as a working animal, they accept that companion animal Beagles still need regular exercise [57]. It should be noted however that changes to the type and volume of diet fed, along with attention to broader feeding practices, are considered critical for effective weight loss in dog that are already obese [58]. A UK questionnaire survey of owners of 17,028 dogs identified Beagles as a breed given frequent exercise by owners, with 80% of owners stating that they gave their Beagle more than one hour of exercise daily [59]. The current results suggest that overweight/obesity should be considered as a priority disorder in Beagles, with owners encouraged to take proactive actions to ward off obesity as a high welfare condition that is highly preventable [46, 60].

Potentially linked to a predisposition to obesity, the current study identified that lipoma had a prevalence of 5.50%, making lipoma the sixth most commonly diagnosed disorder in Beagles. This prevalence was almost four times higher than the 1.44% prevalence previously identified in dogs overall in the UK, using a similar methodology [21]. Supporting predisposition to lipoma, a previous study that specifically focused on lipoma in dogs under primary veterinary care in the UK reported Beagles with 2.03 times the odds of lipoma compared to crossbred dogs, after accounting for other confounding factors [61]. Owners should be made aware of these high risks of lipoma in Beagles, both to reduce owner alarm when encountering a lipoma mass on their dog and also to encourage regular inspection for suspicious masses that can promote earlier formal veterinary diagnosis and management.

The current study identified periodontal disease as the second most common disorder diagnosed in Beagles in the UK, with an annual prevalence of 17.78%. This value is substantially higher than the 12.52% annual prevalence

previously reported in dogs overall in the UK using a similar methodology to the current study [62]. Analysis of US veterinary clinical records reported a 5-year period prevalence of 23.2% periodontal disease in Beagles that was also substantially higher than the 18.2% prevalence reported for dogs overall [10]. The higher prevalence values in the US study compared to the UK study may be explained by the US study using a 5-year period to identify cases which would give a longer time for dogs to meet the periodontal disease case definition compared to the one-year period used in the current study. However, both studies consistently showed higher results for Beagles compared to dogs overall, suggesting a breed predisposition to periodontal disease in Beagles. However, even the relatively high prevalence of clinically diagnosed disease may substantially underestimate the true level. A study of research Beagles used full mouth examination under anaesthesia and identified 84% of Beagles aged over 3 years as affected by periodontal disease [63]. Periodontal disease carries high welfare costs for dogs from both local sequelae including tooth loss, tooth mobility, dental abscesses and halitosis, and also systemic effects on renal, myocardial and hepatic function [64–67]. The current results suggest that owners and veterinary surgeons should place increased emphasis on maintaining good oral hygiene in Beagles to both prevent and manage periodontal disease as a priority disorder in the breed [68–70].

Anxious/distressed was the seventh most common disorder recorded in Beagles, with 4.92% of Beagles affected compared to a previous report 0.58% dogs overall affected in the wider UK dog population [21]. Anxious behaviours include, but are not limited to, social anxiety, separation anxiety, noise phobia, compulsive behaviours, and fear [71]. It may be that a high contribution of rehomed laboratory Beagles to the overall wider Beagle population could partially explain this apparently high risk for anxious behaviours. Rehomed laboratory Beagles could be at increased risk of developing anxious behaviours because of their previous exposure to potentially stress-inducing circumstances such as decreased interactions with humans and confined living areas, and also because of their common stereotypies observed in laboratory-based settings that could cultivate or enhance anxious behaviours [72]. However, an observational test study of 74 laboratory Beagles in their new homes at 6 weeks post-adoption in Germany reported that most of the re-homed dogs showed friendly behaviour towards both humans and dogs and were generally tolerant during physical manipulations by the owner, although the results did show that those dogs bred in the research facility itself scored significantly better than the dogs purchased externally from commercial laboratory dog breeders [73]. A questionnaire survey of owners who had rehomed 16 laboratory Beagles reported the dogs had generally adjusted well to their new home environment, although those particular dogs had undergone a socialisation training programme lasting several months while the dogs were still in the laboratory [19]. Any potentially increased risk of anxious behaviours is a concern because anxious behaviours have been shown to reduce the welfare of the dog over the duration of their life and also to contribute to a shortened lifespan either due to chronic stress or early euthanasia [74]. It is important that current and future owners of Beagles are aware of the health risks for dogs from stress so that they can aim to reduce levels of stress/anxiety, although this requires time and commitment from the owners as well as potentially accessing professional help from behaviour specialists [75].

There is increasing focus on understanding the roles that extreme conformation play as factors predisposing to health and welfare issues in dogs [38, 76, 77]. Extreme conformation in dogs is defined as 'a physical appearance that has been so significantly altered by humankind away from the ancestral natural canine appearance that affected dogs commonly suffer from poor health and welfare, with negative impacts on their quality and quantity of life' [38]. Breeds that are highly affected by extreme conformation tend to show several of their common disorders as strongly linked to conformation. For example, five of the 20 most common disorders for the French Bulldog are linked to extreme conformation: skin fold dermatitis, prolapsed nictitans gland, brachycephalic obstructive airway syndrome (BOAS), patellar luxation and corneal ulceration [78]. For the English Bulldog, six of the top 20 disorders are linked to extreme conformation: skin fold dermatitis, prolapsed gland of third eyelid, entropion, BOAS, corneal ulceration and prognathism [79]. And for the Pug, four of the top 20 disorders are linked to extreme conformation: corneal disorder, BOAS, retained deciduous tooth and intertrigo [80]. However, a similar analysis of the top 20 disorders of Beagles in the current study does not reveal any disorders linked to extreme conformation. Indeed, the five most common disorders reported in the current paper are exactly the same as the top five previously reported in dogs overall in the UK, albeit with the order jumbled and with the Beagle showing generally higher prevalence [21]. This suggests that the Beagle cannot be considered as an extreme breed but largely as dog with a typical canine conformation, perhaps a very good example of the so-called Goldilocks dog that is 'just right' from a conformational perspective [81].

The median age at death of Beagles in the current study was 11.28 years, which is shorter than the 12.0 years median age at death previously reported for dogs overall in England based on a similar methodology to the current study [82]. In support of this slightly shorter age at

death, a life table study based on UK primary care veterinary data reported a median life expectancy of 9.85 years from the first year of life for Beagles that was shorter than the 11.23 years life expectancy for the study dogs overall [83]. In contrast, however, a questionnaire survey sent to UK breed clubs reported a median age at death of 12.67 years for Kennel Club registered Beagles in the UK which was longer than the 11.25 years overall median age at death across all the breeds included [84]. This contrast in relative age at death may reflect the effects of the differing underlying comparator populations used, with the veterinary study comparing Beagle age at death to all dogs including crossbreds whereas the Kennel Cub study was restricted to only a limited set of 165 recognised pedigree breeds. Crossbred dogs are widely reported to outlive purebred dogs by at least one year [82, 85]. Laboratory Beagles have also been reported with a age at death of 12.5 years that is higher than the current study, although this may be related to selection bias towards the healthier subset of dogs that live past a certain age that are included in laboratory research [86]. Overall, it would seem that Beagles fare well in terms of age at death compared to many other pure breeds but do not live as long as many other types of dog in the wider population that are not pure breed. It should be noted that the current study reported the ages at death within a limited temporal window among a random sample of dogs under primary veterinary care but these data are subject to right censoring bias when interpreted as reflecting true longevity [87]. While the current methods offer some comparative data on lifespan within Beagles that can be compared with results for other breeds from studies that used the same methods [20, 22], future work that follows a cohort of dogs from birth to death in all the dogs, e.g. Golden Retriever Lifetime Study [88] or Dogslife [89], would offer stronger evidence on true longevity. The most common causes of mortality in Beagles at *grouped-level* of diagnostic precision was neoplasia (19.26%) and mass (13.18%), with many of the latter potentially also being unconfirmed neoplasia. However, neoplasia is widely reported as the most common cause of death in canines overall [82, 84, 90, 91]. Subsequent analysis of the data from the Kennel Club study discussed above reported that 27.0% of deaths across all the pedigree dogs were ascribed to cancer but this proportion was higher at 32.8% for Beagles [84, 92]. Cancers with evidence of predisposition in the Beagle include mammary, urinary tract, prostate and thyroid neoplasia [92]. This could suggest some genetic or environmental predisposition to neoplasia in Beagles but equally could reflect an effect from their non-extreme conformation whereby the breed is spared the competing effects from other disorders related to extreme conformation that can promote premature mortality. Either way, neoplasia is linked with the mortality of around a quarter of Beagle dogs and owners should be adequately prepared for this potential eventuality.

Limitations

The current study had some limitations. Although the study reports on absolute disorder risk, future work that also extracted diagnosis data on the non-Beagle dogs in the underlying population would be needed for formal reporting of breed predispositions [93]. Similarly, the current study used the disorder prevalence results to infer somewhat on welfare impact but fuller welfare impact assessment would also require additional extraction of disorder duration and severity data [48]. The current study relied on the accuracy of record-making and clinical acumen of the primary care veterinary teams for the current data. The current study represented only the subset of Beagles that were owned as pets in the UK but did not include those Beagles that are being commercially bred, or currently being used, as laboratory animals. Following decades of reproductive isolation along with genetic selection to meet the physical and behavioural requirements for a life in an experimental environment, it is possible that laboratory Beagles may now be quite phenotypically, behaviourally and genetically different from their pet Beagles counterparts. Future work that compares these two sub-populations of Beagles would be important to better understand how the current results can generalise to laboratory Beagles and also perhaps to gain more insight into the extent to which scientific results based on laboratory Beagles can be generalised to the wider population of Beagles or even to dogs overall [94].

Conclusions

Beagles represent almost 1% of all UK dogs. Their disorder profile suggests the breed should not be considered to have an extreme conformation. However, while the list of the most commonly diagnosed disorders is similar between Beagles and all other non-Beagle dogs, the prevalence of the most common disorders appear generally higher in Beagles. Consequently, owners and veterinary teams should put special emphasis on care related to bodyweight control and dental hygiene in Beagles. Their median longevity of 11.28 years suggests reasonable overall health but neoplasia is a common biomedical cause of death in Beagles.

Abbreviations

AKC	American Kennel Club
BCS	Body condition score
BOAS	Brachycephalic obstructive airway syndrome
CI	Confidence interval
EHR	Electronic health record
IQR	Interquartile range
KC	The Kennel Club
OR	Odds ratio

KC Kennel Club

Acknowledgements
Thanks to Noel Kennedy (RVC) for VetCompass™ software and programming development. We acknowledge the Medivet Veterinary Partnership, Vets4Pets/Companion Care, Goddard Veterinary Group, CVS Group, Linnaeus Group, IVC Evidensia, Beaumont Sainsbury Animal Hospital, Blue Cross, PDSA, Dogs Trust, Vets Now and the other UK practices who collaborate in VetCompass. We are grateful to the Kennel Club Charitable Trustand Agria Pet Insurance and the Kennel Club, for supporting VetCompass.

Author contributions
DON and DB were responsible for the acquisition of the originating veterinary data used in the study. DON was responsible for the conception, design, methods and data collation. MS and DON were responsible for the data extraction from the clinical records. KE was responsible for the data analysis. DON and KE were responsible for drafting the manuscript. DON, KE, MS, DB, DC and SG were involved in interpreting the results and revising the manuscript, and gave final approval of the version to be published. DON, KE, MS, DB, DC and SG agree to be accountable for all aspects of the accuracy or integrity of the work.

Funding
This study was supported at the RVC by an award from the Kennel Club Charitable Trust and Agria Pet Insurance. Neither the Kennel Club Charitable Trust nor Agria Pet Insurance had any input in the design of the study, the collection, analysis and interpretation of data or in writing the manuscript. KE was financed by a grant from Agria Djurförsäkring and the Swedish Kennel Club Research Fund in Sweden.

Data availability
The dataset supporting the conclusions of this article are openly available on Figshare https://doi.org/10.6084/m9.figshare.27226815.

Declarations

Ethics approval
Ethics approval was granted by the RVC Ethics and Welfare Committee (reference number URN 2015 1369).

Consent for publication
Not applicable.

Competing interests
SG is KC Health Coordinator for the UK Beagle Clubs. The other authors have no competing interests to declare.

Author details
[1]Pathobiology and Population Science, The Royal Veterinary College, Hawkshead Lane, North Mymms, Hatfield, Herts AL9 7TA, UK
[2]Clinical Science and Services, The Royal Veterinary College, Hawkshead Lane, North Mymms, Hatfield, Herts AL9 7TA, UK
[3]Department of Clinical Sciences, Swedish University of Agricultural Sciences, PO Box 7054, Uppsala 750 07, Sweden

Received: 15 October 2024 / Accepted: 18 December 2024
Published online: 28 January 2025

References

1. AKC. American Kennel Club: Breeds: American Kennel Club. 2024 [Available from: http://www.akc.org/breeds/index.cfm?nav_area=breeds
2. The Kennel Club. Breed Information Centre: The Kennel Club Limited. 2024 [Available from: https://www.thekennelclub.org.uk/search/breeds-a-to-z
3. The Kennel Club. Breed registration statistics: The Kennel Club Limited. 2024 [Available from: https://www.thekennelclub.org.uk/media-centre/breed-registration-statistics/
4. Anderson KL, Casey RA, Cooper B, Upjohn MM, Christley RM. National Dog Survey: describing UK Dog and Ownership demographics. Animals. 2023;13(6):1072.
5. The Kennel Club. Breed Watch: The Kennel Club. 2024 [Available from: https://www.thekennelclub.org.uk/services/public/breed/watch/Default.aspx
6. The Kennel Club. The Kennel Club Assured Breeders scheme: The Kennel Club Limited. 2024 [Available from: https://www.thekennelclub.org.uk/breeding/assured-breeder-scheme/
7. Siracusa A, Raschi A, Mannucci T, Matteini A, Carlucci F, Citi S. Musladin-Leuke Syndrome's Beagle: first Italian report. Veterinaria. 2017;31(1):51–5.
8. Flegel T, Dirauf C, Kehl A, Dietzel J, Holtdirk A, Langbein-Detsch I, et al. Clinical signs in 166 beagles with different genotypes of Lafora. Genes. 2024;15(1):122.
9. Gough A, Thomas A, O'Neill D. Breed predispositions to Disease in Dogs and cats. 3rd ed. Chichester, West Sussex: Wiley-Blackwell; 2018. p. 398.
10. Wallis C, Saito EK, Salt C, Holcombe LJ, Desforges NG. Association of periodontal disease with breed size, breed, weight, and age in pure-bred client-owned dogs in the United States. Vet J. 2021;275:105717.
11. Pegram C, Raffan E, White E, Ashworth AH, Brodbelt DC, Church DB, et al. Frequency, breed predisposition and demographic risk factors for overweight status in dogs in the UK. J Small Anim Pract. 2021;62(7):521–30.
12. O'Neill DG, Volk AV, Soares T, Church DB, Brodbelt DC, Pegram C. Frequency and predisposing factors for canine otitis externa in the UK – a primary veterinary care epidemiological view. Canine Med Genet. 2021;8(1):7.
13. Balls M. Scientific issues raised by the Use of Dogs as Laboratory animals. Altern Lab Anim. 2016;44(1):1–4.
14. Shearin AL, Ostrander EA. Leading the way: canine models of genomics and disease. Dis Models Mech. 2010;3(1–2):27–34.
15. Karlsson EK, Lindblad-Toh K. Leader of the pack: gene mapping in dogs and other model organisms. Nat Rev Genet. 2008;9(9):713–25.
16. Cadieu E, Ostrander EA. Canine Genetics offers New mechanisms for the study of Human Cancer. Cancer Epidemiol Biomarkers Prev. 2007;16(11):2181–3.
17. Bolman B. Dogs for life: beagles, drugs, and Capital in the Twentieth Century. J Hist Biol. 2022;55(1):147–79.
18. Helmreich S, Labruto N, Species biocapital. 2008, and speciating biocapital, 2017. In: Meloni M, Cromby J, Fitzgerald D, Lloyd S, editors. The Palgrave Handbook of Biology and Society: Palgrave Handbooks; 2018. pp. 851 – 76.
19. Hänninen L, Norring M. The First Rehoming of Laboratory Beagles in Finland: the complete process from Socialisation Training to follow-up. Altern Lab Anim. 2020;48(3):116–26.
20. Engdahl KS, Brodbelt DC, Cameron C, Church DB, Hedhammar Å, O'Neill DG. Demography and disorders of English Cocker spaniels under primary veterinary care in the UK. Canine Med Genet. 2023;10(1):4.
21. O'Neill DG, James H, Brodbelt DC, Church DB, Pegram C. Prevalence of commonly diagnosed disorders in UK dogs under primary veterinary care: results and applications. BMC Vet Res. 2021;17(1):69.
22. O'Neill DG, Engdahl KS, Leach A, Packer RMA, Church DB, Brodbelt DC. Is it now time to iron out the wrinkles? Health of Shar Pei dogs under primary veterinary care in the UK. Canine Med Genet. 2023;10(1):11.
23. Ausvet. EpiTools epidemiological calculators: Ausvet; 2023 [Available from: https://epitools.ausvet.com.au/
24. R Core Team. R: A language and environment for statistical computing Vienna, Austria2023 [Available from: http://www.R-project.org/
25. Wickham H. Programming with ggplot2. Ggplot2: elegant graphics for data analysis. 2016:241 – 53.
26. Kirkwood BR, Sterne JAC. Essential medical statistics. 2nd ed. Oxford: Blackwell Science; 2003.
27. Agresti A, Coull BA. Approximate is better than exact for interval estimation of binomial proportions. Am Stat. 1998;52(2):119–26.
28. Aragon TJ, Fay M, Wollschlaeger D, Omidpanah A. epitools: epidemiology tools. R package version 0.5–10.1. 2020. 2020.
29. Kassambara A. ggpubr:'ggplot2'based publication ready plots. R package version 0.4. 0. 2020.
30. Wilke CP. 'cowplot: Streamlined plot theme and plot annotations for 'ggplot2'. R package version 1.1.1'. 2020.
31. PDSA. PDSA Animal Wellbeing Report 2023. PDSA; 2023.
32. Asher L, Buckland E, Phylactopoulos CL, Whiting M, Abeyesinghe S, Wathes C. Estimation of the number and demographics of companion dogs in the UK. BMC Vet Res. 2011;7(1):74.
33. Murray JK, Browne WJ, Roberts MA, Whitmarsh A, Gruffydd-Jones TJ. Number and ownership profiles of cats and dogs in the UK. Vet Rec. 2010;166(6):163–8.

34. Murray JK, Gruffydd-Jones TJ, Roberts MA, Browne WJ. Assessing changes in the UK Pet cat and dog populations: numbers and household ownership. Vet Rec. 2015.
35. O'Neill DG, McMillan KM, Church DB, Brodbelt DC. Dog breeds and conformations in the UK in 2019: VetCompass canine demography and some consequent welfare implications. PLoS ONE. 2023;18(7):e0288081.
36. Burnett E, Brand CL, O'Neill DG, Pegram CL, Belshaw Z, Stevens KB, et al. How much is that doodle in the window? Exploring motivations and behaviours of UK owners acquiring designer crossbreed dogs (2019–2020). Canine Med Genet. 2022;9(1):8.
37. Hladky-Krage B, Hoffman CL. Expectations versus reality of designer dog ownership in the United States. Anim [Internet]. 2022; 12(23).
38. ICECDogs. International Collaborative on Extreme Conformations in Dogs: International Partnership for Dogs; 2024 [Available from: https://www.icecdogs.com/
39. American Kennel Club. Dog Breeds: This is the official list of all American Kennel Club dog breeds.: AKC Global Services. 2024 [Available from: http://www.akc.org/breeds/index.cfm
40. The Kennel Club. Breed standards: The Kennel Club. 2024 [Available from: https://www.thekennelclub.org.uk/breed-standards/
41. Corbee RJ. Obesity in show dogs. J Anim Physiol Anim Nutr. 2013;97(5):904–10.
42. Usui S, Yasuda H, Koketsu Y. Characteristics of obese or overweight dogs visiting private Japanese veterinary clinics. Asian Pac J Trop Biomed. 2016;6(4):338–43.
43. Oberbauer AM, Belanger JM, Famula TR. A review of the impact of Neuter Status on expression of inherited conditions in Dogs. Front Veterinary Sci. 2019;6(397):1–11.
44. Wallis NJ, Sumanasekera NT, Raffan E. Obesity risk factors in British Labrador retrievers: Effect of sex, neuter status, age, chocolate coat colour and food motivation. Vet Rec. 2023;n/a(n/a):e3410.
45. Bjørnvad CR, Gloor S, Johansen SS, Sandøe P, Lund TB. Neutering increases the risk of obesity in male dogs but not in bitches — a cross-sectional study of dog- and owner-related risk factors for obesity in Danish companion dogs. Prev Vet Med. 2019;170:104730.
46. The Kennel Club. Breed Health and Conservation Plans (BHCPs): The Kennel Club Limited. 2024 [Available from: https://www.thekennelclub.org.uk/health-and-dog-care/what-we-do-for-dog-health/breeding-resources-and-health-schemes/breed-health-and-conservation-plans/
47. Collins LM, Asher L, Summers JF, Diesel G, McGreevy PD. Welfare epidemiology as a tool to assess the welfare impact of inherited defects on the pedigree dog population. Anim Welf. 2010;19:67–75.
48. Summers JF, O'Neill DG, Church D, Collins L, Sargan D, Brodbelt DC. Health-related welfare prioritisation of canine disorders using electronic health records in primary care practice in the UK. BMC Vet Res. 2019;15(1):163.
49. Park H-J, Lee S-E, Kim H-B, Isaacson RE, Seo K-W, Song K-H. Association of Obesity with serum leptin, Adiponectin, and Serotonin and Gut Microflora in Beagle Dogs. J Vet Intern Med. 2015;29(1):43–50.
50. Zeng RuiXia Z, YiBo D. The SNPs of melanocortin 4 receptor (MC4R) associated with body weight in Beagle dogs. Exp Anim. 2014;63(1):73–8.
51. Nagaoka D, Mitsuhashi Y, Angell R, Bigley KE, Bauer JE. Re-induction of obese body weight occurs more rapidly and at lower caloric intake in beagles. J Anim Physiol Anim Nutr. 2010;94(3):287–92.
52. Salt C, Morris PJ, Wilson D, Lund EM, German AJ. Association between life span and body condition in neutered client-owned dogs. J Vet Intern Med. 2019;33(1):89–99.
53. German AJ, Holden SL, Wiseman-Orr ML, Reid J, Nolan AM, Biourge V, et al. Quality of life is reduced in obese dogs but improves after successful weight loss. Vet J. 2012;192(3):428–34.
54. German AJ. The growing problem of obesity in dogs and cats. J Nutr. 2006;136(7):S1940–6.
55. Lund EM, Armstrong PJ, Kirk CA, Klausner JS. Prevalence and risk factors for obesity in adult dogs from private US veterinary practices. Int J Appl Res Veterinary Med. 2006;4(2):177–86.
56. Raffan E. The big problem: battling companion animal obesity. Vet Rec. 2013;173(12):287–91.
57. Darren ERW, Crystal Whitney N, Shannon SDB. Health benefits of physical activity: the evidence. Can Med Assoc J. 2006;174(6):801.
58. German AJ. Weight management in obese pets: the tailoring concept and how it can improve results. Acta Vet Scand. 2016;58(1):57.
59. Pickup E, German AJ, Blackwell E, Evans M, Westgarth C. Variation in activity levels amongst dogs of different breeds: results of a large online survey of dog owners from the UK. J Nutritional Sci. 2017;6:e10.
60. Kipperman BS, German AJ. The responsibility of veterinarians to address Companion animal obesity. Animals. 2018;8(9):143.
61. O'Neill DG, Corah CH, Church DB, Brodbelt DC, Rutherford L. Lipoma in dogs under primary veterinary care in the UK: prevalence and breed associations. Canine Genet Epidemiol. 2018;5(1):9.
62. O'Neill D, Mitchell CE, Humphrey J, Church D, Brodbelt D, Pegram C. Epidemiology of periodontal disease in dogs in the UK primary-care veterinary setting. J Small Anim Pract. 2021;62(12):1051–61.
63. Kortegaard HE, Eriksen T, Baelum V. Periodontal disease in research beagle dogs – an epidemiological study. J Small Anim Pract. 2008;49(12):610–6.
64. Pavlica Z. Periodontal disease burden and pathological changes in organs of dogs. J Vet Dent. 2008;25(2):97–105.
65. Glickman LT, Glickman NW, Moore GE, Goldstein GS, Lewis HB. Evaluation of the risk of endocarditis and other cardiovascular events on the basis of the severity of periodontal disease in dogs. J Am Vet Med Assoc. 2009;234(4):486–94.
66. Bellows J, Berg ML, Dennis S, Harvey R, Lobprise HB, Snyder CJ, et al. 2019 AAHA dental care guidelines for dogs and cats. J Am Anim Hosp Assoc. 2019;55(2):49–69.
67. Pereira dos Santos JD, Cunha E, Nunes T, Tavares L, Oliveira M. Relation between periodontal disease and systemic diseases in dogs. Res Vet Sci. 2019;125:136–40.
68. Cunha E, Tavares L, Oliveira M. Revisiting Periodontal Disease in Dogs: how to manage this New Old Problem? Antibiotics. 2022;11(12):1729.
69. Barbosa E, Pires PGS, Hauptli L, Moraes P. Strategies to improve the home care of periodontal disease in dogs: a systematic review. Res Vet Sci. 2023;154:8–14.
70. Enlund KB, Brunius C, Hanson J, Hagman R, Höglund OV, Gustås P, et al. Dental home care in dogs - a questionnaire study among Swedish dog owners, veterinarians and veterinary nurses. BMC Vet Res. 2020;16(1):90.
71. Tiira K, Sulkama S, Lohi H. Prevalence, comorbidity, and behavioral variation in canine anxiety. J Veterinary Behav. 2016;16:36–44.
72. Lee G-H, Jo W, Kang T-K, Oh T, Kim K. Assessment of stress caused by Environmental Changes for Improving the Welfare of Laboratory Beagle Dogs. Animals. 2023;13(6):1095.
73. Döring D, Nick O, Bauer A, Küchenhoff H, Erhard MH. How do rehomed laboratory beagles behave in everyday situations? Results from an observational test and a survey of new owners. PLoS ONE. 2017;12(7):e0181303.
74. Dreschel NA. The effects of fear and anxiety on health and lifespan in pet dogs. Appl Anim Behav Sci. 2010;125(3–4):157–62.
75. Rooney NJ, Clark CCA, Casey RA. Minimizing fear and anxiety in working dogs: a review. J Veterinary Behav. 2016;16:53–64.
76. LAGECDogs. Legal Advisory Group on Extreme Conformation in Dogs: A-LAW UK Centre for Animal Law. 2024 [Available from: https://www.alaw.org.uk/companion-animals/extreme-dog-conformation/
77. BWG. The Brachycephalic Working Group: The Brachycephalic Working Group. 2024 [Available from: http://www.ukbwg.org.uk/
78. O'Neill DG, Baral L, Church DB, Brodbelt DC, Packer RMA. Demography and disorders of the French Bulldog population under primary veterinary care in the UK in 2013. Canine Genet Epidemiol. 2018;5(1):3.
79. O'Neill DG, Skipper AM, Kadhim J, Church DB, Brodbelt DC, Packer RMA. Disorders of Bulldogs under primary veterinary care in the UK in 2013. PLoS ONE. 2019;14(6):e0217928.
80. O'Neill DG, Darwent EC, Church DB, Brodbelt DC. Demography and health of pugs under primary veterinary care in England. Canine Genet Epidemiol. 2016;3(1):1–12.
81. Chadwick J. Meet Goldilocks, the breedless dog of the future. Dly Mail. 2024 6th April.
82. O'Neill DG, Church DB, McGreevy PD, Thomson PC, Brodbelt DC. Longevity and mortality of owned dogs in England. Vet J. 2013;198(3):638–43.
83. Teng KT-y, Brodbelt DC, Pegram C, Church DB, O'Neill DG. Life tables of annual life expectancy and mortality for companion dogs in the United Kingdom. Sci Rep. 2022;12(1):6415.
84. Adams VJ, Evans KM, Sampson J, Wood JLN. Methods and mortality results of a health survey of purebred dogs in the UK. J Small Anim Pract. 2010;51(10):512–24.
85. Roccaro M, Salini R, Pietra M, Sgorbini M, Gori E, Dondi M et al. Factors related to longevity and mortality of dogs in Italy. Prev Vet Med. 2024:106155.

86. Book SA, Spangler WL, Swartz LA. Effects of Lifetime Ingestion of90 Sr in Beagle Dogs. Radiat Res. 1982;90(2):244–51.
87. Urfer SR. Right censored data ('cohort bias') in veterinary life span studies. Vet Rec. 2008;163(15):457–8.
88. Guy MK, Page RL, Jensen WA, Olson PN, Haworth JD, Searfoss EE et al. The Golden Retriever Lifetime Study: establishing an observational cohort study with translational relevance for human health. Philosophical Trans Royal Soc Lond B: Biol Sci. 2015;370(1673).
89. Clements D, Handel I, Rose E, Querry D, Pugh C, Ollier W, et al. Dogslife: a web-based longitudinal study of Labrador Retriever health in the UK. BMC Vet Res. 2013;9(1):13.
90. Lewis TW, Wiles BM, Llewellyn-Zaidi AM, Evans KM, O'Neill DG. Longevity and mortality in Kennel Club registered dog breeds in the UK in 2014. Canine Genet Epidemiol. 2018;5(1):10.
91. Fleming JM, Creevy KE, Promislow DEL. Mortality in north American dogs from 1984 to 2004: an investigation into age-, size-, and breed-related causes of death. J Vet Intern Med. 2011;25(2):187–98.
92. Dobson JM. Breed-predispositions to cancer in pedigree dogs. ISRN Veterinary Sci. 2013;2013(Article ID 941275):1–23.
93. Engdahl KS, Brodbelt DC, Cameron C, Church DB, O'Neill DG. English Cocker spaniels under primary veterinary care in the UK: disorder predispositions and protections. Canine Med Genet. 2024;11(1):1.
94. Giraud E, Hollin G. Laboratory beagles and affective co-productions of knowledge. In: Bastian M, Jones O, Moore N, Roe E, editors. Participatory research in more-than-human worlds. Abingdon, Oxon, UK: Routledge; 2016. pp. 163–77.

Publisher's note