Original Article

jfms Journal of Feline Medicine and Surgery

Life tables of annual life expectancy and risk factors for mortality in cats in the UK

Journal of Feline Medicine and Surgery
1–11

DOI: 10.1177/1098612X241234556
journals.sagepub.com/home/jfm

This paper was handled and processed by the European Editorial Office (ISFM) for publication in *JFMS*

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Kendy Tzu-yun Teng[1], Dave C Brodbelt[2], David B Church[3] and Dan G O'Neill[2]

Abstract

Objectives The aims of the present study were to generate the first life tables for the UK companion cat population overall as well as broken down by sex and breed status, and to quantify associations between mortality and traits such as sex, neuter status, breed status and body weight in relation to mortality.

Methods Life table construction and modelling included data on 7936 confirmed deaths in cats under primary veterinary care at clinics participating in the VetCompass Programme in 2019. The life tables were built for cats overall, female and male cats, and crossbred and purebred cats. Multivariable generalised linear regression models were generated to explore the risk factors for a shortened lifespan.

Results Life expectancy at age 0 for UK companion cats overall was 11.74 years (95% confidence interval [CI] 11.61–11.87). The probability of death at each year interval increased with age from year interval 3–4, with the probability value not exceeding 0.05 before year 9. Female cats (12.51 years; 95% CI 12.32–12.69) had a 1.33-year longer life expectancy than male cats (11.18 years; 95% CI 11.01–11.38) at age 0. Among the 12 breeds (including crossbred) analysed, Burmese and Birman had the longest life expectancy at year 0, showing 14.42 years (95% CI 12.91–15.93) and 14.39 years (95% CI 12.87–15.91), respectively. Sphynx had the shortest life expectancy at year 0 among the analysed breeds at 6.68 years (95% CI 4.53–8.83). Being entire, purebred and with a non-ideal body weight were significantly linked to a decreased lifespan.

Conclusions and relevance The life tables presented here for companion cats in the UK overall, by sex, and by crossbred and purebred cats can contribute to a better understanding of the life trajectory of cats, helping with evidence-based decision-making for cat owners and the veterinary profession. We have also provided an updated life expectancy at age 0 for various cat breeds for 2019 and showed evidence of the association between non-ideal weight and a decreased lifespan.

Keywords: VetCompass; electronic patient record; EPR; breed; epidemiology; primary care; veterinary; death; lifespan; weight; body condition score; BCS

Accepted: 5 February 2024

Introduction

Reliable and generalisable information about mortality and life expectancy is crucial for improved understanding of the health and welfare of the companion cat population.[1–3] Changing trends over time in the life expectancy of a cat population may suggest changes in the general health of the population.[1] In addition, a lifespan comparison between different subgroups of cats can identify potentially less-healthy cat groups.[2,4] Various factors have previously been suggested to be associated with a shortened lifespan in cats, such as male sex,[1,2,4,5] specific breeds (eg, Bengal and Ragdoll)[2,4] and non-ideal body condition.[1,3]

[1]Department of Veterinary Medicine, College of Veterinary Medicine, National Chung Hsing University, Taichung City, Taiwan
[2]Pathobiology and Population Sciences, The Royal Veterinary College, Hatfield, Hertfordshire, UK
[3]Clinical Sciences and Services, The Royal Veterinary College, Hatfield, Hertfordshire, UK

Corresponding author:
Kendy Tzu-yun Teng DVM, PhD, Department of Veterinary Medicine, College of Veterinary Medicine, National Chung Hsing University, Taichung City, 402, Taiwan
Email: kendy.t.teng@gmail.com

There are two main ways of reporting the overall mortality of cats described in the literature: average (mean or median) overall ages at death and, more recently, life table methods. The average overall ages at death have been investigated and reported using various data sources, including primary veterinary caseloads,[2] insurance databases,[4] mortality cases reported by veterinary clinics and hospitals,[5] and cases examined post mortem.[6] However, summarising the complexity of lifespan information from a large population into just a single value (ie average age at death) provides relatively limited information about cat mortality when compared with life tables. A life table presents the life expectancy and probability of death at a range of different ages or age groups within a given population.[1,7–9] One of the most important features is that the life expectancy (ie, average remaining lifespan) at different ages is estimated by excluding information on cats in the population that have died at a younger age. Thus, a reliable life table can illustrate that life expectancy at each age is not the average lifespan minus that age and allow veterinary professionals to deliver more accurate life expectancy information at different ages to (potential) cat owners whenever applicable.

Life tables have been widely used in human public health for many years but recently have started to be applied to dog and cat populations to better understand their mortality.[1,7–9] Two published studies on cat life tables currently exist in the academic literature based on two distinct cat populations.[1,10] Hayashidani et al[10] used cemetery data of 3936 cats in Tokyo, Japan, between 1981 and 1982, and Montoya et al[1] generated life tables for cats across survey years 2013–2019 with clinical records from >1000 Banfield Pet Hospitals in the USA. However, effects from demographical boundaries that promote different genetic reservoirs as well as different breeding, ownership and cat healthcare practices may result in life tables from one region being poorly generalisable to other regions.[1,7–9] Consequently, a more ideal situation is for each geographical area to have representative life tables for its domestic populations.

The aim of the present study was to generate the first life tables for the UK companion cat population overall and with further differentiation for cats of different sexes and breed statuses using death data from clinical records of cats under primary veterinary care in the UK. The study also aimed to explore and quantify associations between different traits of cats and early mortality. In the current investigation, life expectancy is defined as "the mean lifespan of animals alive in the population," while lifespan refers to "the duration of an individual's life." The results of the study were expected to improve our understanding of mortality and the life expectancy patterns of companion cats in the UK and help to identify subpopulations with lower life expectancies.

Materials and methods

Ethics approval was obtained from the RVC Ethics and Welfare Committee (SR2018-1652). The sampling frame of the present study included all cats under primary veterinary care at clinics participating in the VetCompass Programme during 2019. Cats under veterinary care were defined as those with at least one electronic patient record (EPR) (free-text clinical note, treatment or body weight) recorded during 2019. VetCompass collates de-identified EPR data from primary care veterinary practices in the UK for epidemiological research.[11] Relevant data fields available for the present study included a unique animal identifier along with veterinary group identifier, species, breed, date of birth, sex and neuter status, plus body weight, free-form text clinical notes and treatment data with relevant dates.[12]

To identify deaths, case-finding involved initial screening of all EPRs to identify candidate death cases by using search terms in the clinical note field (search terms: euth*, pts*, crem*, ashes, pento*, casket, beech, decease*, death, 'put to sleep', doa, died, killed, 'home bury'~1, ['bury' and 'home']) and treatment field (search terms: euth*, pento*, crem*, casket, scatter, beech). Unique candidate cases identified from these searches were randomly ordered, and the clinical notes of a random subset of candidates were manually reviewed in detail to evaluate for case inclusion. A confirmed death required firm evidence in the EPR that the cat had died at any date from 1 January 2019 onwards until the end of the study period (31 March 2021). The date of confirmed death and the methods of death were extracted for each death.

For deceased cats, breed-descriptive information entered by the participating practices was cleaned and mapped to a VetCompass breed list derived and extended from the VeNom Coding breed list.[12] A breed status variable categorised cats of recognisable breeds as 'purebred' and cats recorded as mixes of breeds, domestic shorthair, domestic mediumhair and domestic longhair as 'crossbred'. Sex and neuter status were defined by the final available EPR value. Adult body weight was defined as the mean of all body weight values (in kg) recorded for each cat after reaching the age of 9 months.

After checking for internal validity, data cleaning and management were performed using Excel 2013 (Microsoft Corp) and R program version 4.2.2 (RStudio 2022.12.0+353 'Elsbeth Geranium').[13,14] Descriptive and inferential analyses, cohort life table construction and regression modelling were facilitated by R packages 'tidyverse', 'ggrepel' and 'janitor'.[15–17]

Life tables were constructed using the lifespan of deceased cats for cats overall, both sexes, crossbred cats and purebred cats with the methods described in the study by Teng et al,[9] originally presented in the study by Chiang (1972).[18] The 95% confidence interval (CI)

for life expectancy at each year was generated using empirical bootstrapping with 10,000 iterations.[19] In addition to the life tables, descriptive information about longevity for breeds with ⩾15 cats was generated.

One multivariable logistic regression model and one multivariable linear regression model were built to explore the risk factors for a shortened lifespan. Logistic regression was conducted to examine the factors associated with early-age mortality (defined as death before the age of 3 years). The cut-off age was determined due to year interval 3–4 having the lowest probability of death within the population. The potential risk factors considered in the modelling included sex, neuter status, breed status (cats without breed information were combined into crossbred) and breed (breeds with <15 deaths were grouped into 'other'). Linear regression examined factors that might be associated with a shorter lifespan after turning into adult (ie cats died aged ⩾9 months), including those considered in the logistic regression and the absolute value of the difference between the adult body weight of each cat and the median adult body weight within breed and sex strata ("body weight deviance"). Both models were conducted with two steps. First, the subset of covariates with the lowest weighted sum of standardised differences between the Akaike information criterion and Bayesian information criterion from all possible combinations of the covariates was selected.[20] Next, all possible models using the selected subset of covariates with biologically meaningful pairwise interactions between the covariates were made, and the final model was chosen from these models using the aforementioned method.[20] Diagnostic plots and variance inflation factors were generated to examine the assumptions and collinearity of the final models, respectively. The significance level was set at 0.05 for all analyses.

Results

From an available population of 1,254,484 cats under veterinary care across six veterinary groups during 2019, initial screening identified 159,590 (12.72%) candidate death cases at any date after 1 January 2019 until 31 March 2021 in the available records. From 11,974 (7.50%) of these candidate deaths that were manually checked, 7936 (66.28%) were confirmed as having died and therefore included in the analyses. Among the 7936 confirmed deaths, 3826 (48.2%) were female, 4000 (50.4%) were male and 110 (1.4%) had unrecorded sex and neuter status. Among the cats with recorded sex and neuter status, 2701/3826 (70.6%) female cats and 2929/4000 (73.2%) male cats were recorded as neutered. The 7936 deaths included 819 (10.3%) purebred cats, 6998 (88.2%) crossbred cats and 119 (1.5%) cats without recorded breed information. At least one adult body weight value was available for 6003/7936 (75.64%) cats. The median number of adult body weight values available for each cat was 2 (interquartile range [IQR] 1–7, range 0–91). For cats that died after 9 months (n = 7722, 97.3%), the median adult body weight for 4951 (64.1%) cats with body weight information recorded was 5.5 kg (IQR 4.1–7.2, range 1.5–15.0). The mechanism of death for most cats was euthanasia (n = 6642, 83.7%), with 987 (12.4%) cats having an unassisted death and 307 (3.9%) cats with no records.

Table 1 presents the overall life table for cats under primary veterinary care in the UK in 2019. The life expectancy at age 0 for UK companion cats was 11.74 years (95% CI 11.61–11.87), and the life expectancy decreased with age (Figure 1). The probability of death within each year interval increased with age from year interval 3–4, and the value did not exceed 0.05 before year 9. The probability of cats dying in year 1–2 (0.047) was higher than in years 0–1 (0.039) and 2–3 (0.041).

Female cats (life expectancy 12.51 years; 95% CI 12.32–12.69) had a 1.33-years longer life expectancy than male cats (life expectancy 11.18 years; 95% CI 11.01–11.38) at age 0 (Tables 2 and 3, Figure 2). The life expectancy gap between female and male cats shrank with time and became not significantly different at year 15–16. The life expectancy of crossbred cats at age 0 was 11.89 years (95% CI 11.76–12.03), more than 1.5 years longer than purebred cats (10.41 years; 95% CI 9.99–10.83) (Tables 4 and 5, Figure 3). The difference decreased sharply to 0.65 years in year 3–4 and stayed relatively steady until year 13–14 (range of difference in this period 0.53–0.65 years).

Among the 12 breeds with 15 or more deaths (including crossbred), Burmese and Birman had the longest life expectancy at age 0 at 14.42 years (95% CI 12.91–15.93) and 14.39 years (95% CI 12.87–15.91), respectively (Table 6). Crossbred cats (0.00–26.69 years) had the widest and Sphynx cats (0.13–14.67 years) had the narrowest range of lifespans among the breeds analysed. Sphynx had the shortest life expectancy at age 0 among the breeds analysed at 6.68 years (95% CI 4.53–8.83). Cats that were euthanased had a longer life expectancy at age 0 at 12.09 years (95% CI 11.95–12.23) than cats without records of method of death at 10.36 years (95% CI 9.68–11.04) and cats having unassisted deaths at 9.81 years (95% CI 9.43–10.19).

Two covariates, neuter status and breed status, were included in the final multivariable model for early age mortality (death before 3 years of age) (Table 7). Entire cats had 4.29 times (95% CI 3.72–4.95) the odds of death before 3 years compared with neutered cats. Purebred cats had 1.83 times (95% CI 1.50–2.23) higher odds of dying before 3 years than crossbred cats.

Sex, neuter status, breed status and body weight deviance were significantly associated with the length of lifespan among cats that died after the age of 9 months (Table 8). After accounting for the effects of the other covariates, male cats lived 1.20 years (95% CI 0.91–1.49) less than female cats, and neutered cats lived 1.07 years

Table 1 Cohort life table of cats under primary veterinary care at practices participating in VetCompass in the UK in 2019

Age (years) (x, $x+1$)	Number of cats died in (x, $x+1$) (d_x)	Number of cats living at x (l_x)	Probability of cats dying in (x, $x+1$) ($\hat{q}_x$)	Mean fraction of last year of life lived by cats died in (x, $x+1$) ($\hat{a}_x$)	Number of cat-years lived in (x, $x+1$) (L_x)	Number of cat-years lived beyond year x (T_x)	Life expectancy (95% CI) at year x ($\hat{e}_x$)
0–1	309	7936	0.039	0.55	7797.72	93,171.81	11.74 (11.61–11.87)
1–2	359	7627	0.047	0.51	7450.89	85,374.09	11.19 (11.07–11.32)
2–3	300	7268	0.041	0.48	7111.91	77,923.20	10.72 (10.60–10.84)
3–4	220	6968	0.032	0.51	6861.28	70,811.29	10.16 (10.05–10.27)
4–5	242	6748	0.036	0.55	6639.07	63,950.01	9.48 (9.37–9.58)
5–6	256	6506	0.039	0.53	6385.53	57,310.95	8.81 (8.71–8.91)
6–7	245	6250	0.039	0.48	6123.26	50,925.42	8.15 (8.05–8.24)
7–8	248	6005	0.041	0.50	5881.23	44,802.15	7.46 (7.37–7.56)
8–9	283	5757	0.049	0.54	5625.60	38,920.92	6.76 (6.67–6.85)
9–10	349	5474	0.064	0.53	5311.24	33,295.32	6.08 (6.00–6.17)
10–11	355	5125	0.069	0.52	4953.31	27,984.08	5.46 (5.38–5.54)
11–12	417	4770	0.087	0.49	4559.24	23,030.77	4.83 (4.75–4.91)
12–13	475	4353	0.109	0.54	4136.86	18,471.54	4.24 (4.17–4.32)
13–14	508	3878	0.131	0.54	3642.43	14,334.68	3.70 (3.62–3.77)
14–15	573	3370	0.170	0.51	3090.44	10,692.25	3.17 (3.10–3.24)
15–16	593	2797	0.212	0.51	2505.83	7601.81	2.72 (2.65–2.79)
16–17	542	2204	0.246	0.52	1941.77	5095.98	2.31 (2.24–2.38)
17–18	567	1662	0.341	0.49	1373.49	3154.21	1.90 (1.83–1.97)
18–19	442	1095	0.404	0.48	866.54	1780.72	1.63 (1.54–1.71)
19–20	321	653	0.492	0.45	476.51	914.18	1.40 (1.30–1.51)
20+	174	332	0.524	0.45	235.91	437.67	1.32 (1.19–1.46)

CI = confidence interval

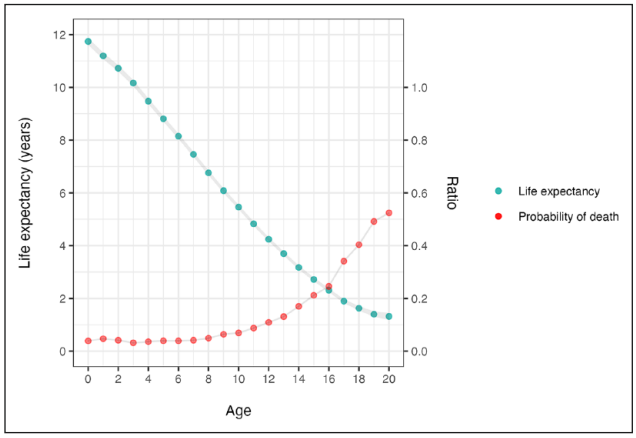

Figure 1 Life expectancy (years) and probability of death for cats under primary veterinary care at practices participating in VetCompass in the UK in 2019

(95% CI 0.72–1.42) longer than entire cats on average. Crossbred cats lived 1.27 years (95% CI 0.80–1.74) longer than purebred cats. Lifespan decreased by 0.02 years (95% CI 0.01–0.03) for each 100 g of increase or decrease in adult body weight from the median adult body weight within the breed and sex strata.

Discussion

This study generated the first cohort life tables for the UK companion cat population to provide information regarding annual life expectancy and the probability of death. We also identified some factors associated with early death and the length of lifespan in cats.

Compared with previously published life tables for cats in Japan and the USA, life expectancy at age 0 was highest in the UK at 11.74 years (95% CI 11.61–11.87), followed by the USA (11.18 years; 95% CI 11.16–11.20) and Japan (4.2 years).[1,21] In addition to the life table studies, one study using 1325 mortality cases from 233 primary care veterinary clinics and referral veterinary hospitals in Taiwan reported a mean lifespan of 8.4 years for the study population,[5] and another with 3108 necropsy cases from a single veterinary medical teaching hospital in the USA between 1989 and 2019 showed a median lifespan of 9.07 years (IQR 4.20–12.92).[6] In addition, using 4009 cats with confirmed deaths from 90 primary care veterinary clinics in the UK between 1 September 2009 and 20

Table 2 Cohort life table of female cats under primary veterinary care at practices participating in VetCompass in the UK in 2019

Age (years) $(x, x+1)$	Number of cats died in $(x, x+1)$ (d_x)	Number of cats living at x (l_x)	Probability of cats dying in $(x, x+1)$ $(\hat{q}_x)$	Mean fraction of last year of life lived by cats died in $(x, x+1)$ $(\hat{a}_x)$	Number of cat-years lived in $(x, x+1)$ (L_x)	Number of cat-years lived beyond year x (T_x)	Life expectancy (95% CI) at year x $(\hat{e}_x)$
0–1	137	3826	0.036	0.58	3768.56	47,846.92	12.51 (12.32–12.69)
1–2	150	3689	0.041	0.49	3613.12	44,078.35	11.95 (11.77–12.13)
2–3	131	3539	0.037	0.47	3469.82	40,465.23	11.43 (11.27–11.60)
3–4	83	3408	0.024	0.52	3367.78	36,995.41	10.86 (10.70–11.01)
4–5	96	3325	0.029	0.52	3279.08	33,627.63	10.11 (9.97–10.26)
5–6	95	3229	0.029	0.58	3188.84	30,348.55	9.40 (9.26–9.54)
6–7	102	3134	0.033	0.47	3079.59	27,159.72	8.67 (8.54–8.80)
7–8	96	3032	0.032	0.48	2981.65	24,080.13	7.94 (7.82–8.07)
8–9	122	2936	0.042	0.53	2878.20	21,098.48	7.19 (7.07–7.31)
9–10	133	2814	0.047	0.53	2751.47	18,220.28	6.47 (6.36–6.59)
10–11	156	2681	0.058	0.54	2609.90	15,468.81	5.77 (5.66–5.89)
11–12	197	2525	0.078	0.48	2422.61	12,858.91	5.09 (4.99–5.20)
12–13	209	2328	0.090	0.53	2229.16	10,436.30	4.48 (4.38–4.59)
13–14	238	2119	0.112	0.55	2012.75	8207.14	3.87 (3.78–3.97)
14–15	283	1881	0.150	0.52	1745.75	6194.39	3.29 (3.20–3.39)
15–16	335	1598	0.210	0.52	1437.73	4448.64	2.78 (2.69–2.88)
16–17	292	1263	0.231	0.51	1120.44	3010.91	2.38 (2.30–2.48)
17–18	320	971	0.330	0.49	808.13	1890.47	1.95 (1.85–2.05)
18–19	259	651	0.398	0.49	518.07	1082.34	1.66 (1.56–1.77)
19–20	184	392	0.469	0.48	296.68	564.27	1.44 (1.32–1.57)
20+	113	208	0.543	0.46	147.14	267.59	1.29 (1.13–1.46)

CI = confidence interval

Table 3 Cohort life table of male cats under primary veterinary care at practices participating in VetCompass in the UK in 2019

Age (years) $(x, x+1)$	Number of cats died in $(x, x+1)$ (d_x)	Number of cats living at x (l_x)	Probability of cats dying in $(x, x+1)$ $(\hat{q}_x)$	Mean fraction of last year of life lived by cats died in $(x, x+1)$ $(\hat{a}_x)$	Number of cat-years lived in $(x, x+1)$ (L_x)	Number of cat-years lived beyond year x (T_x)	Life expectancy (95% CI) at year x $(\hat{e}_x)$
0–1	135	4000	0.034	0.55	3938.91	44,720.45	11.18 (11.01–11.36)
1–2	195	3865	0.050	0.52	3772.01	40,781.54	10.55 (10.38–10.72)
2–3	164	3670	0.045	0.48	3585.24	37,009.53	10.08 (9.92–10.25)
3–4	135	3506	0.039	0.51	3440.45	33,424.29	9.53 (9.38–9.69)
4–5	132	3371	0.039	0.57	3313.78	29,983.84	8.89 (8.75–9.04)
5–6	160	3239	0.049	0.50	3159.68	26,670.06	8.23 (8.09–8.38)
6–7	138	3079	0.045	0.50	3009.45	23,510.38	7.64 (7.50–7.77)
7–8	151	2941	0.051	0.52	2868.47	20,500.93	6.97 (6.84–7.10)
8–9	159	2790	0.057	0.54	2717.29	17,632.45	6.32 (6.20–6.45)
9–10	215	2631	0.082	0.54	2531.23	14,915.16	5.67 (5.55–5.79)
10–11	195	2416	0.081	0.49	2317.30	12,383.93	5.13 (5.01–5.24)
11–12	218	2221	0.098	0.51	2113.30	10,066.63	4.53 (4.42–4.65)
12–13	261	2003	0.130	0.56	1887.59	7953.33	3.97 (3.86–4.08)
13–14	267	1742	0.153	0.52	1613.95	6065.73	3.48 (3.38–3.59)
14–15	288	1475	0.195	0.50	1332.06	4451.79	3.02 (2.91–3.13)
15–16	256	1187	0.216	0.49	1056.57	3119.73	2.63 (2.52–2.74)
16–17	248	931	0.266	0.52	812.57	2063.16	2.22 (2.11–2.32)
17–18	242	683	0.354	0.49	559.21	1250.58	1.83 (1.72–1.94)
18–19	182	441	0.413	0.48	345.95	691.37	1.57 (1.44–1.70)
19–20	136	259	0.525	0.41	178.76	345.43	1.33 (1.17–1.50)
20+	61	123	0.496	0.42	87.77	166.66	1.35 (1.14–1.59)

CI = confidence interval

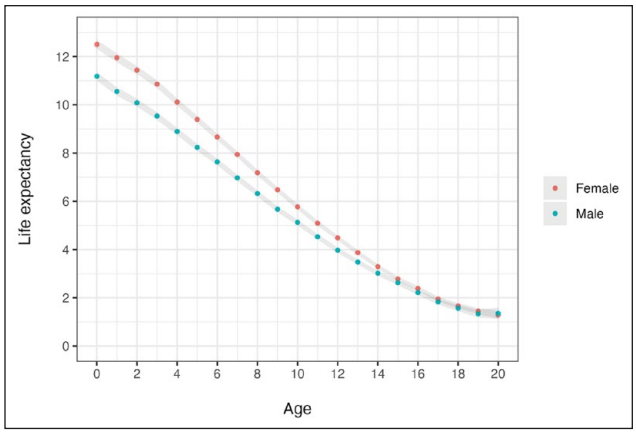

Figure 2 Life expectancy (dot) and the 95% confidence interval (grey area) for female and male cats at different ages (years) under primary veterinary care at practices participating in VetCompass in the UK in 2019

December 2012, O'Neill et al[2] reported a median lifespan of 14.0 years (IQR 9.0–17.0; range 0.0–26.7). This value is substantially higher than the average lifespan in other studies, which might partly be attributed to selection bias (most of the 90 clinics were from one veterinary group).

These differences might have resulted from a combination of various factors. First, among the present and the other aforementioned studies, only Montoya et al[1] estimated life expectancy using population in different calendar years rather than a hypothetical cohorts. The use of a hypothetical (ie, not predetermined) cohort in the estimation of life expectancy requires an assumption of a stable population input and output,[9] which might be the case for the companion cat population in the UK.[22] Second, the year of data collection and study population varied widely between each of the studies. With advances in care for companion animals, including veterinary care, longer life expectancy can be expected with more recent studies.[1,21] Data from primary care veterinary clinics are expected to be more representative of the life expectancy of the companion cat population in a geographical region than information from referral hospitals and universities.[23] The Japanese life table was constructed using cats that died in 1981 and 1982 and had the shortest life expectancy at age 0 among the aforementioned studies; however, even that might still be an overestimation of the life expectancy of cats in that period because cats that were buried in the cemetery in the early 1980s in Japan were likely to represent a subpopulation that received better

Table 4 Cohort life table of crossbred cats under primary veterinary care at practices participating in VetCompass in the UK in 2019

Age (years) (x, $x+1$)	Number of cats died in (x, $x+1$) (d_x)	Number of cats living at x (l_x)	Probability of cats dying in (x, $x+1$) ($\hat{q}_x$)	Mean fraction of last year of life lived by cats died in (x, $x+1$) ($\hat{a}_x$)	Number of cat-years lived in (x, $x+1$) (L_x)	Number of cat-years lived beyond year x (T_x)	Life expectancy (95% CI) at year x ($\hat{e}_x$)
0–1	238	6998	0.034	0.55	6890.31	83,231.21	11.89 (11.76–12.03)
1–2	302	6760	0.045	0.52	6614.52	76,340.91	11.29 (11.16–11.42)
2–3	248	6458	0.038	0.48	6329.12	69,726.39	10.80 (10.67–10.92)
3–4	195	6210	0.031	0.52	6115.81	63,397.27	10.21 (10.09–10.33)
4–5	213	6015	0.035	0.55	5919.40	57,281.46	9.52 (9.41–9.64)
5–6	232	5802	0.040	0.53	5692.73	51,362.06	8.85 (8.74–8.96)
6–7	215	5570	0.039	0.48	5459.12	45,669.32	8.20 (8.10–8.30)
7–8	216	5355	0.040	0.51	5248.09	40,210.21	7.51 (7.41–7.61)
8–9	253	5139	0.049	0.53	5020.45	34,962.12	6.80 (6.71–6.90)
9–10	308	4886	0.063	0.52	4739.02	29,941.66	6.13 (6.04–6.22)
10–11	313	4578	0.068	0.52	4427.10	25,202.64	5.51 (5.42–5.59)
11–12	371	4265	0.087	0.49	4074.47	20,775.54	4.87 (4.79–4.95)
12–13	416	3894	0.107	0.55	3706.76	16,701.07	4.29 (4.21–4.37)
13–14	443	3478	0.127	0.54	3273.64	12,994.31	3.74 (3.66–3.81)
14–15	497	3035	0.164	0.50	2788.92	9720.67	3.20 (3.13–3.28)
15–16	532	2538	0.210	0.51	2276.75	6931.75	2.73 (2.66–2.80)
16–17	498	2006	0.248	0.52	1766.80	4655.00	2.32 (2.25–2.39)
17–18	506	1508	0.336	0.50	1253.24	2888.20	1.92 (1.84–1.99)
18–19	403	1002	0.402	0.48	792.81	1634.95	1.63 (1.55–1.72)
19–20	292	599	0.487	0.45	437.12	842.15	1.41 (1.30–1.51)
20+	163	307	0.531	0.45	216.80	405.02	1.32 (1.18–1.47)

CI = confidence interval

Table 5 Cohort life table of purebred cats under primary veterinary care at practices participating in VetCompass in the UK in 2019

Age (years) (x, $x+1$)	Number of cats died in (x, $x+1$) (d_x)	Number of cats living at x (l_x)	Probability of cats dying in (x, $x+1$) ($\hat{q}_x$)	Mean fraction of last year of life lived by cats died in (x, $x+1$) ($\hat{a}_x$)	Number of cat-years lived in (x, $x+1$) (L_x)	Number of cat-years lived beyond year x (T_x)	Life expectancy (95% CI) at year x ($\hat{e}_x$)
0–1	58	819	0.071	0.54	792.35	8527.93	10.41 (9.99–10.83)
1–2	54	761	0.071	0.46	731.68	7735.58	10.17 (9.77–10.56)
2–3	46	707	0.065	0.47	682.41	7003.90	9.91 (9.53–10.28)
3–4	24	661	0.036	0.49	648.67	6321.49	9.56 (9.21–9.90)
4–5	26	637	0.041	0.54	625.13	5672.82	8.91 (8.57–9.23)
5–6	24	611	0.039	0.53	599.80	5047.69	8.26 (7.94–8.57)
6–7	30	587	0.051	0.47	571.15	4447.89	7.58 (7.28–7.88)
7–8	25	557	0.045	0.47	543.77	3876.75	6.96 (6.68–7.24)
8–9	28	532	0.053	0.56	519.78	3332.97	6.26 (5.99–6.54)
9–10	36	504	0.071	0.58	488.94	2813.19	5.58 (5.32–5.84)
10–11	36	468	0.077	0.47	448.95	2324.25	4.97 (4.72–5.22)
11–12	39	432	0.090	0.55	414.55	1875.30	4.34 (4.11–4.58)
12–13	51	393	0.130	0.52	368.59	1460.76	3.72 (3.48–3.96)
13–14	60	342	0.175	0.53	313.50	1092.16	3.19 (2.97–3.43)
14–15	67	282	0.238	0.57	252.94	778.66	2.76 (2.53-3.00)
15–16	55	215	0.256	0.49	187.10	525.72	2.45 (2.21–2.68)
16–17	37	160	0.231	0.43	138.80	338.62	2.12 (1.88–2.36)
17–18	53	123	0.431	0.44	93.48	199.83	1.62 (1.38–1.88)
18–19	31	70	0.443	0.48	53.87	106.34	1.52 (1.23–1.83)
19–20	20	39	0.513	0.52	29.37	52.48	1.35 (1.01–1.73)
20+	19	19	1	1.22	23.10	23.10	1.22 (0.77–1.77)

CI = confidence interval

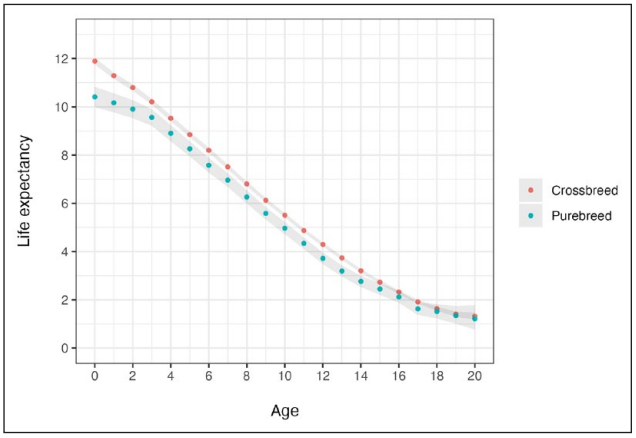

Figure 3 Life expectancy (dot) and the 95% confidence interval (grey area) for crossbred and purebred cats at different ages (years) under primary veterinary care at practices participating in VetCompass in the UK in 2019

care from their owners while alive.[21] Third, the composition of popular cat breeds likely varies between different countries. Although the phenomenon of international variation in breed structure is well known in the dog population,[9] information on cats is currently scarce.[2,4] In the present study, only 819 (10.3%) cats were purebred compared with higher percentages of 15.8% and 17.3% for the two studies from the USA.[1,6] It is likely that the composition differs even more between Western and Asian countries.[24,25] Lastly, factors such as the frequency of cats going outdoors and the culture of decision-making for euthanasia, especially for non-life-threatening reasons, affect the lifespan of the cat population but can differ widely geographically.

In line with previous results showing a longer lifespan in female cats than male, the current study identified that female cats lived 1.33 years longer than male cats.[1,2,4,5] Sex-related differences in life expectancy in mammals have been documented extensively.[26,27] Lemaître et al[27] examined 101 wild mammal species and found that the female median lifespan is 18.6% longer than that of conspecific males on average, and it was 10.6% and 8.2% for the cats in the present study and in the study by Montoya et al,[1] respectively. However, the mechanisms and molecular drivers for sex differences in ageing are currently unclear.[26] In cats, several health conditions predisposed in male cats could lead to their earlier death, such as urinary tract obstruction,[28] conditions related to fights or traffic accidents[25] and more infections with feline leukaemia virus and feline immunodeficiency virus.[29]

Table 6 Lifespan statistics for purebreed and crossbred cats (including cats without breed information) under primary veterinary care at practices participating in VetCompass in the UK in 2019

Breed	Life expectancy (95% CI) at age 0	Lifespan (years)	Number of deaths
Burmese	14.42 (12.91–15.93)	0.74–21.29	45
Birman	14.39 (12.87–15.91)	0.94–22.25	38
Crossbred	11.89 (11.75–12.03)	0.00–26.69	7117
Siamese	11.69 (10.56–12.82)	0.66–21.48	88
Persian	10.93 (9.63–12.23)	0.01–21.68	80
Ragdoll	10.31 (8.86–11.76)	0.36–21.34	69
Norwegian Forest Cat	9.95 (7.55–12.35)	1.71–19.05	15
Maine Coon	9.71 (8.42–11.00)	0.03–21.61	69
Russian cats*	9.65 (7.20–12.10)	0.32–19.39	19
British cats†	9.58 (8.73–10.43)	0.01–22.32	194
Bengal	8.51 (7.12–9.90)	0.14–21.22	73
Sphynx	6.68 (4.53–8.83)	0.13–14.67	18

*Russian Blue and Russian (unspecified)
†British Blue, British Longhair
CI = confidence interval

Table 7 Multivariable early-life mortality logistic regression model for factors associated with early death in cats (died before 3 years of age) under primary veterinary care at practices participating in VetCompass in the UK in 2019

Covariate	Category	Odds ratio (95% CI)	Category *P* value	*P* value for the covariate
Neuter status	Neutered	1	–	<0.001
	Entire	4.29 (3.72–4.95)	<0.001	
	Unknown	14.05 (9.52–20.75)	<0.001	
Breed status	Crossbred	1	–	<0.001
	Purebred	1.83 (1.50–2.23)	<0.001	

CI = confidence interval

Table 8 Results of the final multivariable later life mortality linear regression model for factors associated with a longer lifespan for cats that died after 9 months of age under primary veterinary care at practices participating in VetCompass in the UK in 2019

Covariate	Category	Estimate (95% CI)	*P* value	*P* value for the covariate
Intercept		12.68 (12.30–13.06)	–	<0.001
Sex	Female	0	–	<0.001
	Male	−1.20 (−1.49–−0.91)	<0.001	–
	Unknown	−3.53 (−5.58–−1.48)	0.001	–
Neuter status	Entire	0	–	<0.001
	Neutered	1.07 (0.72–1.42)	–	–
Breed status	Crossbred	0	–	<0.001
	Purebred	−1.27 (−1.74–−0.80)	–	–
Body weight deviance* (per 100 g)		−0.02 (−0.03–−0.01)	–	<0.001

*Body weight deviance: the absolute value of the difference between the adult body weight of each cat and the median adult body weight within the breed and sex strata
CI = confidence interval

Similar to O'Neill et al,[2] crossbred cats had a longer life expectancy than purebred cats in the present study, and the odds for purebred cats dying before 3 years of age were 1.83 times higher than crossbred cats. Interestingly, the life tables built using the clinical records from Banfield Pet Hospitals in the USA showed the opposite effect, with consistently longer life expectancies in purebred cats than crossbred cats.[1] Close inspection of the results from both studies shows that the life expectancy at age 0 of crossbred cats in 2019 is not appreciably different between

these two countries (UK 11.89 years, 95% CI 11.76–12.03 vs USA 11.69 years, 95% CI 11.63–11.76). However, the life expectancy at age 0 for purebred cats seemed to differ substantially (UK 10.41 years, 95% CI 9.99–10.83 vs USA 11.85 years, 95% CI 11.7–12). This difference might result from a combination of factors, such as study design and study population, the composition of popular cat breeds in the countries, general health for the same breed in the countries, veterinary care and euthanasia decision-making. In addition, purebred cats in the USA were mainly kept indoors,[1] which could reduce the mortality caused by accidents, fights, and infection.

In a previous VetCompass study using clinical data from 1 September 2009 to 20 December 2012,[2] the median lifespan among cat breeds was longest for Birman at 16.1 years, followed by Burmese, Siamese, Persian and crossbred, whose median lifespans were in the range of 14.0–14.3 years. Although the median lifespan of most cat breeds reported in the present study was lower than that in the study of 2009–2012 (range of difference 0.68–1.24 years),[2] the values for Ragdoll (12.22 years in the present study and 10.1 years in O'Neill et al)[2] and Bengal (8.40 years in the present study and 7.3 years in O'Neill et al)[2] were higher in the present study. Sphynx cats had a particularly short life expectancy at age 0 at 6.68 years (95% CI 4.53–8.83) among the reported breeds in the present study. Currently, there is scarce peer-reviewed information about the mortality of Sphynx cats. UK pet insurance provider PetPlan states on its website that 'The Sphynx has a life expectancy of around 15 years',[30] more than twice the life expectancy at age 0 reported by the present study. The Sphynx has been reported with several breed-predisposed diseases. One prospective study from France that screened for heart conditions in Sphynx cats without a previous record of heart disease reported that 16/114 (14.0%) and 23/114 (20.2%) cats had congenital heart diseases and hypertrophic cardiomyopathy, respectively.[31] In the same paper, approximately 65% of Sphynx cats aged over 4 years were diagnosed with at least one heart condition.[31] Besides cardiomyopathy, the Sphynx is also predisposed to variably progressive hereditary myopathy (ie, skeletal myopathy),[32,33] corneal sequestrum and entropion.[34] With Sphynx cats becoming one of the top 10 most popular cat breeds globally,[35] the current lifespan results suggest that more research on the mortality, health and welfare of Sphynx cats is needed.

In our study, increasing body weight deviance from the median adult body weight within breed and sex strata was negatively associated with lifespan. While the World Health Organization defines overweight and obesity as 'abnormal or excessive fat accumulation that may impair health',[36] contemporary epidemiological studies examining the link between feline overweight conditions and lifespan do not consistently align with this definition.[1,3] In a study using EPRs from a cat clinic in Sydney, Australia, cats with a maximum body condition score (BCS) recorded for individuals over time of 6–8 on a 9-point scale had the longest lifespan.[3] The Australian result was supported by the study using EPRs from Banfield Pet Hospitals in the USA, reporting that cats with a median BCS recorded for individuals of 4/5, which is generally considered 'overweight', had the longest life expectancy at age 0.[1] Our study further challenges the current definition of a healthy weight for cats. In our investigation, the median adult body weight for all cats was 5.5 kg, falling outside the 'cat healthy weight range of domestic cats: 3.6–4.5 kg' recommended by the Association for Pet Obesity Prevention.[37] With the results from the Australian, American and our UK studies indicating a protective effect of mild overweight conditions on feline longevity, we strongly recommend a reassessment of the current validity of BCS systems and healthy weight ranges for cats, which should be grounded in empirical evidence. It is crucial to note that relationships between longevity and BCS or weight should not discount the evidence for the adverse impact of being overweight on the health of cats.[38,39] The negative impact of excessive fats on cats' health and longevity should be integral to the development of BCS systems and healthy weight ranges for cats, ensuring a comprehensive approach to feline wellbeing.

Cat life tables enable an improved understanding of cat mortality and life expectancy across the full spectrum of cat ages. Access to reliable data on the expected remaining lifespan of cats at different ages provides important information for decision-making related to cat ownership, such as adoption and timing of euthanasia. Thus, we encourage veterinary professionals and cat owners to develop life table literacy so that more realistic predictions of cats' lifespans can be made and shared to support evidence-based decision-making for current and prospective owners. The trends in life expectancy at different ages for a specific population across time could also be used to indicate and interpret the general health and welfare of the population. If life expectancy increases with time, a healthier population or a population receiving better healthcare would be suggested, and vice versa.

There are some limitations that we would like to acknowledge. First, there was likely an underestimation of the probability of death of cats at age 0–1. As cats are generally considered fully immunocompetent over 12 months of age,[40] the probability of death should be expected to be higher for cats at age 0–1 than at age 1–2 rather than the opposite, as shown in our results. This outcome could be attributed to the absence of information in the current clinical data set on deaths before any visit to a primary care veterinary clinic, such as death on the street, in the shelter, or during or after a home birth. Second, more than 83.7% of the deaths were due to euthanasia, resulting in an underestimation of life expectancy compared to the life expectancy if those cats had an unassisted death.[41] Distinctly differing cultures on euthanasia for companion animals between countries and regions

could heavily influence national life tables in addition to effects from the differing composition of cat breeds and the differing general health of the population.[42,43] However, as almost all aspects of companion cats' lives were managed by their owners, including receiving veterinary care and euthanasia, reporting how long the cats actually live rather than how long they might live without human intervention has more real-world significance. In addition, as VetCompass data only include cats attending primary care veterinary practices, the life tables might be less representative of unowned cats or cats not attending veterinary clinics. Although death at home or in emergency out-of-hours clinics may be reported by the owners to the primary care clinics, it is still possible that some of those cats were missing from the current data. Last, the adult body weight used in our modelling is a relatively rough representation of the body weight of a cat. It did not take into account the age information when the weight was recorded nor the effects of changes in body weight over time. How representative the value also depended on how many visits a cat made to the primary care clinic.

Conclusions

To the best of our knowledge, the present study has produced the first life tables for companion cats overall, as well as by sex and crossbred/purebred status in cats in the UK. These life tables can promote a better understanding of the typical life trajectory of cats and have practical applications for the veterinary profession to inform better on life expectancy to cat owners. The study shows evidence of an association between both increases and decreases in adult body weight from the median and a decreased lifespan. Unlike the abundance of evidence on relationships between certain breeds and impaired longevity and welfare in dogs, equivalent information for cat breeds is relatively sparse. However, the present study shows that purebred cats lived over 1.5 years less than crossbred cats and suggests that some breeds, such as Sphynx and Bengal, had a particularly short life expectancy. Further epidemiological studies on the mortality and morbidity of various cat breeds are warranted. The results of the current research can be used to promote the health and welfare of cats and invite future research on the topics.

Acknowledgements Thanks to Noel Kennedy (RVC) for VetCompass software and programming development. We are grateful to the following researchers who assisted with data collection during this project: Charlotte Keddy, Jessica Moffat and Natasha McGuire. We acknowledge the Medivet Veterinary Partnership, Vets4Pets/Companion Care, Goddard Veterinary Group, CVS Group, IVC Evidensia, Linnaeus Group, Beaumont Sainsbury Animal Hospital, Blue Cross, PDSA, Dogs Trust, Vets Now and the other UK practices that collaborate in VetCompass. We are grateful to The Kennel Club Charitable Trust, Agria Pet Insurance and The Kennel Club for supporting VetCompass.

Author note The data set supporting the conclusions of this article is available open access on Figshare at 10.6084/m9.figshare.25006802.

Conflict of interest The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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.

Ethical approval The work described in this manuscript involved the use of non-experimental (owned or unowned) animals. Established internationally recognised high standards ('best practice') of veterinary clinical care for the individual patient were always followed and/or this work involved the use of cadavers. Ethical approval from a committee was therefore not specifically required for publication in *JFMS*. Although not required, where ethical approval was still obtained, it is stated in the manuscript.

Informed consent Informed consent (verbal or written) was obtained from the owner or legal custodian of all animal(s) described in this work (experimental or non-experimental animals, including cadavers) for all procedure(s) undertaken (prospective or retrospective studies). No animals or people are identifiable within this publication, and therefore additional informed consent for publication was not required.

ORCID iD Kendy Tzu-yun Teng https://orcid.org/0000-0003-3200-1545
Dan G O'Neill https://orcid.org/0000-0003-1115-2723

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