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Conformation-associated health in pet rabbits in the UK: A VetCompass cohort study

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Abstract

Background: Domestic rabbit breeds vary substantially from the wild rabbit body type. However, little is known about how the conformation of pet rabbits influences their health.

Methods: Data were extracted from VetCompass anonymised clinical records of rabbits under UK primary veterinary care during 2019.

Results: The study included 162,107 rabbits. Based on 88,693 rabbits with relevant breed information recorded, skull shape was classified as brachycephalic (79.69%), mesaticephalic (16.80%) and dolichocephalic (3.51%). Based on 83,821 rabbits with relevant breed information recorded, ear carriage was classified as lop-eared (57.05%) and erect-eared (42.95%). From a random sample of 3933 rabbits, the most prevalent disorders recorded overall were overgrown nail(s) (28.19%), overgrown molar(s) (14.90%) and obesity (8.82%). Compared to those with a mesaticephalic skull shape, brachycephalic rabbits had lower odds of obesity, anorexia and gastrointestinal stasis and higher odds of perineal faecal impaction, tear duct abnormality and haircoat disorder. Compared to erect-eared rabbits, lop-eared rabbits had higher odds of perineal faecal impaction and tear duct abnormality.

Limitation: A large proportion of records with incomplete breed information hindered full analysis for breed-related and conformation-related attributes.

Conclusion: Limited evidence for major links between skull shape or ear carriage conformations and overall disorder risk suggests that factors such as husbandry or even just living life as a domesticated species may be bigger drivers of common health issues in pet rabbits in the UK.

KEYWORDS
electronic health record, epidemiology, primary care, VetCompass, rabbit

INTRODUCTION

Rabbits are one of the most popular pet species kept in the UK, with an estimated 1.1–1.5 million rabbits owned in 2.8% of UK households.[1,2] However, the process of domestication, initially as a food source and latterly as a companion animal species, has led to many differences in conformation and lifestyle between the current population of pet rabbits in the UK and their original wild progenitors. Many distinct and distinctive breeds and varieties have been developed over recent centuries that differ markedly from the European wild rabbit phenotype that had evolved naturally over millions of years.[3–6] The British Rabbit Council (BRC) now recognises over 50 rabbit breeds with more than 500 varieties that vary widely in conformation, including skull shape, ear shape and carriage, coat type and size.[7] In addition, modern pet rabbits tend to have a captive lifestyle with often very little or no appropriate exercise opportunities each day and a typical diet with high levels of commercial concentrates and sugary treats, which differs markedly from their wild counterparts that generally eat high-fibre grasses and forage.[1,8] However, despite their popularity as a pet species and high variation in growth rate, adult bodysize, life expectancy and behaviours across breeds,[9] there is very limited evidence on the common disorders of pet rabbits in the UK and how the risks for these disorders are associated with conformation.

The most commonly reported breed types kept as pet rabbits in the UK appear to be lop-eared breeds (specifically mini lops) and Netherland dwarf rabbits.[8,10–12] These breeds and types have shorter, flatter faces than wild rabbits, with the BRC breed standards specifying that Netherland dwarf rabbits should have a round broad skull and that mini lops should have a head profile that is strongly curved with a broad muzzle.[7] A study investigating preferences for face shape in rabbits among the general public reported mildly brachycephalic rabbits as the most preferred type of rabbit, whereas moderate dolichocephaly was the least preferred rabbit face shape.[13] Those authors suggested that human preference is a driver for increasing proportions of pet rabbits being produced and sold with shorter skulls over time.[14,15] They also raised concerns about the potential health implications of brachycephaly in rabbits, given the extensive evidence on disorder predispositions in dog breeds such as French bulldogs, pugs and English bulldogs.[16–18] A questionnaire study of 24 UK owners of 102 rabbits reported the most common breeds as dwarf lop (37.3%), crossbreeds (16.7%) and mini lop (9.8%).[19] Some early work based on small or biased samples suggested that both dental and ocular disorders were more prevalent in rabbit breeds with brachycephaly, although more recent evidence has been conflicting and appears to suggest that an almost universal degree of brachycephaly in modern pet rabbits means that environmental factors may offer more malleable risk factors for meaningful welfare improvements.[12,19–22] The lop-eared conformation has been proposed to predispose rabbits to otitis externa, possibly due to reduced airflow from pendulous narrow ears resulting in the accumulation of cerumen and secondary infections.[13,22,23] A study comparing 15 erect-eared and 15 lop-eared rabbits relinquished to a rescue centre in the UK reported an increased prevalence of both aural and dental disease in rabbits with lop ears, although the inference is limited due to the small sample size and it is unknown how these findings apply to the general UK rabbit population.[22] A survey of 551 rabbit owners in the UK also reported that 25% of lop-eared rabbits had ear conditions diagnosed by a veterinarian compared to 10% of erect-eared rabbits.[24] That study was specifically focused on ear health, so owners of rabbits with known ear problems may have been more likely to participate in the survey; nonetheless, the different prevalence reported in rabbits with different ear conformations warrants further investigation.

A previous study investigating common disorders of rabbits presenting to primary care practices in the UK reported that the most common disorder groups were dermatological, oral, gastrointestinal and ocular disorders.[11] However, that study did not explore risk factors for these disorders in detail, so associations with breed and conformation were not established, although prevalence differences between the sexes for common disorders were reported. Specifically, males had statistically higher prevalence than females for oral and aural disorders. Analysis of clinical records from 1420 rabbits treated at a single private practice in Chile similarly identified a male predisposition, with males showing 1.59 times the odds of acquired dental disease compared to females.[25]

Current evidence on causes of death in pet rabbits is also limited, with a previous study based on primary care data reporting a median age at death of 4.3 years and the most commonly recorded causes of death as myiasis, anorexia, recumbency/collapse and ileus.[11] Again, risk factors were not analysed in detail, although the median age of death was reported to be higher for males than for females.

In an effort to fill these data gaps on disorder occurrence and risk factors in pet rabbits, the current study aimed to report the frequency and conformational risk factors for common disorders and mortality in rabbits under primary veterinary care in the UK using anonymised veterinary clinical data from the VetCompass programme.[26] Based on growing concerns about the negative health and welfare effects of the increasing public demand for extreme conformations in other companion animal species,[15] this study placed particular focus on exploring disorder associations with breed, skull and ear conformation in addition to sex associations. There is currently high interest in developing an improved evidence base on how breed and conformation are associated with disease risk to identify opportunities to improve the welfare of rabbits at a population level as well as to support research into the aetiopathogenesis of complex disorders.[27,28] Based on previously published results,[22] the current study hypothesised that lop-eared rabbits have a higher prevalence of dental and aural disorders than erect-eared rabbits.

METHODS

The study population included all rabbits under primary veterinary care at 1224 clinics participating in the VetCompass programme during 2019.[26] Rabbits under veterinary care were required to have at least one electronic health record (EHR) (free-text clinical note, treatment or bodyweight) recorded during 2019. VetCompass collates de-identified EHR data from primary-care veterinary practices in the UK for epidemiological research.[26] Data fields available for the current study included a unique animal identifier along with time-fixed (species, breed, date of birth, sex and neuter status at the final available EHR) and time-varying variables (bodyweight, clinical information from free-form text clinical notes and treatment details with relevant dates). The design and analytic plans for the current study were aligned with previous VetCompass species-based studies to facilitate reliable comparisons of common disorders between species.[11,29,30]

A retrospective cohort study design with a cross-sectional analysis was used to estimate the prevalence of common disorders within the available clinical records and to explore mortality in this population. Power calculations showed that a sample of 3661 rabbits was needed from a population of 162,017 rabbits to estimate the prevalence of a disorder occurring in 2.5% of rabbits within a 0.5% margin of error.[31] Ethics approval was obtained from the RVC Ethics and Welfare Committee (reference SR2018-1652). All owners provided opt-out consent for the inclusion of their animal's clinical records within VetCompass.

Breed descriptive information entered by the participating practices was cleaned and mapped to a VetCompass list of rabbit breeds. In the context of this paper, 'breed' was defined broadly to include phenotypically described types of rabbits (e.g., lop rabbit) as well as breed terms (e.g., French lop) that are recognised by groups such as the BRC.[7] Based on the available breed and type information, rabbits were subclassified as either a single breed (or type) of rabbit, an unspecified cross between various types of rabbit, or as having no breed or type information beyond being a domestic rabbit. The breed variable was used to further subclassify rabbits by skull conformation (brachycephalic, mesaticephalic [also known as mesocephalic], dolichocephalic, unrecorded), ear carriage (erect-eared, lop-eared, unrecorded), fur length (short-haired, semi-long-haired, long-haired, unrecorded) and typical body size (dwarf, average size, giant, unrecorded). These classifications were generated by searching a wide range of published and online resources to visually check images of rabbit breeds and assess for written phenotypic descriptions (Supporting Information S1). Neuter status reported the status at the final available EHR. Adult bodyweight was defined as the median of all bodyweight (kg) values recorded for each rabbit after they reached 9 months of age.[32] Age (years) was defined at 31 December 2019. The study included anonymised clinical data shared from six UK veterinary groups.

All available clinical records from a randomly selected subset of rabbits were manually reviewed and all disorder events in the cohort data were followed over time to determine the most definitive diagnosis term recorded, as previously described.[29] Randomisation used the RAND (transact-SQL) function within SQL Server. Incident and pre-existing presentations were not differentiated. Recurring ongoing conditions (e.g., dental overgrowth) were recorded only once. Clinical conditions that were not recorded with a formal biomedical diagnostic term were extracted using the first recorded presenting sign term (e.g., 'lethargy') as previously described.[30] Mortality data were extracted for all deaths recorded at any date and included the stated biomedical cause, date and mechanism (euthanasia, unassisted death, unrecorded). Diagnosis terms were mapped to both precise and grouped levels of diagnostic precision as described previously.[30] Precise-level terms provided disorder information to the highest level of diagnostic precision available within the clinical notes (e.g., cystitis would remain as cystitis) while disorder groups provided information at a more general level of diagnostic precision (e.g., cystitis would map to urinary system disorder).

Excel (Microsoft Office Excel 2013, Microsoft Corp.) was used for data checking and cleaning, and Stata (version 16; Stata Corp.) was used for analysis. Demographic results were reported for breed, sex, neuter status, age and adult (>9 months[32]) bodyweight across all 162,017 rabbits under primary veterinary care in 2019. Disorder risk analysis included a random sample of 3933 rabbits. Prevalence values described the probability of diagnosis on at least one occasion within all available records for that disorder. The 95% confidence interval (CI) estimates were calculated from standard errors based on approximation to the binomial distribution.[33] The median age (years) and median adult bodyweight (kg) were reported for each common cause of morbidity and mortality. Chi-squared and Mann–Whitney *U*-tests were used for univariable comparisons as appropriate.[33] Associations between skull shape and ear carriage and the odds of diagnosis of common disorders were assessed using multivariable binary logistic regression modelling. A separate model was built for each common disorder as an outcome and for either skull shape or ear carriage as a key a priori risk factor of interest. Each model also included a standard bank of covariables to account for confounding factors (sex, neuter, age and veterinary group).[14,34] An 'information theory' approach was used to decide which covariables to include in these standard models.[35] The results from each regression model were reported only for the association with skull shape or ear carriage (of a priori interest). Statistical significance was set at the 5% level.

RESULTS

Demographics

The study population included 162,017 rabbits under primary veterinary care at 1224 clinics within six veterinary groups during 2019. Among these rabbits, 81,452 (50.27%) were recorded as a single breed (or type) of rabbit, 28,148 (17.37%) were recorded as being an unspecified cross between various types of rabbits and 52,417 (32.35%) were not recorded with any breed or type information beyond being a domestic rabbit. The proportion of rabbits that were not recorded with any breed or type information beyond being a domestic rabbit varied across the six veterinary groups in the study: 34.13% ($n = 31{,}930$), 33.41% ($n = 10{,}889$), 29.86% ($n = 6006$), 27.95% ($n = 362$), 22.58% ($n = 3192$) and 11.34% ($n = 38$) ($p < 0.001$). The most commonly recorded breed types included crossbreeds ($n = 16{,}026$, 9.89%), mini/Holland lop ($n = 14{,}285$, 8.82%), lop rabbit—breed unspecified ($n = 12{,}082$, 7.46%) and lionhead ($n = 11{,}187$, 6.90%)

TABLE 1 Number, age (years on 31 December 2019) and bodyweight (kg) of the 30 most commonly recorded rabbit breeds and types under primary veterinary care at practices participating in the VetCompass programme in the UK between 1 January and 31 December 2019 ($n = 162{,}017$)

Rabbit breed	No.	%	Median adult (>9 months) bodyweight (kg)	Median age (years)
Rabbit—breed or type unspecified	52,417	32.35	2.35	1.91
Crossbreed	16,026	9.89	2.40	1.65
Mini lop—Holland lop	14,285	8.82	2.07	1.78
Lop rabbit—breed unspecified	12,082	7.46	2.47	2.50
Lionhead	11,187	6.90	2.12	2.35
Dwarf lop—mini lop	9187	5.67	2.30	2.46
Netherland Dwarf	8664	5.35	1.42	2.45
Dutch—unspecified	4668	2.88	2.17	2.31
Crossbreed—lionhead	3146	1.94	2.26	2.00
Crossbreed—lop	2965	1.83	2.53	1.75
English—lop	2901	1.79	2.50	2.29
Rabbit—dwarf	2844	1.76	1.77	2.36
Rex—unspecified	2685	1.66	2.51	2.26
English—spot	2401	1.48	2.52	2.42
Crossbreed—dwarf	1951	1.20	1.76	1.86
French—lop	1795	1.11	3.66	2.66
Crossbreed—lop lionhead	1495	0.92	2.29	1.80
Mini lion lop	1216	0.75	2.15	1.79
Mini rex	1024	0.63	2.17	2.09
Continental giant	908	0.56	5.99	1.73
Crossbreed—rex	667	0.41	2.45	1.36
Crossbreed—dwarf lop	665	0.41	2.26	1.49
Harlequin	537	0.33	2.57	2.41
Dutch—standard	506	0.31	2.10	2.31
Dutch—lop—Holland lop	473	0.29	2.40	2.56
Lionhead—dwarf	464	0.29	1.84	2.58
English—unspecified	377	0.23	2.44	2.92
Crossbreed—average	311	0.19	2.53	1.63
Rex—opossum	250	0.15	2.60	2.64
Angora—unspecified	240	0.15	2.40	2.00

(Table 1). The median adult bodyweight of the rabbits overall was 2.26 kg (interquartile range [IQR] 1.85–2.73, range 0.50–9.80). The median bodyweight of females (2.30 kg, IQR 1.89–2.78, range 0.50–9.80) was greater than that of males (2.24 kg, IQR 1.83–2.70, range 0.54–9.10) ($p < 0.001$). Across the 30 most common breeds and types, the median adult bodyweight varied from 1.42 kg in the Netherland dwarf to 5.99 kg in the continental giant (Table 1). The overall median age of rabbits at the end of the study year (31 December 2019) was 2.04 years (IQR 1.00–4.33, range 0.00–14.99). The median age of males (2.00 years, IQR 1.01–4.27, range 0.00–14.99) was older than that of females (1.95 years, IQR 0.97–4.08, range 0.01–14.99) ($p < 0.001$). The median age varied across breeds, from 1.36 years in the crossbreed—rex to 2.92 years in the English—unspecified (Table 1). Among the 151,392 of 162,017 (93.44%) rabbits with information on sex and neuter status recorded, 69,947 (46.20%) were females and 81,445 (53.80%) were males. Overall, 36,459 of these 151,459 (24.08%) rabbits were recorded as neutered. Males (21,518/81,445, 26.42%) were significantly more likely to be neutered than females (14,941/69,947, 21.36%) ($p < 0.001$).

Skull shape information based on breed and type was available for 88,693 of 162,017 (54.74%) rabbits. Of these, 70,676 (79.69%) were classified as brachycephalic, 14,904 (16.80%) as mesaticephalic and 3113 (3.51%) as dolichocephalic. Ear carriage information was available based on breed and type for 83,821 of 162,017 (51.74%) rabbits. Of these, 35,997 (42.95%) were classified as erect-eared and 47,824 (57.05%) were classified as lop-eared. Fur length information was available based on breed and type for 70,927 of 162,017 (43.78%) rabbits. Of these, 52,944 (74.65%) were classified as short-haired, 17,562 (24.76%) as semi-long-haired and 421 (0.59%) as long-haired. Typical body size information was available based on breed and type for 72,577 of 162,017 (44.80%) rabbits. Of these, 41,164 (56.72%) were classified as dwarf, 24,989 (34.43%) as average sized and 6424 (8.85%) as giant.

Disorder prevalence

The EHRs of a random sample of 3933 of the 162,017 (2.43%) rabbits were manually examined to extract information on all recorded disorders at any date in the available clinical records. At least one disorder was recorded for 2723 of the 3933 (69.23%) rabbits. The remaining 30.77% did not have any disorder recorded and received other forms of veterinary care instead, such as vaccination and neutering. There was no evidence that the probability of having at least one disorder recorded differed between females (1161/1712, 67.82%) and males (1361/1977, 68.84%) (p = 0.504). There was no evidence that the probability of having at least one disorder recorded differed between skull shapes (brachycephalic 1239/1739, 71.25%; mesaticephalic 255/367, 69.48%; dolichocephalic 55/74, 74.32%) (p = 0.651). There was no evidence that the probability of having at least one disorder recorded differed between ear carriage types (erect 635/889, 71.43%; lop 827/1165, 70.99%) (p = 0.827). The median disorder count per rabbit was one disorder (IQR 0–2, range 0–15). There was no evidence that the median disorder count varied between the sexes (p = 0.176), skull shapes (p = 0.369) or ear carriage types (p = 0.373).

There were 6793 unique disorder events recorded across the 3933 rabbits, spanning 347 separate precise-level disorder terms. The most prevalent precise-level disorders recorded across all rabbits were overgrown nail(s) (n = 1109, 28.19%, 95% CI 26.79–29.63), overgrown molar(s) (n = 586, 14.90%, 95% CI 13.80–16.05), obesity (n = 347, 8.82%, 95% CI 7.95–9.75) and perineal faecal impaction (n = 291, 7.40%, 95% CI 6.60–8.26) (Table 2).

Among the 25 most common precise-level disorders, females had a significantly higher prevalence for one disorder (obesity), while males had a significantly higher prevalence for five disorders (overgrown molar(s), tear duct abnormality, overgrown incisor(s), conjunctivitis and ocular discharge). The median age of affected rabbits varied across the precise-level disorders, from 1.57 years (postoperative complication) to 6.46 years (collapse). The median adult bodyweight varied across the precise-level disorders, from 1.92 kg (overgrown incisor(s)) to 2.71 kg (obesity) (Table 2). Skull shape was associated with significant differential risk for six of the 25 most common precise-level disorders. Compared to rabbits with a mesaticephalic skull shape, rabbits with a brachycephalic skull shape had lower odds of obesity, anorexia and gastrointestinal stasis but had higher odds of perineal faecal impaction, tear duct abnormality and haircoat disorder. Compared to rabbits with erect ear carriage, rabbits with lop ear carriage had higher odds of perineal faecal impaction and tear duct abnormality (Table 3).

Fifty-nine distinct grouped-level disorder terms were recorded. The most prevalent grouped-level disorders recorded across all rabbits were claw/nail disorder (n = 1121, 28.50%, 95% CI 27.10–29.94), dental disorder (n = 717, 18.23%, 95% CI 17.03–19.47), skin disorder (n = 639, 16.25%, 95% CI 15.11–17.44) and enteropathy (n = 437, 11.11%, 95% CI 10.15–12.14). Among the 20 most common grouped-level disorders, females had significantly higher prevalence for one disorder group (obesity), while males had significantly higher prevalence for two disorder groups (dental disorder and ophthalmological disorder). The median age of affected rabbits varied across the grouped disorders, from 1.49 years (complication associated with clinical care) to 6.14 years (musculoskeletal disorder). The median adult bodyweight varied across the grouped disorders, from 1.98 kg (thin) to 2.71 kg (obesity) (Table 4). Skull shape was associated with differential risk for five of the 20 most common grouped-level disorders. Compared to rabbits with a mesaticephalic skull shape, rabbits with a brachycephalic skull shape had significantly lower odds of enteropathy, obesity and appetite disorder but had higher odds of skin disorder and ophthalmological disorder. Compared to rabbits with erect ear carriage, rabbits with lop ear carriage had higher odds of skin disorder and parasite infestation (Table 5).

Mortality

There were 614 deaths recorded among the 3933 (15.61%) rabbits. Information on the age at death was available for 566 of 614 (92.18%) deaths. The overall median age at death was 5.00 years (IQR 2.34–7.74, range 0.00–14.86). The median age at death in females (5.07 years, IQR 2.76–7.53, range 0.00–13.27) did not differ significantly from that in males (4.78 years, IQR 2.11–7.81, range 0.00–14.86) (p = 0.342). There was no evidence that the age at death varied between brachycephalic (n = 251, median 4.81 years, IQR 2.52–7.44, range 0.01–13.29), mesaticephalic (n = 65, median 4.18 years, IQR 1.40–7.00, range 0.01–9.79) and dolichocephalic (n = 10, median 6.02 years, IQR 2.00–8.40, range 0.35–9.00) (p = 0.148) skull conformations. Rabbits with erect ear carriage had an older age at death (n = 131, median 5.44 years, IQR 3.00–8.22, range 0.00–13.29) than rabbits with lop ear carriage (n = 177, median 4.29 years, IQR 2.15–6.61, range 0.00–12.23) (p = 0.006).

The mechanism of death was recorded for 554 of 613 (90.38%) of deaths. Among the deaths with the mechanism recorded, 354 (63.90%) deaths were by euthanasia and 200 (36.10%) were unassisted deaths. The probability of death by euthanasia did not differ between females (167/255, 65.49%) and males (149/245, 60.82%) (p = 0.279). The median age at death for deaths by euthanasia (5.65 years, IQR 3.22–8.42, range 0.00–14.86) was higher than for unassisted deaths (4.04 years, IQR 1.63–6.32, range 00.00–11.44) ($p < 0.001$). There was no

TABLE 2 Prevalence of the 25 most common disorders, at a precise level of diagnostic precision, recorded in rabbits ($n = 3933$) under veterinary care at UK primary care practices participating in the VetCompass programme between 1 January and 31 December 2019

Precise-level disorder	No.	Prevalence (%)	95% CI	Female (%)	Male (%)	*p*-value	Median age (years)	Median bodyweight (kg)
Overgrown nail(s)	1109	28.19	26.79–29.63	28.04	28.33	0.846	3.04	2.30
Overgrown molar(s)	586	14.90	13.80–16.05	13.03	16.08	**0.009**	4.39	2.23
Obesity	347	8.82	7.95–9.75	10.51	7.44	**0.001**	3.93	2.71
Perineal faecal impaction	291	7.40	6.60–8.26	7.83	6.58	0.141	4.87	2.40
Disorder not diagnosed	236	6.00	5.28–6.79	5.84	5.82	0.975	4.86	2.35
Anorexia	227	5.77	5.06–6.55	5.26	6.02	0.318	3.75	2.31
Gastrointestinal stasis[a]	217	5.52	4.82–6.28	5.55	5.21	0.649	3.76	2.34
Tear duct abnormality	137	3.48	2.93–4.10	2.28	4.35	**0.001**	5.71	2.10
Haircoat disorder[b]	134	3.41	2.86–4.02	2.75	3.84	0.064	4.40	2.30
Postoperative complication	126	3.20	2.68–3.80	2.63	3.59	0.095	1.57	2.14
Diarrhoea	125	3.18	2.65–3.78	3.10	3.19	0.875	2.89	2.30
Dental disease[c]	122	3.10	2.58–3.69	2.75	3.29	0.338	4.93	2.21
Bite injury	106	2.69	2.21–3.25	2.69	2.68	0.991	1.93	2.19
Overgrown incisor(s)	104	2.64	2.17–3.19	1.87	3.49	**0.003**	3.66	1.92
Conjunctivitis	94	2.39	1.94–2.92	1.52	2.83	**0.007**	4.49	2.30
Thin	84	2.14	1.71–2.64	1.99	2.12	0.768	3.25	1.98
Upper respiratory tract infection	78	1.98	1.57–2.47	1.75	2.23	0.307	4.43	2.33
Ocular discharge[d]	74	1.88	1.48–2.36	1.29	2.18	**0.040**	4.59	2.27
Mites	70	1.78	1.39–2.24	1.58	1.77	0.649	3.96	2.35
Ileus	69	1.75	1.37–2.22	1.52	1.82	0.476	4.13	2.36
Cheyletiellosis	65	1.65	1.28–2.10	1.23	1.87	0.116	5.28	2.43
Collapse	65	1.65	1.28–2.10	1.75	1.62	0.753	6.46	2.21
Nasal discharge[e]	64	1.63	1.26–2.07	1.58	1.57	0.982	3.83	2.40
Encephalitozoon cuniculi infection	63	1.60	1.23–2.04	1.40	1.67	0.511	5.38	2.17
Abscess	62	1.58	1.21–2.02	1.29	1.87	0.157	4.82	2.17

Note: The *p*-value reflects a comparison between the prevalence in females and males. The median age and bodyweight for affected rabbits are also shown. The values in bold indicate a p-value < 0.05.
Abbreviation: CI, confidence interval.
[a] Not specifically recorded as ileus.
[b] Not also recorded as mites or cheyletiellosis.
[c] Not also recorded as overgrown incisor(s) or overgrown molar(s).
[d] Not recorded as linked with conjunctivitis or tear duct abnormality.
[e] Not also recorded as upper respiratory tract infection.

evidence that the mechanism of death varied between brachycephalic (142/233 euthanasia, 60.94%), mesaticephalic (38/59 euthanasia, 64.41%) and dolichocephalic (3/8 euthanasia, 37.50%) skull conformations ($p = 0.342$). There was no evidence that the mechanism of death varied between rabbits with erect ear carriage (74/124 euthanasia, 59.68%) and rabbits with lop ear carriage (103/160 euthanasia, 64.38%) ($p = 0.418$).

There were 37 unique grouped-level terms for cause of death described across the 613 deaths in the study. Among the 377 of 613 (61.50%) deaths with a formal recorded cause, the most common causes of death at a grouped level were collapse (n = 53, 14.06%, 95% CI 10.71–17.98), enteropathy (n = 31, 8.22%, 95% CI 5.66–11.47) and brain disorder (n = 30, 7.96%, 95% CI 5.43–11.17). Dental disorder was the only grouped-level cause of death that varied significantly between the sexes, with higher prevalence in males than females. The median age at death across the most common causes of death at a grouped level varied from 0.65 years (complication associated with clinical care) to 8.53 years (ophthalmological disorder). The median adult bodyweight varied from 1.75 kg (appetite disorder) to 3.61 kg (viral infectious disorder) (Table 6).

DISCUSSION

This study, based on demographic information from more than 160,000 rabbits under primary veterinary care and with the clinical records of almost 4000 animals reviewed in detail, has provided updated evidence on the frequency and risk factors for common disorders and mortality in pet rabbits under primary veterinary care in the UK. This information can

TABLE 3 Skull shape (brachycephalic [*n* = 1739] compared to mesaticephalic [*n* = 367], and dolichocephalic [*n* = 74] compared to mesaticephalic) and ear carriage (lop-eared [*n* = 1165] compared to erect-eared [*n* = 889]) as risk factors for the 25 most common disorders at a precise level of diagnostic precision, recorded in rabbits under veterinary care at UK primary care practices participating in the VetCompass programme between 1 January and 31 December 2019

Precise-level disorder	Odds ratio (95% CI) (brachycephalic vs. mesaticephalic)	*p*-value (brachycephalic vs. mesaticephalic)	Odds ratio (95% CI) (dolichcephalic vs. mesaticephalic)	*p*-value (dolichcephalic vs. mesaticephalic)	Odds ratio (95% CI) (lop vs. erect)	*p*-value (lop vs. erect)
Overgrown nail(s)	1.26 (0.97–1.64)	0.088	0.70 (0.38–1.28)	0.246	1.06 (0.87–1.29)	0.556
Overgrown molar(s)	1.27 (0.91–1.77)	0.166	0.71 (0.33–1.53)	0.380	1.25 (0.98–1.60)	0.074
Obesity	0.68 (0.47–0.98)	**0.040**	0.52 (0.21–1.30)	0.162	1.25 (0.91–1.71)	0.167
Perineal faecal impaction	2.57 (1.49–4.42)	**0.001**	0.93 (0.29–3.01)	0.902	2.35 (1.65–3.35)	**<0.001**
Disorder not diagnosed	1.01 (0.63–1.61)	0.976	0.83 (0.30–2.33)	0.725	1.44 (0.99–2.10)	0.057
Anorexia	0.60 (0.39–0.91)	**0.017**	0.92 (0.38–2.20)	0.847	0.71 (0.49–1.02)	0.061
Gastrointestinal stasis[a]	0.49 (0.32–0.74)	**0.001**	0.23 (0.05–0.98)	**0.047**	1.05 (0.72–1.53)	0.815
Tear duct abnormality	3.51 (1.39–8.87)	**0.008**	0.64 (0.07–5.84)	0.695	1.97 (1.19–3.24)	**0.008**
Haircoat disorder[b]	2.43 (1.04–5.69)	**0.041**	~ (~)	~	1.20 (0.74–1.95)	0.453
Postoperative complication	1.16 (0.62–2.17)	0.650	1.26 (0.34–4.61)	0.727	1.01 (0.63–1.61)	0.971
Diarrhoea	1.21 (0.61–2.41)	0.579	0.46 (0.06–3.65)	0.460	0.98 (0.60–1.60)	0.936
Dental disease[c]	1.08 (0.54–2.17)	0.832	1.23 (0.32–4.72)	0.761	0.79 (0.47–1.33)	0.382
Bite injury	0.90 (0.45–1.81)	0.766	1.53 (0.41–5.73)	0.529	1.65 (0.91–3.01)	0.100
Overgrown incisor(s)	1.82 (0.82–4.05)	0.144	2.41 (0.67–8.65)	0.176	0.84 (0.50–1.39)	0.492
Conjunctivitis	1.67 (0.70–3.98)	0.250	~ (~)	~	1.33 (0.74–2.38)	0.345
Thin	1.23 (0.54–2.78)	0.622	1.26 (0.25–6.24)	0.781	1.58 (0.85–2.92)	0.145
Upper respiratory tract infection	0.92 (0.42–2.02)	0.827	0.48 (0.06–3.98)	0.496	0.80 (0.42–1.49)	0.474
Ocular discharge[d]	1.47 (0.57–3.82)	0.428	1.58 (0.29–8.52)	0.593	0.90 (0.47–1.71)	0.739
Mites	0.85 (0.39–1.87)	0.688	0.47 (0.06–3.89)	0.485	1.41 (0.74–2.70)	0.298
Ileus	2.78 (0.85–9.14)	0.092	4.53 (0.86–23.8)	0.074	1.36 (0.71–2.59)	0.352
Cheyletiellosis	1.90 (0.66–5.45)	0.233	~ (~)	~	2.45 (1.17–5.12)	**0.017**
Collapse	0.76 (0.30–1.91)	0.555	0.48 (0.05–4.31)	0.514	0.98 (0.46–2.08)	0.955
Nasal discharge[e]	1.36 (0.47–3.94)	0.572	1.05 (0.11–9.61)	0.969	2.26 (0.99–5.11)	0.051
Encephalitozoon cuniculi infection	0.72 (0.32–1.63)	0.432	0.49 (0.06–4.06)	0.507	0.60 (0.30–1.18)	0.140
Abscess	0.80 (0.34–1.87)	0.604	~ (~)	~	1.15 (0.56–2.35)	0.703

Note: The odds ratios reported account for confounding by sex, neuter status, age and veterinary group attended. Symbol '~' denotes that no cases were recorded in dolichocephalic rabbits. The values in bold indicate a p-value < 0.05.
Abbreviation: CI, confidence interval.
[a]Not specifically recorded as ileus.
[b]Not also recorded as mites or cheyletiellosis.
[c]Not also recorded as overgrown incisor(s) or overgrown molar(s).
[d]Not recorded as linked with conjunctivitis or tear duct abnormality.
[e]Not also recorded as upper respiratory tract infection.

TABLE 4 Prevalence of the 20 most common disorders, at a grouped level of diagnostic precision, recorded in rabbits ($n = 3933$) under veterinary care at UK primary care practices participating in the VetCompass programme between 1 January and 31 December 2019

Grouped-level disorder	No.	Prevalence (%)	95% CI	Female (%)	Male (%)	*p*-value	Median age (years)	Median bodyweight (kg)
Claw/nail disorder	1121	28.50	27.10–29.94	28.27	28.63	0.810	3.04	2.30
Dental disorder	717	18.23	17.03–19.47	15.83	19.93	**0.001**	4.22	2.22
Skin disorder	639	16.25	15.11–17.44	15.60	15.68	0.944	4.31	2.30
Enteropathy	437	11.11	10.15–12.14	10.69	10.88	0.856	3.53	2.30
Ophthalmological disorder	363	9.23	8.34–10.18	6.13	11.03	**<0.001**	5.27	2.19
Obesity	347	8.82	7.95–9.75	10.51	7.44	**0.001**	3.93	2.71
Parasite infestation	275	6.99	6.21–7.83	6.54	6.93	0.640	4.52	2.36
Appetite disorder	241	6.13	5.04–6.92	5.78	6.17	0.620	3.73	2.33
Disorder not diagnosed	236	6.00	5.28–6.79	5.84	5.82	0.975	4.86	2.35
Traumatic injury	232	5.90	5.18–6.68	5.84	5.72	0.871	2.15	2.24
Upper respiratory tract disorder	193	4.91	4.25–5.63	4.61	5.01	0.578	3.65	2.36
Complication associated with clinical care	158	4.02	3.43–4.68	3.50	4.40	0.165	1.49	2.21
Mass	119	3.03	2.51–3.61	2.80	2.88	0.885	5.84	2.40
Musculoskeletal disorder	104	2.64	2.17–3.19	2.57	2.53	0.937	6.14	2.30
Thin	103	2.62	2.14–3.17	2.34	2.63	0.568	3.65	1.98
Ear disorder	94	2.39	1.94–2.92	1.99	2.48	0.314	4.55	2.30
Brain disorder	85	2.16	1.73–2.67	1.99	2.02	0.936	3.79	2.01
Urinary system disorder	79	2.01	1.59–2.50	2.22	1.57	0.145	3.82	2.60
Collapse	69	1.75	1.37–2.22	1.81	1.72	0.834	5.77	2.15
Abscess	63	1.60	1.23–2.04	1.34	1.87	0.206	4.76	2.17

Note: The *p*-value reflects a comparison between the prevalence in females and males. The median age and bodyweight for affected rabbits are also shown. The values in bold indicate a p-value < 0.05.
Abbreviation: CI, confidence interval.

support ongoing efforts to enhance rabbit welfare by reducing the impact of a 'lack of owner/vet knowledge on basic rabbit behaviour and health (and recognition of diseases/pain)', which was reported as the fourth highest welfare priority issue for individual rabbits in a UK Delphi study.[36] The most common disorders reported were overgrown nail(s), overgrown molar(s), obesity and perineal faecal impaction. The link to husbandry for each of these is notable. The most common causes of death reported were collapse, enteropathy and brain disorder. There was limited evidence that skull shape or ear carriage conformations were linked to a meaningful overall increased disorder risk in domestic rabbits, suggesting that other factors, such as husbandry or even living life as a domesticated species, were bigger drivers for the most common health issues in pet rabbits in the UK.

The study population comprised predominantly crossbreed rabbits, with mini/Holland lops, unspecified lops and lionheads being the most recorded breed types. This aligns with other studies reporting that lop-eared rabbits (specifically mini lops) are among the most kept breed types in the UK.[8,10,11] Unfortunately, information on breed was not recorded in 32.35% of records, which limited interpretation of these results because it was unknown if the breed structure of those with missing information mirrored that of those with recorded information. This proportion of records with missing breed information is similar to the 31.9% with missing information in an earlier 2013 study using primary care veterinary clinical records of rabbits,[11] which suggests that poor levels of veterinary record keeping on breed in rabbits continue. Of those rabbits where breed was recorded and skull shape could therefore be classified, the majority (79.69%) were brachycephalic types, with only 3.51% being classified as dolichocephalic. In line with rising public demand for brachycephaly in dogs, which is heavily driven by perceptions of cuteness,[37–39] the current findings support the proposition that the general public increasingly favours ownership of rabbits with brachycephalic features, which could have a significant impact on their health and welfare if having a flat face is associated with chronic health conditions, as previously suggested.[13] Such health risks formed part of the core question that the current study sought to answer.

The overall median adult bodyweight of rabbits in the current study was 2.3 kg, with 50% of rabbits weighing between 1.85 and 2.73 kg, giving an interquartile variability (0.88 kg) that is just 38.3% of the median bodyweight. Cats have previously been reported with a median adult bodyweight of 5.5 kg, with 50% of cats weighing between 4.0 and 7.4 kg, giving an interquartile variability (3.40 kg) that represents 61.8% of the median bodyweight.[40] Dogs, on the other hand, have previously been reported with a median adult bodyweight of 13.7 kg, with 50% of dogs weighing

TABLE 5 Skull shape (brachycephalic [$n = 1739$] compared to mesaticephalic [$n = 367$], and dolichocephalic [$n = 74$] compared to mesaticephalic) and ear carriage (lop-eared [$n = 1165$] compared to erect-eared [$n = 889$]) as risk factors for the 20 most common disorders at a grouped level of diagnostic precision, recorded in rabbits under veterinary care at UK primary care practices participating in the VetCompass programme beyween 1 January and 31 December 2019

Grouped-level disorder	Odds ratio (95% CI) (brachycephalic vs. mesaticephalic)	*p*-value (brachy-cephalic vs. mesaticephalic)	Odds ratio (95% CI) (dolichcephalic vs. mesaticephalic)	*p*-value (dolichcephalic vs. mesaticephalic)	Odds ratio (95% CI) (lop vs. erect)	*p*-value (lop vs. erect)
Claw/nail disorder	1.27 (0.97–1.64)	0.079	0.74 (0.41–1.35)	0.331	1.07 (0.88–1.30)	0.506
Dental disorder	1.27 (0.93–1.73)	0.138	0.96 (0.49–1.88)	0.909	1.16 (0.92–1.46)	0.216
Skin disorder	1.59 (1.13–2.24)	**0.008**	0.88 (0.41–1.87)	0.737	1.32 (1.03–1.68)	**0.027**
Enteropathy	0.68 (0.49–0.95)	**0.025**	0.53 (0.23–1.23)	0.137	0.94 (0.72–1.25)	0.686
Ophthalmological disorder	1.97 (1.22–3.17)	**0.006**	0.98 (0.36–2.66)	0.965	1.31 (0.96–1.80)	0.088
Obesity	0.68 (0.47–0.98)	**0.040**	0.52 (0.21–1.3)	0.162	1.25 (0.91–1.71)	0.167
Parasite infestation	1.08 (0.69–1.71)	0.734	0.42 (0.12–1.48)	0.178	1.55 (1.09–2.21)	**0.014**
Appetite disorder	0.56 (0.38–0.85)	**0.006**	0.81 (0.34–1.93)	0.630	0.72 (0.51–1.02)	0.066
Disorder not diagnosed	1.01 (0.63–1.61)	0.976	0.83 (0.30–2.33)	0.725	1.44 (0.99–2.10)	0.057
Traumatic injury	0.97 (0.58–1.61)	0.894	1.61 (0.62–4.20)	0.329	1.45 (0.96–2.20)	0.077
Upper respiratory tract disorder	1.03 (0.59–1.80)	0.912	0.79 (0.22–2.80)	0.710	1.23 (0.80–1.89)	0.342
Complication associated with clinical care	1.22 (0.69–2.15)	0.487	1.79 (0.62–5.12)	0.279	1.01 (0.67–1.52)	0.974
Mass	0.99 (0.52–1.89)	0.974	0.94 (0.25–3.56)	0.931	0.86 (0.53–1.42)	0.563
Musculoskeletal disorder	0.83 (0.41–1.66)	0.594	1.01 (0.26–3.94)	0.986	0.71 (0.41–1.23)	0.226
Thin	1.16 (0.56–2.40)	0.689	2.00 (0.59–6.80)	0.265	1.25 (0.73–2.14)	0.419
Ear disorder	1.09 (0.52–2.26)	0.827	~ (~)	~	1.77 (0.99–3.15)	0.054
Brain disorder	0.66 (0.31–1.42)	0.285	0.43 (0.05–3.52)	0.433	0.7 (0.36–1.36)	0.297
Urinary system disorder	1.08 (0.50–2.36)	0.842	1.84 (0.47–7.26)	0.381	1.25 (0.68–2.31)	0.466
Collapse	0.82 (0.33–2.05)	0.678	0.50 (0.06–4.46)	0.538	1.02 (0.49–2.14)	0.953
Abscess	0.80 (0.34–1.87)	0.604	~ (~)	~	1.16 (0.57–2.36)	0.689

Note: The odds ratios reported account for confounding by sex, neuter status, age and veterinary group attended. Symbol '~' denotes that no cases were recorded in dolichocephalic rabbits. The values in bold indicate a p-value < 0.05.
Abbreviation: CI, confidence interval.

between 8.4 and 24.43 kg, giving an interquartile variability (16.03 kg) that represents 117.0% of the median bodyweight.[41] This limited size variation of less than 1 kg across the pet rabbit population for the central 50% of rabbits by weight suggests that the general public does not favour extreme breed sizes of rabbits even if the public does find extreme facial and ear conformations to be cute.[13] However, it is also possible that there are biological constraints that limit the degree of morphological change that mankind can introduce into rabbits or that efforts to introduce morphological change into rabbits are still in their early days and greater change will be introduced over time.

The consistently smaller bodysize of rabbits that are popular as pets compared to the typical adult bodyweights of cats and dogs, which are the other two commonly owned mammalian pets in the UK, may be linked to emotional drivers in owners who choose to own rabbits based on the perception of cuteness. There is a substantial body of literature on

TABLE 6 Proportional mortality overall and within the sexes from the 15 most common disorders, at a grouped level of diagnostic precision, causing deaths in rabbits ($n = 613$) under veterinary care at UK primary care practices participating in the VetCompass programme between 1 January and 31 December 2019.

Grouped-level disorder	No.	Proportional mortality (all deaths—$n = 613$)	95% CI	Proportional mortality (deaths with an ascribed cause—$n = 377$)	95% CI	Female—proportional mortality % if cause death recorded	Male—proportional mortality % if cause death recorded	p-value	Median age at death (years)	Median bodyweight (kg)
Disorder not diagnosed	236	38.50	34.63–42.48							
Collapse	53	8.65	6.54–11.16	14.06	10.71–17.98	13.81	16.03	0.569	6.41	2.22
Enteropathy	31	5.06	3.46–7.10	8.22	5.66–11.47	9.39	7.05	0.438	3.72	2.26
Brain disorder	30	4.89	3.33–6.91	7.96	5.43–11.17	6.08	9.62	0.225	4.03	2.07
Parasite infestation	29	4.73	3.19–6.72	7.69	5.21–10.86	8.29	6.41	0.512	6.10	2.70
Mass	26	4.24	2.79–6.15	6.90	4.55–9.94	8.29	5.13	0.252	6.74	2.59
Dental disorder	21	3.43	2.13–5.19	5.57	3.48–8.39	3.31	8.97	**0.028**	4.34	2.48
Lower respiratory tract disorder	21	3.43	2.13–5.19	5.57	3.48–8.39	6.08	5.77	0.905	4.00	2.15
Appetite disorder	17	2.77	1.62–4.40	4.51	2.65–7.12	6.08	3.21	0.216	5.42	1.75
Traumatic injury	16	2.61	1.50–4.20	4.24	2.44–6.80	2.76	7.05	0.065	5.08	1.98
Viral infectious disorder	13	2.12	1.13–3.60	3.45	1.85–5.82	3.87	2.56	0.502	1.10	3.61
Musculoskeletal disorder	11	1.79	0.90–3.19	2.92	1.47–5.16	1.66	2.56	0.561	8.25	2.50
Ophthalmological disorder	11	1.79	0.90–3.19	2.92	1.47–5.16	2.21	2.56	0.831	8.53	2.10
Complication associated with clinical care	10	1.63	0.78–2.98	2.65	1.28–4.82	2.76	3.21	0.811	0.65	1.94
Spinal cord disorder	10	1.63	0.78–2.98	2.65	1.28–4.82	4.97	0.64	0.019	4.07	2.51

Note: The median age at death and adult bodyweight for affected rabbits are also shown. The values in bold indicate a p-value < 0.05.
Abbreviation: CI, confidence interval.

commodities, including animals that are sold and purchased based on cuteness. Vulnerability induced by smallness is widely recognised as a key feature that elicits the cuteness perception that is often also called the 'awww effect'.[42,43] Other factors linked to perceptions of cuteness include fluffiness and softness[44] and also a neotenic baby-like appearance (also called baby schema or kinder schema) including a small mouth, a round face and small chin, which may explain the moves away from the more angular and pointed facial features of the wild types when rabbits are bought as 'cute pets'.[45,46] Overall, these motivations help to explain why humans tend to choose to evolve the physical and behavioural suites of domestic pet species away from those that have been successful for survival over millions of years. However, it is when the exaggeration of phenotypes leads to health and welfare issues for these animals that ethical, legal and moral questions begin to be asked about the appropriateness of mankind's intervention to reshape nature to suit our current preferences for animal ownership.[47] Their popularity as pets may also be driven by the common public perception that rabbits are easier and cheaper to keep than dogs or cats, but this belief may unfortunately result in many pet rabbits experiencing inappropriate housing and husbandry.[48,49]

At the highest precision of diagnostic terms, the most commonly recorded disorders were overgrown nail(s), overgrown molar(s), obesity and perineal faecal impaction. At a grouped level of diagnostic precision, the most common groups were claw/nail disorders, dental disorders, skin disorders and enteropathy. These findings align closely with a survey of UK-practising veterinary surgeons that reported the body systems most commonly affected by disease in rabbits as dental (29.9%), skin (25.3%) and gastrointestinal (15.2%).[50] It is notable that these most common disorders can all be linked with underlying deficits in husbandry and diet related to lifestyles typical of pet rabbits in the UK that are likely to apply regardless of ear or skull conformation.[1,8] These top-ranked disorders mirror those in an earlier 2013 study using primary care veterinary clinical records,[11] suggesting that efforts to share information on good rabbit husbandry over the intervening years have had little real-world impact on the disorder profiles that continue to affect pet rabbits.[51] Indeed, obesity was reported in only 3.7% of rabbits in 2013 compared with 8.8% of rabbits in the current 2019 study, where obesity was the third most common disorder overall, suggesting that either levels of obesity itself or the reporting and recognition of obesity have increased during the intervening period. This latter possibility of a general overall increase in diagnosis and recording of disorders is supported by the observation that proportional diagnosis rose for many of the common disorders between 2013 and 2019. Other studies have similarly reported a high prevalence of overweight in rabbits, ranging between 5.9% and 35%,[52,53] but assessment methods varied. Furthermore, although body condition scoring systems exist for rabbits, these have not yet been adequately validated so their interpretation remains subjective.[54] Regardless of exact prevalence, obesity remains an important health and welfare concern for pet rabbits and ongoing owner education is vital to prevent weight gain at an early stage.

Overgrown nails, with a prevalence of 28.19%, was by quite some margin the most common specific disorder recorded among rabbits in the current study. This finding is in line with a previous study of rabbits under primary veterinary care in England that also identified overgrown nails as the most common specific disorder diagnosed in rabbits.[11] Despite this high prevalence, there is limited primary literature on overgrown nails as a health and welfare issue in rabbits kept as domestic pets. The plantar and palmar surfaces of rabbit feet are protected by thick, coarse fur rather than bearing footpads as in dogs and cats, so rabbit enclosures should offer access to soft padded areas.[55] Their nonretractable nails also makes declawing an inappropriate procedure for rabbits.[55,56] Although previously commonly used by veterinary practitioners and with 59.9% of UK owners in a recent survey reporting using this method of handling, it is no longer recommended to use trancing (hypnosis) by lying rabbits on their back for procedures such as nail clipping because this immobility response is believed to lead to high rabbit stress.[3,57] Ageing or overweight rabbits are also reported to develop rotated digits that require more frequent trimming of the nail to avoid overgrowth or possibly penetration into the adjacent toe.[58] Nail overgrowth could indicate husbandry deficits of limited opportunities for exercise and inappropriate flooring/bedding that could be discussed during veterinary visits.[48,49]

Of rabbits with information available on ear carriage based on breed and type, 42.95% were classified as erect-eared and 57.05% were classified as lop-eared. Among the 25 most common disorders, rabbits with a lop-eared carriage were predisposed to just two, specifically perineal faecal impaction (odds ratio [OR] 2.35) and tear duct abnormality (OR 1.97). Compared to mesaticephalic rabbits, rabbits with a brachycephalic skull were predisposed to three disorders, specifically tear duct abnormality (OR 3.51), perineal faecal impaction (OR 2.57) and haircoat disorder (OR 2.43). There was a high level of overlap between lop-eared carriage and brachycephaly for the breeds and types in the current study, so the consistency of predisposition between the two conformations is unsurprising. However, despite being paired in many rabbit types, lop-eared carriage and brachycephalic conformation should be considered as separate risk factors given that this pairing is not universal across rabbit breeds. Further research is necessary to establish the impact of having a lop-eared but non-brachycephalic conformation and vice versa.

Perineal faecal impaction was the fourth most commonly recorded disorder, affecting 7.4% of rabbits overall, with lop-eared rabbits having 2.35 times the odds compared to erect-eared rabbits and brachycephalic rabbits having 2.57 times the odds compared to mesaticephalic rabbits. There are multiple possible causes for faecal impaction in a rabbit, including inability to groom adequately and suboptimal husbandry or diet, some of which may be linked to biomechanical changes away from the innate health status of wild rabbit types consequent to selection for the lop-eared or brachycephalic conformation.[59] Increased vigilance is recommended for owners of lop-eared or brachycephalic rabbits that includes a minimum of at least a daily perineal check to identify and remove any faecal or caecotroph build up, in addition to ensuring good levels of parasite prevention for vulnerable individuals.[60]

Tear duct abnormalities were the eighth most common disorder, affecting 3.51% of rabbits overall, with lop-eared rabbits having 1.97 times the odds of tear duct abnormality compared to erect-eared rabbits and brachycephalic rabbits having 3.51 times the odds compared to mesaticephalic rabbits. A previous retrospective analysis of 821 pet rabbits in the UK also reported an association between breed and the presence of dacryocystitis, with a higher prevalence of dacryocystitis in lionheads/lionhead crossbreeds (erect-eared) and dwarf lop/dwarf lop crossbreeds compared to crossbreed rabbits.[12] Similarly, increased prevalence in lionhead rabbits that are not lop-eared and in dwarf lop breeds may suggest that it is the brachycephalic skull conformation rather than the ear type that is the main conformational driver for tear duct disorders such as dacryocystitis. The application of a rabbit brachycephaly grading system in a randomised clinical trial to assess nasolacrimal drainage disorders would be beneficial for further deconstructing brachycephaly as a risk factor for dacryocystitis, as previously proposed.[12]

The current results did not support the hypothesis that lop-eared rabbits have a higher prevalence of aural disease compared with erect-eared rabbits. This is surprising considering the increased risk of aural pathology that has been reported by some previous studies.[22,24] Aural problems could be easily missed by owners so that affected rabbits are not presented for veterinary care, although it might be expected that any underdetection by owners should apply similarly to all types of rabbits and therefore not bias the results. Alternatively, diagnosis of aural problems may be more likely to be missed by veterinarians in lop-eared rabbits because full assessment of the external ear canal is impossible on conscious examination of a lop-eared rabbit due to the limited gap between the tragus and the cartilaginous acoustic meatus, which allows the ear canal to fold but limits assessment.[23] Disorders such as otitis media have also previously been reported to be more prevalent in lop-eared breeds, but many diagnoses were still missed clinically in those studies, with 27%–61% of cases identified on computed tomography scan not being associated with any clinical signs.[61,62]

The current results also did not support the hypothesis that lop-eared rabbits have a higher prevalence of dental disease compared with erect-eared rabbits. Dental disorders in rabbits can be missed by owners, especially at an early stage of disease development, with a survey of British rabbit owners reporting that 14.9% of owners never checked their rabbit's gums and 8.1% never checked their rabbit's teeth.[63] However, more advanced dental disease is more likely to be noted as it ultimately leads to obvious clinical signs such as changes in appetite, drooling or gut stasis with progression of disease, which can be identified by both owners and veterinarians compared to the lack of clinical signs with many aural disorders.[64] However, there is no reason to suspect that any levels of underdiagnosis or delayed diagnosis of dental disease would be greater in lop-eared rabbits than in other types of rabbits. The lack of an association between lop-eared conformation and dental disease contrasts with the results from a study of a small population of rescue rabbits that reported approximately 23 times and 12 times higher odds of incisor pathology and molar overgrowth in lop-eared rabbits than in erect-eared rabbits, respectively, although that study was limited by a very small sample size of only 30 rabbits and perhaps suggests greater caution is needed when attempting to generalise from datasets of rabbits with high selection bias to the wider rabbit population.[22] In contrast, and in agreement with the current study, a recent larger study that included 2219 rabbits under primary veterinary care diagnosed with dental disease did not identify an association between lop-eared and brachycephalic conformation and dental disease.[65] The authors of that study suggested that an almost-universal brachycephalic status combined with pervasive husbandry changes such as access to low-fibre high-energy diets may mean that just being a companion rabbit per se is the greatest risk factor for dental disease in rabbits. Similarly, a Finnish survey of 167 rabbits also failed to identify associations between lop-eared rabbits and dental disease, and in fact reported increased dental pathology in erect-eared lionhead rabbits.[21] The contradictory evidence on associations between ear type and dental disorders suggests that other risk factors that commonly affect both lop-eared and erect-eared rabbits, such as skull shape, may be significant in the development of dental disease in rabbits.[20,66] It is also possible that dental disease has a highly multifactorial aetiopathogenesis and that effects from husbandry and dietary deficits related to living as a domestic pet rabbit may overwhelm any residual effects related to the lop-eared conformation.

This study also identified some notable prevalence differences for common disorders between the sexes, with female rabbits having a significantly higher prevalence of obesity compared to males (10.5% vs. 7.4%, respectively). These results are in line with a previous study of 150 pet rabbits, where 48% of female rabbits were classed as overweight compared to 17% of male rabbits,[53] although an earlier study based on primary care clinical records in England did not identify sex as a risk factor for obesity.[11] In contrast, males had a higher prevalence of five other common disorders, namely, overgrown molar(s), tear duct abnormality, overgrown incisor(s), conjunctivitis and ocular discharge. An earlier study of rabbits under primary veterinary care did not identify sex as a risk factor for tear duct abnormality, conjunctivitis or ocular discharge.[11] However, predisposition to dental disease in males has been previously reported in several studies[11,20,67] and has been suggested to result from sexual dimorphism expressed in rabbit masseter muscle fibres.[68] However, dental disorders in rabbits appear to be multifactorial, with husbandry, diet, age, sex, breed and genetic predisposition all proposed to play contributory roles.[69] Awareness of differential disorder risk between the sexes can assist veterinary professionals in tailoring the advice they give to owners on husbandry and disorder monitoring.

The overall median age at death in rabbits in the current study was 5 years, which is consistent with previous studies that reported average ages at death of between 4.2 and 5.6 years.[8,11,70] However, the current study also reported that some rabbits lived up to 15 years, which suggests that longer lifespans are possible but not occurring routinely in those rabbits presented to veterinary practices. In the present study, rabbits with erect ear carriage were found to live more than a year longer than lop-eared rabbits (median 5.44 vs. 4.29 years, respectively). Although most of the common disorders did not differ significantly in prevalence between erect-eared and lop-eared rabbits, this difference in median age at death could suggest that other intrinsic differences between these types of rabbits may lead to cumulative negative overall health impacts as humans select for greater divergence from the wild rabbit type. However, it is notable that skull conformation was not statistically associated with longevity in the current results. Veterinary professionals can share these results on typical ages at death to give owners realistic expectations of rabbit lifespans.

There were some limitations to the current study. There was a large proportion of incomplete or unclear records for breed information, which hindered analysis based on breed and breed-related attributes. For example, 'lop unspecified' could refer to any one of nine different pure breeds or a larger number of crossbreeds with varying degrees of skull shape. The current study was limited to rabbits presented to veterinary practices participating in the VetCompass programme and therefore may not generalise fully to the wider population of UK pet rabbits. Future work to explore the accuracy of recording of breed information for rabbits under veterinary care could assist in validating the breed data from this resource. As discussed above, rabbits affected with disorders such as aural disease, which often do not have obvious clinical signs, may not have been recognised by owners as requiring veterinary treatment; therefore, the prevalence of such 'silent' conditions may have been underrecognised. Other conditions, such as dental disease, are known to be multifactorial, with factors such as diet likely to play a role. Therefore, conclusions about contributing factors need to be interpreted carefully, especially as the current study did not have access to information on diet and other husbandry factors. As the frequency of the disorders dropped, the power of the study to detect significant differences between the conformational types of rabbits dropped, and therefore the probability of type II errors (false negatives) would rise. The current study used multiple comparisons but without adopting any correction factors, such as Bonferroni correction. This decision was made because it was not critical to avoid type I errors (false positives) in any single statistical test carried out in the current study and because the study was exploratory rather than confirmatory in nature.[71–73] Consequently, the statistically significant results presented here should be considered as exploratory in nature, with apparent associations reported here considered as potentially 'false positives' until future testing provides stronger evidence. Any wider inference based on these apparent associations should also consider other reported work and biological plausibility.[74] Proportional recording with rabbit breed or type information varied across the six veterinary groups in the study, which may have introduced some bias if this breed or type information was not missing at random. The current analysis placed minimal emphasis on interpreting effects of neuter status on disorder risk because the current data did not extract the date of neutering; therefore, it was unclear whether the neutering event preceded or followed each disorder diagnosis. The 24.08% proportional neutering identified in the current study was substantially lower than the 54% reported in the UK PDSA 2019 PAW Report and could reflect either poorly updated veterinary clinical records on the one hand or selection bias towards more invested owners who contributed data to the YouGov surveys used for the PAW report on the other.[75]

CONCLUSIONS

This study of pet rabbits under primary veterinary care in the UK has revealed some important breed and sex predispositions for common disorders. The findings of increased risk of faecal impaction and tear duct problems in lop-eared and brachycephalic types of rabbit, which are both increasing in popularity as pets, raise some worrying welfare concerns. However, it is important to note that the causation of most common disorders reported in rabbits is multifactorial, so other factors, such as underlying husbandry or diet deficits, should also be considered. The increased risk of dental disease in males and of obesity in females highlights opportunities to prevent generally chronic problems with the potential for significant long-term welfare implications. However, the limited evidence that skull shape or ear carriage conformations were linked to overall increased disorder risk in domestic rabbits suggests that other factors, such as husbandry or even living life as a domesticated species, are bigger drivers for the common health issues in pet rabbits in the UK. Improved owner education on common disorders and their prevention is important to protect the welfare of rabbits kept as pets.

AUTHOR CONTRIBUTIONS

Dan G. O'Neill, Dave C. Brodbelt and David B. Church were responsible for the acquisition of the clinical data used in the study. Dan G. O'Neill was responsible for the collation of the study data. Dan G. O'Neill, Abbie Williams and Joanna Hedley were responsible for the conception and design of the study. Abbie Williams and Dan G. O'Neill were responsible for the extraction of data. Dan G. O'Neill carried out the data preparation and analysis. Dan G. O'Neill, Joanna Hedley and Abbie Williams were mainly responsible for drafting the manuscript. Dan G. O'Neill, Joanna Hedley, Abbie Williams, David B. Church and Dave C. Brodbelt were involved in interpreting the results, revised the manuscript, have read and approved the manuscript, gave final approval of the version to be published and agreed to be accountable for all aspects of the accuracy and integrity of the work.

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CONFLICT OF INTEREST STATEMENT

The authors declare they have no conflicts of interest.

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DATA AVAILABILITY STATEMENT

The datasets analysed during the current study are available on Figshare at https://doi.org/10.6084/m9.figshare.24717699

ETHICS STATEMENT

Ethics approval was obtained from the Royal Veterinary College Social Science Ethical Review Board (reference number SR2018-1652).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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