



Roberts, C., Gruffydd-Jones, T. J., Williams, J., & Murray, J. K. (2020). Influence of living in a multicat household on health and behaviour in a cohort of cats from the United Kingdom. *Veterinary Record*. Advance online publication. <https://doi.org/10.1136/vr.104801>

Peer reviewed version

Link to published version (if available):
[10.1136/vr.104801](https://doi.org/10.1136/vr.104801)

[Link to publication record in Explore Bristol Research](#)
PDF-document

This is the author accepted manuscript (AAM). The final published version (version of record) is available online via BMJ at <https://veterinaryrecord.bmj.com/content/early/2020/01/02/vr.104801>. Please refer to any applicable terms of use of the publisher.

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1 Influence of living in a multi-cat household on health and behaviour in a cohort of cats from
2 the United Kingdom

3

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13

14 Keywords: Cats, aggression, behaviour, epidemiology, human-animal interactions, welfare

15 Word count: 3171

16 **Abstract**

17 Background

18 Living in a multi-cat household has been implicated as a risk factor for various feline issues,
19 but evidence is often anecdotal or based on retrospective studies.

20

21 Methods

22 Data from the Bristol Cats Study, a UK longitudinal study of pet cats, were used. Cats were
23 included if they had remained in either a single or multi-cat household between
24 questionnaires one (two to four-month-old) and five (two-and-a-half-year-old). Univariable
25 and multivariable logistic regression models were used to analyse associations between
26 single/multi-cat households and measures of health and behaviour (overweight/obesity,
27 abscesses/cat bites, negative interactions with owner, periuria). Multi-cat households were
28 also subcategorised according to whether owners had reported agonistic behaviour between
29 household cats.

30

31 Results

32 There was no evidence of association between household type and the likelihood of obesity,
33 abscesses or periuria. The likelihood of negative interactions with the owner (for example
34 growling or hissing) was influenced by the cats' relationships; cats in non-agonistic multi-cat
35 households had decreased odds of negative interactions with the owner, compared to single
36 and agonistic multi-cat households ($P < 0.001$).

37

38 Conclusion

39 Living in a multi-cat households *per se* was not a risk factor for the health and behaviour
40 issues investigated, but the inter-cat relationship is important.

41 **Introduction**

42 The problems and benefits afforded by multi-cat households can be a contentious issue, with
43 strong views expressed regarding the welfare of cats housed with other cats. Although multi-
44 cat households can be an enforced abnormal social structure, the influence of domestication
45 and the ability of cats to adapt should be considered, and information based on evidence
46 rather than anecdotes and preconceptions. Although traditionally regarded as an asocial
47 species¹, cats are able to form stable colonies around resources, as seen in populations of feral
48 and farm cats^{2,3}. Nearly half of pet cats in the UK live with other cats; estimates of the
49 proportion of pet cats residing in a multi-cat household in the UK are around 42 to 43 per
50 cent^{4,5} of an estimated population of between 9 and 11 million^{5,6}. If living in a multi-cat
51 household is a risk factor for stress, disease and/or behavioural problems, this would apply to
52 around four million cats in the UK.

53

54 Various health issues have been scientifically and anecdotally associated with living in a
55 multi-cat household. For example, obesity is one of the most frequent health issues in cats⁷.
56 This could be associated with multi-cat households where it is more difficult to control food
57 intake, although results from a cross-sectional study found no evidence that this was the
58 case⁸. Cat bite injuries and resulting abscesses are another frequent health issue⁷, and fighting
59 can lead to the transmission of some infectious diseases. To our knowledge no studies have
60 investigated association between abscesses/cat bites and multi-cat households, although bite
61 wounds from inter-cat fighting were proposed as a reason for an association between multi-
62 cat households and pyothorax⁹.

63

64 Multi-cat households could also be associated with unwanted behaviours. A reported 38% of
65 returns and 7% of relinquishments of cats to rehoming shelters within a UK sample were as a

66 result of unwanted behaviours, with house-soiling and aggression towards people two of the
67 main issues¹⁰. These are also both common reasons for behavioural referral in the UK¹¹.
68 House-soiling includes periuria; although this can be an indicator of feline lower urinary tract
69 disease¹², there is evidence that stressful events can lead to an increase in this behaviour¹³ and
70 it has been reported to occur more commonly in multi-cat households¹⁴. There also appears to
71 be an increased risk of lower urinary tract signs where there is conflict between the cats¹⁵ and
72 relationships between cats in the household should therefore be considered. Conversely, the
73 other behavioural issue, aggression towards people, has been linked with living in a single cat
74 household, where it was most commonly directed towards the owner¹⁶.

75

76 Many of these studies on associations between health/behaviour and multi-cat households,
77 have been retrospective^{14,15,17} and/or cross-sectional^{8,18}. Longitudinal studies have some
78 distinct advantages, including the use of prospective data which are less susceptible to recall
79 bias than retrospectively collected data¹⁹. Using owner-reported rather than veterinary-
80 reported data allows the inclusion of cats who may have had, for example, an abscess, but did
81 not visit a veterinary practice. Additionally, many studies on behaviour use a cohort of cats
82 selected from a behaviour referral centre^{14,15,17}. Inclusion of cats who have not visited a
83 veterinary surgery or been referred is likely to be more representative of the whole UK pet cat
84 population.

85

86 The objective of this study was to use prospectively-collected data from a longitudinal study
87 to identify evidence of associations between multi-cat households and potentially associated
88 health and behaviour issues (overweight/obesity, abscesses/cat bites, negative interactions
89 with owner, periuria). A distinction between multi-cat households where cats had reported
90 conflict and no reported conflict was also made.

91

92 **Materials and methods**

93 *Data collection*

94 The Bristol Cats Study (BCS) is an ongoing longitudinal study of health, behaviour and
95 environment of pet cats in the UK. Owners of pet kittens between two and four months of age
96 were recruited between May 2010 and December 2013. Recruitment was initially restricted to
97 the Bristol area and expanded nationwide in 2011. Recruits were self-selected through
98 advertisements placed in locations including veterinary practices, rehoming centres and cat
99 interest websites. Owners could register multiple cats from the same household. The BCS has
100 been described in more detail elsewhere²⁰.

101

102 The BCS is primarily based on owner-completed questionnaires at specific ages of the
103 registered cat(s). For this study, questionnaire one (Q1: age two to four months), two (Q2:
104 age six months), three (Q3: age 12 months), four (Q4: age 18 months) and five (Q5: age two-
105 and-a-half years) were used. These can be accessed at:

106 <https://smvsfa.onlinesurveys.ac.uk/bristol-cats-study-questionnaire-1-kitten-aged-8-16-wks-2>
107 (Q1), [https://smvsfa.onlinesurveys.ac.uk/bristol-cats-study-questionnaire-2-6-month-old-](https://smvsfa.onlinesurveys.ac.uk/bristol-cats-study-questionnaire-2-6-month-old-cats-c)
108 [cats-c](https://smvsfa.onlinesurveys.ac.uk/bristol-cats-study-questionnaire-2-6-month-old-cats-c) (Q2), [https://smvsfa.onlinesurveys.ac.uk/bristol-cats-](https://smvsfa.onlinesurveys.ac.uk/bristol-cats-study-questionnaire-3-12-month-old-cats-c)
109 [study-questionnaire-3-12-month-](https://smvsfa.onlinesurveys.ac.uk/bristol-cats-study-questionnaire-3-12-month-old-cats-c)
110 [old-cats-c](https://smvsfa.onlinesurveys.ac.uk/bristol-cats-study-questionnaire-3-12-month-old-cats-c) (Q3), <https://smvsfa.onlinesurveys.ac.uk/q4bc> (Q4) and
111 <https://smvsfa.onlinesurveys.ac.uk/bristol-cats-study-questionnaire-5-25-years-old-cats-2>
112 (Q5).

112

113 *Participants*

114 Cats from the BCS were included in this study if their owners had completed Q1 through Q5
115 inclusive. Only cats who had remained either in a multi-cat (defined as two or more cats) or

116 a single cat household throughout the selected time period were included. Cats with
117 incongruent data, that is where the owner reported interactions between household cats, but
118 the household was classified as single cat household, or where the owner reported no cat-cat
119 interactions within a multi-cat household, were excluded. Where more than one cat from the
120 same household was eligible for the study, one was chosen at random for inclusion. Figure 1
121 describes how the study sample was reached after removal of ineligible cats.

122

123 ***Household***

124 Cats reported to have lived with no other cats in Q1 to Q5 inclusive were classed as living in
125 single cat households. Cats reported to have lived with one or more other cats in Q1 to Q5
126 were classified as living in multi-cat households. Owners were asked “which of these
127 statements best describes how your Bristol Study cat interacts with other cats in the
128 household”. Within multi-cat households, cats for whom the owner answered ‘yes’ to this
129 question for one of the following behaviours: ‘hisses or spits at another cat’, ‘is hissed or spat
130 at by another cat’, ‘is reluctant to pass another cat in a narrow space’ and/or ‘blocks or
131 inhibits the movement of another cat’ were classed as agonistic multi-cat households. Multi-
132 cat households where none of these behaviours were selected were classed as non-agonistic
133 multi-cat households.

134

135 ***Health and behaviour outcomes***

136 The outcomes were chosen to reflect common health and behaviour issues in pet cats
137 anecdotally or scientifically associated with single or multi-cat households. They were also
138 based on the data available for the Bristol Cats Study, having sufficient frequency within the
139 population to allow statistical power.

140

141 *Overweight/obesity*

142 Cases were cats who were reported by their owner at Q5 to have been at body condition score
143 four (overweight) or five (obese) within the past year, based on a five point scoring system²¹.

144 Controls were cats who were reported by their owners to have not been at body condition
145 score four or five within the past year.

146

147 *Abscess/cat bite*

148 Cases were obtained from two questions in Q5; cats whose owner reported them to have
149 visited a veterinary surgeon for an abscess or cat bite wound within the past 12 months, and
150 those whose owners had reported that their cat had had an abscess or bite wound within the
151 past 12 months but had not been presented to a veterinary surgeon. Control cats were those
152 who were reported by their owner to have not had an abscess or bite wound within the past 12
153 months.

154

155 *Periuria*

156 The frequency with which the owner reported that the cat urinated in the house but not in the
157 litter tray was recorded in Q5 as 'always', 'usually', 'occasionally' and 'never'. Cats who
158 'never' urinated in the house (excluding the litter tray) were classed as controls and cats
159 whose owners had selected 'always', 'usually' or 'occasionally' were cases.

160

161 *Negative interactions with owners*

162 Owners were asked in Q5 how the cat responded (sometimes or always) when approached or
163 handled 'nowadays', with a selection of answers. Those who had chosen one or more of the
164 following statements were defined as cases: 'runs away', 'growls, hisses or spits', 'swipes at
165 me'. Cats who had not shown any of these behaviours, but where the owner had selected one

166 or more of the other options were classified as controls.

167

168 Calculations indicated that based on the sample size for the four outcomes (at least 63 cases
169 and 315 controls), at a significance level of 0.05 there was 80% power to detect an odds ratio
170 of at least 2.5. Hence this study had the power to detect fairly large effect sizes only. (Epi
171 Info 2000).

172

173 *Explanatory variables*

174 Potential explanatory variables for the four outcomes of interest were extracted from Q1 and
175 Q5 (supplementary table 1). These were mostly variables that could be reasonably expected
176 to cause stress (for example presence of children, neighbourhood cat density), along with
177 demographics of the owners. Whether or not the cat was from the initial cohort (limited to
178 the Bristol 'BS postcode' area) was included to address potential bias from this sampling
179 method. Six factors had categories that were combined for analysis, based on the results of
180 initial univariable analyses: income, education, playing time, time spent outdoors and cat
181 density.

182

183 *Risk factor analysis*

184 Univariable logistic regression models were used to analyse associations between the four
185 outcomes and single/multi-cat household status. Univariable analyses were then repeated
186 with agonistic and non-agonistic multi-cat households as separate categories. The outcomes
187 that showed an association with household status of $P < 0.2$ were taken to further analysis.
188 Outcomes with an association of $P > 0.2$ with household were not analysed further, since
189 household was the focus of interest.

190

191 Subsequent univariable analyses were run to identify other explanatory factors which were
192 associated at $P < 0.2$ for each outcome. These were then entered into the modelling process for
193 multivariable analysis. For two variables (abscesses/cat bites and negative interactions with
194 the owner) no unneutered cats were cases. One control cat for each of these variables was
195 selected at random to become a case for these two univariable analyses to be conducted, then
196 returned to controls for the other analyses. For each outcome, cats with missing data for any
197 of the explanatory factors with $P < 0.2$ were removed in order to have a complete dataset for
198 each multivariable analysis.

199

200 For the multivariable analyses, the distinction between agonistic and non-agonistic multi-cat
201 households was retained. Backward elimination was used in the multivariable model building
202 process for each outcome; the explanatory factor with the highest P value greater than 0.05
203 was removed at each stage until all remaining variables had P values less than 0.05.
204 Interactions considered biologically plausible were tested for within each final multivariable
205 model.

206

207 IBM SPSS Statistics version 23 was used for all data analyses. The Bristol Cats Study has
208 ethical approval from the University of Bristol ethical committee (reference UIN/13/026).

209

210 **Results**

211 *Descriptive data*

212 The number of cats eligible for, and included in the study, is summarised in Figure 1. Of the
213 cats included in the study, 21.3% were in single cat households and 78.7% in multi-cat
214 households. Of the multi-cat households, the majority (62.2%) were in agonistic households,
215 with 37.8% in non-agonistic households. The minimum number of cats in a multi-cat

216 household was two, with a maximum number of 30 (supplementary table 2). The median of
217 cats in a multi-cat household was three cats and the interquartile range was two-five cats.
218 About half (410/780: 52.4%) of the total number of cats were male and 182/776 (23.5%)
219 were purebred cats. There were 22/783 (2.8%) cats (three male and 19 female) who were not
220 neutered by age two-and-a-half years.

221

222 For overweight/obesity, 150/755 (19.9%) cats were reported by their owners at Q5 to be at
223 body condition score four or five (on a 5-point scoring system) within the past 12 months.
224 Sixty-eight of 783 (8.7%) cats had been reported by the owner to have had an abscess or cat
225 bite within the past 12 months, whether or not they had been to a veterinary surgeon, and
226 83/783 (10.6%) cats were reported to have urinated outside of the litter tray (with no
227 specified timescale). Cats who were reported to have negative interactions with their owner
228 numbered 132/782 (16.9%).

229

230 *Univariable analysis*

231 The results of the univariable analyses for association of the four outcomes with living in a
232 single/multi-cat household are shown in table 1. No evidence of a significant association
233 ($P > 0.2$) was found between living in a single vs multi-cat household and the odds of owner-
234 reported overweight/obesity or periuria. Subsequently, no association was found when multi-
235 cat households were split into agonistic or non-agonistic multi-cat households (supplementary
236 table 3,4) These outcomes were therefore not assessed further.

237

238 Abscesses/cat bites and negative interactions with owner had P values less than 0.2 associated
239 with single/multi-cat household (table 1). For both outcomes, a distinction was then made
240 between agonistic and non-agonistic multi-cat households. The univariable analyses with

241 potential explanatory factors can be found in the supplementary material (supplement 5,6)
242 These factors were taken forward to multivariable risk factor analysis, and the final
243 multivariable models for each of the three outcomes are shown in table 2. As a result of
244 different amounts of missing data for different questions, the total number of cats varies
245 between outcomes.

246

247 *Multivariable analysis*

248 The final multivariable models can be seen in table 2.

249

250 *Abscess/cat bite*

251 The complete dataset for abscesses/cat bites consisted of 465 cats, of which 53 (11.4%) were
252 cases. Household status was not associated with owner-reported abscess/cat bite within the
253 previous 12 months at multivariable level.

254

255 *Negative interactions with owner*

256 For reported negative interactions with the owner, the complete dataset consisted of 656 cats
257 of which 116 (17.7%) were cases. Agonistic multi-cat households were not significantly
258 different from single cat households in the odds of the outcome, but non-agonistic multi-cat
259 households had reduced odds of having a negative interaction with the owner when compared
260 with single cat households (OR 0.26; 95% CI 0.14-0.50).

261

262 **Discussion**

263 This study aimed to use longitudinal prospectively collected data from the Bristol Cats

264 Study to analyse associations between single/multi-cat households and measures of health
265 and behaviour, and to distinguish whether this differed for cats in agonistic and non-agonistic
266 multi-cat households.

267

268 No evidence was found for an association between single/multi-cat households and owner-
269 reported overweight/obesity or periuria in this sample of cats. Although the lack of an
270 association within our dataset could be due to a lack of statistical power, our results
271 do support previous findings for both outcomes^{8,17}. Obesity is one of the most common health
272 issues in cats⁷ and a potential risk factor for numerous diseases²². Periuria is a common
273 reason for relinquishment¹⁰ and behavioural referral¹¹. The finding that neither of these issues
274 is associated with living in a multi-cat household is therefore important. Urination outside the
275 litter tray has been used as an indicator of feline lower urinary tract disease¹². Risk factors for
276 other owner-reported lower urinary tract signs (haematuria, straining and vocalizing when
277 urinating) have already been reported for the BCS cohort²³, where living in multi-cat
278 households was not found to put cats at greater risk. Inappropriate urination can also be a
279 behavioural issue. Periuria as a behavioural issue could have confounding factors associated
280 with the number of cats in a household for which data was not available, for example the
281 location and number of litter trays within the household, although a behaviour-focussed
282 retrospective study supports no association between single/multi-cat households and house
283 soiling¹⁷.

284

285 Cat bites are another common health issue⁷ and fighting is implicated in the spread of
286 infectious disease. Living in a single cat household was associated at univariable level with
287 having an abscess or cat bite within the past 12 months, indicating that abscesses and cat bites
288 are more likely to be a result of an agonistic encounter with an unfamiliar cat rather than

289 between cats within a household. However, household was not retained in the final
290 multivariable model. It may be that confounding factors existed which were not detected,
291 resulting in removal from the final model.

292

293 The finding that negative interactions with the owner were associated with living in a single
294 cat household supports a cross-sectional study where cats living without conspecifics had
295 greater likelihood of aggression towards people¹⁶. In that study, the authors suggested play-
296 related aggression as a potential reason for this finding, and this would be a likely explanation
297 for the young cats in the present study. The distinction between agonistic and non-agonistic
298 multi-cat households in the current study revealed that this association was only found in
299 comparison with non-agonistic households. An explanation for this could be that inter-cat
300 conflict in agonistic multi-cat households can lead to redirected aggression towards the
301 owner²⁴.

302

303 There are several implications for human-directed aggression. It is a common reason for
304 relinquishment to rehoming centres; one study reports 14% of relinquishment in the UK were
305 a result of this¹⁰. There are human health implications, such as cat bite infections and cat
306 scratch fever. Finally, the human-cat relationship may be affected by negative interactions.
307 Cats with whom their owners feel a weaker bond are less likely to receive preventative care²⁵
308 and owners with a weaker bond are less likely to feel emotional support from their pets²⁶. The
309 current study highlights the importance of establishing and maintaining good inter-cat
310 relationships in multi-cat households and human-cat relationships in all households.

311

312 *Limitations*

313 The nature of the cohort, that is, motivated cat owners who are willing to complete annual

314 questionnaires, means that the results from the study are not necessarily representative of the
315 general population of cat owners in the UK. One noticeable difference is the high percentage
316 of cats in multi-cat households (79%), when compared with the general population of 42 to
317 43 per cent^{4,5}. However, this bias is considered more likely to affect prevalence estimates
318 than risk factor analyses²⁰. Additionally, one challenge of longitudinal studies is the retention
319 of participants. Several retention strategies are implemented in the Bristol Cats Study, and
320 have been described elsewhere²⁰. Although the Bristol Cats Study is a reasonably large
321 cohort, the occurrence of health and behaviour outcomes is often low, resulting in a lack of
322 power to detect small but possibly clinically relevant effects. Indeed, limited statistical power
323 within this study may have contributed to one or more of the non-significant findings, if they
324 occurred as a result of a type-I error.

325

326 A final point is that the definition of an agonistic household was derived from the presence of
327 agonistic behaviours, rather than the absence of affiliative behaviours. It is possible that some
328 of the cats in households classed as agonistic by this definition may actually be in mostly
329 harmonious relationships. This could also account for the high proportion of agonistic multi-
330 cat households in the cohort. The relationships between cats within the Bristol Cats Study as
331 well as the influence of number of cats within each household could be assessed more fully in
332 future research.

333

334 *Conclusion*

335 Of the health and behaviour outcomes investigated, none were associated with living in a
336 multi-cat household, despite a seemingly large proportion of agonistic multi-cat households.
337 This suggests that cats may not necessarily be at increased risk of health and behavioural
338 issues when living with other cats and should be taken into account when considering the

339 welfare of cats in multi-cat households. The likelihood of negative interactions with the
340 owner was influenced by the cats' relationships, rather than the multi-cat household itself;
341 veterinary practices and rehoming centres should promote methods of establishing and
342 maintaining good inter-cat and cat-human relationships.

343

344

345 **Acknowledgements**

346 The authors thank Emma Gale for study administration. Thanks to 'Bristol Cat' owners for
347 their continued participation in the Bristol Cats Study.

348

349 **Funding**

350 Zoetis funded Claire Roberts's post. Cats Protection funded Jane Murray's post. The
351 WALTHAM Centre for Pet Nutrition fund administrative support for the Bristol Cats Study

352

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410 **Table 1** Univariable regression for cats two-and-a-half years in from the Bristol Cats Study cohort
 411 showing the association of single and multi-cat households with six health, behaviour and care
 412 outcomes

Outcome*	N (%) Cases	N (%) Controls	P-value	OR (95% CI)
Overweight/obesity Single cat Multi-cat	28 (17.5) 122 (20.5)	132 (82.5) 473 (79.5)	0.398	1.0 0.82 (0.52-1.30)
Abscess/cat bite Single cat Multi-cat	22 (13.2) 46 (7.5)	145 (86.8) 570 (92.5)	0.022	1.0 0.532 (0.31-0.91)
Periuria Single cat Multi-cat	15 (10.8) 68 (13.8)	124 (89.2) 424 (86.2)	0.352	1.0 1.33 (0.73-2.40)
Negative interactions with owner Single cat Multi-cat	40 (24.1) 92 (14.2)	126 (75.9) 524 (85.1)	0.006	1.0 0.58 (0.38-0.88)

413 *For definition of cases/controls, see materials and methods

414

415 **Table 2** Final multivariable logistic regression models for cats aged 2.5 years from the Bristol Cats
 416 Study cohort showing factors associated with abscess/bite wounds, negative interactions with owner
 417 and unvaccinated/lapsed vaccinations

Variable	Factors	N (%) cases	N (%) controls	P-value	OR (95% CI)
Abscess/bite	Education				
	Up to A-level	7 (6.1)	108 (93.9)	0.034	1 2.46 (1.07-5.64)
	Degree and above	46 (13.1)	305 (86.9)		
	Location				
Town/city	23 (8.4)	251 (91.6)	0.012	1 2.11 (1.18-3.78)	
Rural/village	30 (15.7)	161 (84.3)			
Negative interactions with owner	Household				
	SCH	36 (25.9)	103 (74.1)	<0.001	1
	AMCH	63 (20.1)	251 (79.9)	0.178	0.72 (0.44-1.16)
	NMCH	17 (8.4)	186 (91.6)	<0.001	0.26 (0.14-0.50)
	Age of owner (years)*				
	55+	13 (10.8)	107 (89.2)	0.024	1 2.09 (1.10-3.96)
	16-54	103 (19.2)	433 (80.8)		
	Gender of cat				
Male	48 (13.5)	308 (86.5)	0.001	1 2.11 (1.38-3.22)	
Female	68 (22.7)	232 (77.3)			
Breed of cat					
Pure breed	12 (8.2)	135 (91.8)	0.005	1 2.53 (1.33-4.80)	
Mixed/DSH/DLH	104 (20.4)	405 (79.6)			

418 *For negative interactions with owner, there was no significant difference between age groups 16-24
 419 and 25-54, so these were recoded into one category

420 SCH= single cat household; AMCH= agonistic multi-cat household, NMCH= non-agonistic multi-cat
421 household; DLH= domestic longhair; DSH= domestic shorthair