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1 **Research**

2 **A large multi-centre study utilising electronic health records to identify antimicrobial**
3 **prescription risk factors for dogs and cats**

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16

17 **Running title:** Risk factors for antimicrobial prescription in dogs and cats

18 **Article summary:** This **large** multi-centre companion animal electronic health record-based
19 multivariable analysis study **demonstrated** the utility of such data repositories and
20 methodologies to understand clinical presentation prescription variation, the role of preventive
21 healthcare in antimicrobial prescription decision making, and how such factors might be used
22 to encourage responsible antimicrobial use in dogs and cats.

23 **Keywords:** Epidemiology; pets; dogs; cats; veterinary; informatics; anti-bacterial agents

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26 **Abstract**

27 Antimicrobial stewardship is a cornerstone of efforts to curtail antimicrobial resistance
28 dissemination. However, little is known about factors potentially influencing likelihood of
29 companion animal antimicrobial prescription. Here, we analysed unwell canine ($n=155,732$
30 unique dogs, 281,543 consultations) and feline ($n=69,236$ unique cats, 111,139 consultations)
31 electronic health records (EHRs) voluntarily contributed by 173 UK veterinary practices,
32 using multivariable mixed effects logistic regression. Preventive health-focused owner care
33 decisions including vaccination (dogs: odds ratio, OR 0.93, 95% confidence interval, CI,
34 0.90-0.95; cats: OR 0.92, CI 0.89-0.95), insurance (dogs: OR 0.87, CI 0.84-0.90; cats: OR
35 0.82, CI 0.79-0.86) or neutering in dogs (OR 0.90, CI 0.88-0.92) were associated with
36 decreased systemic antimicrobial prescription odds, as were dogs presenting to Royal College
37 of Veterinary Surgeons accredited practices (OR 0.79, CI 0.68-0.92). This large multi-centre
38 companion animal EHR study successfully demonstrated the potential of preventive
39 healthcare and owner engagement to encourage responsible antimicrobial use.

40

41 **Biographical sketch**

42 David Singleton is a veterinary surgeon with an interest in observational and interventional
43 epidemiology, health informatics and antimicrobial resistance within a one health framework.
44 Much of his work has utilised electronic health record data collated by the Small Animal
45 Veterinary Surveillance Network (SAVSNET), based at the University of Liverpool, and he
46 is currently employed within this group as a post-doctoral research associate.

47 **Introduction**

48 Antimicrobial use is a key driver in the promotion and transmission of antimicrobial
49 resistance (AMR) in humans, livestock (e.g. chickens, pigs etc.), and companion animals (e.g.
50 dogs and cats) (1-5). Of these groups, the important role of companion animals for
51 development (1,2), carriage (6) and transmission of AMR bacteria both within animal
52 populations and to/from humans, due at least in part to the close proximity in which
53 companion animals reside with humans (5,7,8), is now being increasingly realised. Indeed,
54 companion animals are now included in recent global action plans aimed at tackling the
55 important global AMR health threat (9).

56

57 Both electronic health records (EHRs) and qualitative research techniques have been used
58 extensively in human medicine to identify many practitioner and patient-led factors
59 associated with antimicrobial prescription likelihood (10-13). In veterinary medicine, studies
60 investigating antimicrobial prescribing practices and related risk factors are more limited
61 (14). To date, companion animal research has largely focused on postal surveys (15,16) and
62 in-person interviews (17) to explore perceptions held by veterinary practitioners. However,
63 recent veterinary health informatics advances have provided opportunities to utilise
64 veterinary EHRs at scale to survey antimicrobial prescription (18,19).

65

66 Thus far, key insights into antimicrobial prescription frequency and variety have been
67 demonstrated (20-23), including an apparent increase in feline cefovecin use (21,22), a third
68 generation cephalosporin considered ‘highest priority critically important’ (HPCIA) by the
69 World Health Organization (24). Considerable inter-practice (20,22) regional (21) and
70 clinical presentation (22,25,26) variability in antimicrobial prescription frequency and choice
71 has also been identified. Though previous studies have indicated divergence of veterinary

72 opinion over when antimicrobial therapy is justified, and which antimicrobial classes would
73 then be most appropriate (15-17), why such observed variation exists is currently unknown.

74

75 There remains a need to identify factors potentially influencing antimicrobial prescribing in
76 the clinical environment. This study utilised the EHRs of a large, diverse veterinary-visiting
77 population of dogs and cats collected from a network of volunteer first-opinion veterinary
78 practices across Great Britain. We explored associations between antimicrobial prescription
79 (including antimicrobials authorised for systemic administration; antimicrobials authorised
80 for topical administration, and HPCIAAs) and a range of veterinary practice, practitioner,
81 owner, and animal-related factors (including socioeconomic factors and preventive healthcare
82 interventions) in animals recorded as primarily presenting for investigation of disease.

83

84 **Materials and methods**

85 *Data collection*

86 This cross-sectional study used EHRs from 178 volunteer veterinary practices (386 unique
87 sites) taking part in the Small Animal Veterinary Surveillance Network (SAVSNET,
88 University of Liverpool ethical approval reference: RETH000964), utilising the Robovet
89 practice management system (Vet Solutions Ltd.). EHRs were retrieved from booked
90 consultations (19) between 1st April 2014 and 31st March 2016. Each consultation record
91 included species, breed, sex, neuter status, insurance status, microchip status, vaccination
92 history, date of birth, owner's postcode and any products dispensed at time of consultation.
93 Every consultation record was further classified by the attending veterinary professional into
94 one of ten main presenting complaints (MPCs) (grouped into 'healthy'; 'unhealthy', or 'post-
95 operative' categories), indicating the main reason the animal was presented to the veterinary
96 practice, as previously described (22).

97

98 *Data management*

99 *General data management*

100 There were 762,648 canine and 300,606 feline consultations initially available. Animals with
101 likely incorrectly recorded dates of birth (dogs and cats exceeding 24.5 and 26.0 years of age
102 at consultation, respectively) were excluded (n canine = 1,577; n feline = 2,467), as were
103 animals lacking a valid owner's postcode (n canine = 23,705; n feline = 9,901). Only
104 consultations where animals were recorded as unhealthy (hence, 'sick animal consultations')
105 by MPC were used in this study (282,263 out of 737,366 remaining canine consultations and
106 111,367 out of 288,238 remaining feline consultations). Veterinary practices ($n=5$) providing
107 insufficient EHRs for adequate statistical analyses (less than 50 consultations) were also
108 removed.

109

110 Antimicrobial prescription was identified via the text-based product description and classified
111 into systemic (oral or injectable) or topical (topical, aural, ocular) administration routes, using
112 a semi-automated rule-based text-mining method as previously described (22). All
113 fluoroquinolones, macrolides and third generation cephalosporins were considered HPCIA
114 (24). Antimicrobials authorised for dog and/or cat use in the UK are summarised in
115 Supplementary material, Table S1.

116

117 *Animal factors*

118 Animals were considered vaccinated if the most recently recorded vaccination date
119 (disregarding vaccine composition) was less than or equal to 3.5 years (broadly reflective of
120 current vaccine interval guidelines) before the relevant consultation date (27). Breeds were
121 summarised to standardised breed terms (28) before categorisation into either genotypically

122 similar breed groups (29), crossbreeds, breeds not yet genetically classified ('unclassified'),
123 or breed not recorded/recognisable ('unknown').

124

125 *Owner factors*

126 Using pet owner's home postcode, a measure of predicted deprivation was assigned to each
127 owner using the most recent English 2015, Scottish 2012 and Welsh 2014 Indices of Multiple
128 Deprivation (IMD). As IMD measures between countries are not directly comparable,
129 country was included in statistical models as a three-level factor and each country's complete
130 set of IMD ranks were rescaled to the range 0 to 1, with 1 corresponding to the least deprived
131 area.

132

133 We determined country of residence and urban/rural status via reference to the National
134 Statistics Postcode Look-up. The recorded centroid associated with each postcode was
135 utilised to place each animal owner within a 1 km² gridded cell, and each EHR was hence
136 associated with an estimate of the number of dogs or cats within each 1 km² gridded cell as
137 defined by Aegerter et al. (2017). Finally, postcode district was used to provide an estimate of
138 the number of dogs or cats per household for each recorded postcode (30).

139

140 *Veterinary practice and practitioner factors*

141 The RCVS Practice Register was utilised (interrogated 18th October 2016) to summarise each
142 veterinary practice by advertised treated species range into four categories: companion
143 animal; mixed (companion animal, large animal and equine); companion and large animal;
144 and companion animal and equine. Practices were considered accredited under the voluntary
145 RCVS Practice Standards Scheme (PSS) if at least one site was recorded as accredited (Core
146 Standards; General Practice, or Veterinary Hospital), and 'RCVS Veterinary Hospital' if

147 practices contained a Veterinary Hospital site. Practices listing ‘referrals’ as an interest were
148 also recorded. Practices employing at least one veterinary surgeon holding ‘RCVS Advanced
149 Veterinary Practitioner (AVP)’ status or separately ‘RCVS specialist’ status in areas of
150 relevance to companion animals were also recorded.

151

152 *Statistical analysis*

153 The statistical programme ‘R’ was used for all analyses. Descriptive proportions and
154 confidence intervals were adjusted for clustering within sites (bootstrap method, $n=5,000$
155 samples) (31). Univariable and multivariable mixed effects logistic regression models were
156 fitted separately in dogs and cats using the R package ‘lme4’ (32). Likelihood ratio tests
157 (LRT), Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and
158 evidence of inter-practice antimicrobial prescription frequency variation (22) indicated that
159 observations were clustered within veterinary practice, site and animal; therefore, all three
160 factors were included as random intercepts in all models. Separate analyses were undertaken
161 to assess the association between explanatory variables and three binary outcomes of interest:
162 antimicrobial prescription authorised for systemic administration (‘systemic antimicrobial’);
163 topical administration (‘topical antimicrobial’); and systemically administered HPCIAAs.

164

165 Initial univariable screening included fifteen categorical variables (sex, neutered status,
166 microchip status, insurance status, vaccination status, genetic breed group, country of
167 residence, owner urban/rural status, MPC, treated species (‘practice type’), RCVS
168 accreditation, RCVS Veterinary Hospital, referral interest, RCVS AVP, and RCVS
169 specialist), and four continuous variables (age at consultation, rescaled IMD rank (‘rIMD’),
170 dog or cat population per km^2 , and mean number of dogs or cats per household at district of
171 residence). For continuous explanatory variables, up to cubic polynomial terms were included

172 if an LRT, AIC and BIC indicated significantly improved fit, compared to linear and lesser
173 polynomial terms. Explanatory variables were retained for multivariable analysis if an LRT
174 indicated $P \leq 0.20$ against a null model.

175

176 Multivariable models underwent manual step-wise backward elimination to minimise AIC
177 and BIC. A two-way interaction between rIMD and the three-level factor country was
178 included in the initial multivariable model (deleted if AIC and BIC decreased upon removal),
179 with country alone as a false intercept. Confounding was accounted for via assessment of
180 effect variation upon removal of variables. Two-way interaction terms between other
181 explanatory variables were assessed via AIC, BIC and an LRT. The Variance Inflation Factor
182 (VIF) was used to assess multicollinearity (33). For continuous variables, projected
183 prescription probabilities and associated 95% confidence intervals were calculated from log
184 odds using ‘sjPlot’ (34). Statistical significance was defined as $P < 0.05$.

185

186 **Results**

187 Data from 281,543 sick dog (155,732 unique dogs) and 111,139 sick cat (69,236 unique cats)
188 consultations from 173 veterinary practices (379 sites) were analysed. A descriptive
189 population summary is included in Table 1, and a summary of genetic breed groups included
190 in this study is included in Supplementary material, Table S2.

191

192 ***Dogs***

193 ***Antimicrobial prescription***

194 Systemic antimicrobials, topical antimicrobials, or systemic HPCIA were prescribed in
195 25.7% (95% Confidence Interval, CI, 24.9-26.6), 14.2% (CI 13.9-14.6) and 1.4% (CI 1.2-1.6)
196 of consultations. Fluoroquinolones were the most commonly prescribed systemic HPCIA

197 class (0.9% of sick consultations, CI 0.7-1.0), followed by 3rd generation cephalosporins
198 (0.5%, CI 0.4-0.6) and macrolides (0.1%, CI 0.0-0.2). Antimicrobial prescription summarised
199 by commonly consulted breed is summarised in Supplementary material, Table S3.

200

201 *Systemic antimicrobial prescription*

202 Descriptive analyses and univariable model results are summarised in Supplementary
203 material, Table S4. Final multivariable model results are available in Table 2. Vaccinated or
204 neutered dogs were less likely to receive a systemic antimicrobial prescription compared to
205 unvaccinated or un-neutered dogs. Insured dogs were less likely than uninsured dogs to be
206 prescribed a systemic antimicrobial up to approximately 12 years of age (Figure 1a). The
207 respiratory MPC was associated with greatest prescription odds compared to the gastroenteric
208 MPC. Mixed practices were associated with significantly increased prescription odds
209 compared to practices treating companion animals only. RCVS accredited practices were less
210 likely to prescribe a systemic antimicrobial.

211

212 *Systemic HPCIA prescription*

213 Descriptive analyses and univariable model results are summarised in Supplementary
214 material, Table S5. Final multivariable model results are available in Table 3. Vaccinated or
215 insured dogs were less likely to be prescribed a systemic HPCIA. The respiratory MPC
216 showed the greatest odds of prescription. Odds increased with age in dogs (Figure 2a).
217 Compared to the retriever, the toy genetic breed group was associated with the greatest odds
218 of systemic HPCIA prescription.

219

220 *Topical antimicrobial prescription*

221 Descriptive analyses and univariable model results are summarised in Supplementary
222 material, Table S6. Final multivariable model results are available in Table 4. Insured dogs
223 were less likely to be prescribed a topical antimicrobial, though male, microchipped, or
224 vaccinated dogs displayed significantly increased prescription odds. The effect of age was
225 varied according to MPC; the pruritus MPC was generally associated with greatest
226 prescription odds throughout life, broadly decreasing with increased age (Figure 3a).
227 Compared to the retriever, sight hounds displayed the smallest prescription odds. Practices
228 employing RCVS specialists were less likely to prescribe a topical antimicrobial.

229

230 *Cats*

231 *Antimicrobial prescription*

232 Systemic antimicrobials, topical antimicrobials or systemic HPCIA were prescribed in
233 32.9% (CI 31.9-33.8), 6.1% (CI 5.9-6.3) and 17.3% (CI 16.2-18.4) of consultations. The most
234 commonly prescribed systemic HPCIA class were 3rd generation cephalosporins (16.4% of
235 sick consults, CI 15.3-17.6), followed by fluoroquinolones (0.7%, CI 0.4-0.9) and macrolides
236 (0.03%, CI 0.0-0.05). Antimicrobial prescription summarised by commonly consulted breed
237 is summarised in Supplementary material, Table S7.

238

239 *Systemic antimicrobial prescription*

240 Descriptive analyses and univariable model results are summarised in Supplementary
241 material, Table S8. Final multivariable model results are available in Table 5. Vaccinated or
242 insured cats had significantly reduced odds of systemic antimicrobial prescription. The
243 respiratory and trauma MPCs were associated with greatest prescription odds, though there
244 was a significant interaction between sex and MPC, with male cats significantly more likely
245 to receive a prescription when presenting with trauma than female cats. Female cats were

246 generally associated with reduced odds until approximately 15 years of age, when females
247 were then associated with increased odds compared to male cats (Figure 1b). Compared to
248 practices treating companion animals only, mixed practices were more likely to prescribe a
249 systemic antimicrobial.

250

251 *Systemic HPCIA prescription*

252 Descriptive analyses and univariable model results are summarised in Supplementary
253 material, Table S9. Final multivariable model results are available in Table 6. Vaccinated or
254 insured cats were less likely to be prescribed a systemic HPCIA. Though the respiratory MPC
255 showed the greatest odds, RCVS accredited practices were associated with increased odds for
256 cats presenting with trauma. Prescription probability increased up to 6-9 years of age before
257 reducing until approximately 18 years of age and increasing again hereafter; compared to
258 females, males were more likely to be prescribed between 5 and 14 years of age (Figure 2b).
259 Compared to the West Europe genetic breed group, the Asian group was associated with the
260 greatest odds of systemic HPCIA prescription.

261

262 *Topical antimicrobial prescription*

263 Descriptive analyses and univariable model results are summarised in Supplementary
264 material Table 10. Final multivariable model results are available in Table 7. Insured cats
265 were less likely to be prescribed a topical antimicrobial. The effect of age at consultation
266 varied according to MPC; in pruritic cats there was a decreasing prescription probability until
267 approximately 7 years of age, before increasing again (Figure 3b). Compared to the West
268 Europe genetic breed group, crossbreeds displayed the smallest prescription odds.

269

270 **Discussion**

271 Here we have demonstrated frequent antimicrobial prescription including systemic HPCIA
272 (particularly in cats), in veterinary practices in the UK. Considering the importance of
273 HPCIA in the context of AMR (35), we have identified a vital need to understand more
274 about factors potentially driving such prescribing behaviours. We have further augmented
275 EHR data using a range of external data sources to identify key owner, animal and practice-
276 related risk factors associated with systemic and topical antimicrobial, and systemic HPCIA,
277 prescription; such factors potentially informing key antimicrobial stewardship targets of
278 importance to companion animal practice.

279

280 Regarding owner care decision-related factors, vaccinated dogs and cats were associated with
281 significantly reduced systemic antimicrobial and HPCIA prescription odds, possibly
282 reflecting perceived or actual reduced risk of antimicrobial-responsive disease in vaccinated
283 animals. Though most companion animal vaccines target viruses, bacterial infection
284 secondary to vaccine-preventable viral disease is documented (36). Risk avoidance plays an
285 important role in antimicrobial prescribing practices (12), potentially prompting more
286 frequent prescription in unwell, unvaccinated animals. We speculate that previous
287 engagement with preventive healthcare might select for owners more likely to seek veterinary
288 attention earlier and/or to pursue diagnostic options in preference to empirical prescription.
289 Regardless of what might be driving these trends, the O'Neill Report has recommended that
290 promoting development and use of vaccines and alternatives to antibiotics should form a key
291 component of efforts to curtail human AMR dissemination (37); our findings suggest that
292 such recommendations should also be considered for companion animals.

293

294 Presence of insurance was also associated with decreased systemic and topical antimicrobial
295 prescription odds, potentially highlighting veterinary practitioners being more likely to seek a

296 wider range of diagnostic options in preference to empirical antibiotics in insured animals.
297 However, insured dogs were also associated with increased systemic HPCIA prescription
298 odds. Cost of therapy has been shown to influence companion animal antimicrobial agent
299 choice (17), and HPCIA are anecdotally considered a more expensive option compared to
300 other antimicrobials. Hence, our findings might reflect increased willingness to prescribe
301 relatively expensive antimicrobials to insured dogs.

302

303 Though HPCIA classification remains under debate, HPCIA use has formed a focus for
304 AMR-related policy (37). Whilst a number of HPCIA classes (e.g. glycopeptides, which are
305 not authorised for use in animals) are very rarely prescribed to companion animals in the UK
306 (22), prescription of fluoroquinolones and 3rd generation cephalosporins (particularly in cats)
307 is relatively commonplace, though current antimicrobial prescribing guidance strongly
308 discourages such practices (38).

309

310 Considering animal-intrinsic factors, male cats were associated with increased systemic
311 antimicrobial prescription odds in younger animals, though the opposite was found for dogs.
312 Sex-based variation in bacterial infection risk has been previously identified (39-41), and cat
313 fight-related injuries are a frequently recorded clinical complaint (42) more commonly
314 associated with young outdoor-ranging male cats (43). Indeed, here we found male cats
315 presenting with trauma to be more commonly prescribed systemic antimicrobials. Further,
316 time of injury is less likely to be known in outdoor ranging cats compared to dogs; such
317 uncertainty might well prompt a more cautious antimicrobial prescribing approach (44).

318

319 Other studies have also identified age- or sex-related variation in AMR risk (39-41). For
320 instance, Radford et al. (2011) demonstrated decreasing systemic antimicrobial prescription

321 probability with increased age (20), potentially reflecting increased actual or perceived non-
322 communicable disease incidence as animals age. This interpretation might partly explain our
323 findings, though a notable exception was observed - systemic HPCIA prescription. In cats an
324 easy-to-administer (injectable) long-acting 3rd generation cephalosporin formulation is widely
325 used (21-23). Although not completely explanatory, our findings may suggest that as an
326 animal ages the owner or veterinary surgeon perceives an increased probability of an animal
327 being refractory to an intervention (e.g. administering oral tablets), increasing the likelihood
328 of a prescriber choosing easy-to-administer formulations. Provision of inappropriate dosages
329 as a result of non-compliance has been previously identified as a key influencer of
330 antimicrobial agent choice (17). Deciding whether the AMR risk posed by a possible under-
331 dose of a first-line antimicrobial outweighs the AMR risk posed by the labelled dose of a
332 third-line HPCIA remains an important unanswered question in companion animal practice.

333

334 As with humans (10,11,13), respiratory clinical signs were most commonly associated with
335 systemic antimicrobial prescription in dogs and cats. Humans suffering from respiratory
336 conditions are often inappropriately prescribed antimicrobials, the majority of such
337 conditions being viral or non-infectious in origin (10). This has also been shown for
338 companion animals, though bacterial sequelae to primary viral disease has been documented
339 (45). Considering these shared patterns, although prescribing guidance is available (46), we
340 suggest respiratory disease as a pertinent area for further investigation of ‘one health’
341 stewardship intervention methods.

342

343 The retriever group, containing a number of breeds commonly associated with dermatological
344 disease (47), was associated with increased odds of topical antimicrobial prescription. This
345 finding and interpretation is plausible, suggesting that the breed summarisation technique

346 employed here to combat the modelling issues posed by over recorded 250 dog and 50 cat
347 breeds in this dataset was useful. However, it should be remembered that genetic linkage does
348 not necessarily imply phenotypic similarity. As such, individual breed-level phenotypes
349 might be responsible for conferring variant bacterial infection risk in ways not explored, and
350 indeed potentially masked, here. We aim to identify additional means by which breeds can be
351 effectively summarised according to both shared genotype and phenotype for future analyses.

352

353 Although the individual animal accounted for the majority of random effect variance seen
354 here, veterinary-led factors might well yield more readily accessible routes towards
355 stewardship. The voluntary RCVS PSS requires antimicrobial usage policies, infection
356 control plans, and established clinical audit for site accreditation (48), and here we observed
357 reduced canine systemic antimicrobial prescription odds in accredited practices. Though
358 practices seeking accreditation might already be more engaged with quality improvement, we
359 would nevertheless recommend further consideration as to whether the RCVS PSS could play
360 a more central role for encouraging stewardship in both first opinion and referral practice.

361

362 Compared to practices only treating companion animals, mixed species practices were
363 associated with increased systemic antimicrobial prescription odds. Veterinary surgeons
364 employed in different sectors express varied attitudes towards AMR (16); a finding perhaps
365 demonstrated at scale here. Practices employing RCVS specialists were also associated with
366 reduced topical antimicrobial prescription odds in dogs, potentially reflecting varied case
367 management approach (49) or caseload compared to first opinion practices.

368

369 Considering limitations of this study, although we successfully augmented EHRs with a
370 variety of data sources, no dataset is infallible. For instance, the veterinary surgeon

371 employment record of the RCVS Practice Register is updated only on an *ad hoc* basis. It is
372 thus possible that the surveyed veterinary surgeon population varied over the two-year study
373 period in ways not captured here. Veterinary practices participating in SAVSNET are
374 recruited by convenience and might not be representative of the wider UK population.
375 Though no clear associations between IMD or pet population density and prescription were
376 found here, the complexities of summarising IMD across the devolved constituent countries
377 of the UK (50), coupled with the relative infancy of pet population demographic studies (30),
378 lead us to recommend re-evaluation as research methodologies further mature. The analysed
379 population was relatively skewed towards less deprived areas; to ascertain whether this is
380 reflective of the wider UK pet owning community, including the charity and low-income
381 veterinary sectors in future analyses would be warranted. We would advise caution for
382 inferring causal relationships between factors and outcome variables explored in this cross-
383 sectional study; similarly, group-level observations might have limited relevance to
384 individual animals. More generalised SAVSNET limitations has been previously discussed;
385 briefly, antimicrobial prescription quantification depends on practitioners charging for
386 antimicrobials, and analysed practices were recruited by convenience (22,30).

387

388 **Conclusions**

389 We have demonstrated the utility of veterinary EHRs collected from a cohort of veterinary
390 practices to identify a range of factors associated with canine and feline antimicrobial
391 prescription. Though factors influencing decision-making remain multifactorial and complex,
392 our findings suggest that gathering clinical evidence surrounding respiratory disease might be
393 of **importance** to stewardship. Preventive healthcare could also play a **valuable** stewardship
394 role, and should form the basis of owner-targeted health messaging, as should the RCVS PSS
395 to veterinary practitioners.

396

397 **Conflict of interest statement**

398 None of the authors of this paper have a financial or personal relationship with other people
399 or organisations that could inappropriately influence or bias the content of this paper.

400

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410

411 **Appendix: Supplementary material**

412 Supplementary data associated with this article can be found, in the online version, at doi: ...

413 **Tables**

414 **Table 1:** Descriptive demographic summary of sick canine and feline consultations utilised for
 415 analyses of factors associated with antimicrobial prescription, gathered from a large sentinel
 416 network of UK-based veterinary practices.

Categorical factors		Dogs (<i>n</i> = 281,543)	Cats (<i>n</i> = 111,139)	
Variable	Category	% of consultations (95% CI)	% of consultations (95% CI)	
Country	England	86.6 (81.4-91.9)	88.6 (83.8-93.5)	
	Scotland	6.1 (3.0-9.1)	4.5 (2.1-6.9)	
	Wales	7.4 (2.8-12.0)	7.0 (2.1-6.9)	
Sex	Male	51.8 (51.3-52.3)	51.8 (51.3-52.4)	
Neuter status	Neutered	64.6 (63.3-65.9)	82.8 (81.7-84.0)	
Microchip status	Microchipped	54.4 (52.4-56.3)	37.8 (36.0-39.5)	
Vaccination status	Vaccinated	70.0 (68.6-71.3)	52.7 (51.2-54.1)	
Insurance status	Insured	33.5 (31.1-35.9)	19.3 (17.3-21.3)	
Owner urban status	Urban	63.8 (59.5-68.1)	70.2 (66.2-74.2)	
Main presenting complaint	Gastroenteric	11.3 (11.0-11.6)	8.3 (8.0-8.7)	
	Respiratory	4.0 (3.8-4.1)	5.5 (5.2-5.8)	
	Pruritus	18.0 (17.3-18.6)	10.3 (9.9-10.7)	
	Trauma	16.8 (16.1-17.5)	17.0 (16.3-17.7)	
	Tumour	6.0 (5.8-6.3)	3.9 (3.6-4.1)	
	Kidney disease	0.7 (0.6-0.8)	2.9 (2.5-3.2)	
	Other unwell	43.3 (42.0-44.6)	52.1 (50.9-53.4)	
	Practice type	Mixed	22.7 (15.1-30.3)	18.1 (11.6-24.6)
		Companion animal	70.6 (62.4-78.8)	76.0 (68.9-83.1)
		Companion & equine	2.4 (0.7-4.0)	2.3 (0.7-4.0)
Companion & large		4.3 (0.4-8.2)	3.5 (0.3-6.8)	
Accreditation	True	83.9 (77.1-90.6)	83.5 (76.5-90.5)	
Hospital status	True	20.2 (14.4-26.0)	20.0 (14.5-25.5)	
Referral interest	True	27.9 (20.9-34.9)	27.3 (20.3-34.2)	
Employed RCVS AVP ^b	True	24.5 (17.2-31.7)	26.7 (19.2-34.2)	
Employed RCVS specialist ^b	True	2.5 (0.8-4.2)	1.9 (0.6-3.1)	
Continuous factors				
Age at consultation	Mean	7.1 (7.1-7.2)	9.5 (9.5-9.6)	
	Median [min-max]	7.2 [0-22]	9.7 [0-25.9]	
Rescaled Indices of multiple deprivation (rIMD) rank	Mean	0.59 (0.59-0.60)	0.60 (0.60-0.61)	
	Median [min-max]	0.62 [0.0-1.0]	0.63 [0.0-1.0]	
Animals per household ^c	Mean	0.59 (0.59-0.59)	0.50 (0.49-0.50)	
	Median [min-max]	0.47 [0-6.0]	0.39 [0-3.6]	
Animals per km ² ^c	Mean	399.4 (397.8-401.0)	409.4 (407.0-411.8)	
	Median [min-max]	266 [0-4360]	288 [0-5363]	

417 ^a 95% Confidence interval418 ^b At least one employed veterinary surgeon holding Royal College of Veterinary Surgeons (RCVS) Advanced
 419 Veterinary Practitioner (AVP) and / or specialist status420 ^c Aegerter et al., 2017

421 **Table 2:** Results from a multivariable mixed effect logistic regression model assessing the
 422 association between a range of categorical animal, owner, practitioner and practice-related
 423 factors and the probability of prescribing a systemic antimicrobial in dogs ($n = 72,436/281,543$
 424 sick consultations). Significant ($P < 0.05$) results are displayed in bold.

Random effect	Variance	SD ^a	Variable	Category	β	SE ^b	OR ^c (CI ^d)	P
Animal	0.57	0.76	Intercept	England	-0.08	0.08	0.93 (0.80-1.08)	-
Site	0.05	0.23		Scotland	-0.06	0.09	0.94 (0.79-1.12)	-
Practice	0.06	0.24		Wales	-0.13	0.09	0.88 (0.73-1.05)	-
Categorical factors								
			Main	Gastroenteric	-	-	1.00	-
			presenting	Kidney disease	-0.38	0.06	0.68 (0.61-0.76)	<0.01
			complaint	Other unwell	-0.94	0.02	0.39 (0.38-0.40)	<0.01
				Pruritus	-0.68	0.02	0.51 (0.49-0.53)	<0.01
				Respiratory	0.10	0.03	1.11 (1.06-1.17)	<0.01
				Trauma	-0.89	0.02	0.41 (0.40-0.43)	<0.01
				Tumour	-1.18	0.03	0.31 (0.29-0.32)	<0.01
			Neuter status	Not neutered	-	-	1.00	-
				Neutered	-0.11	0.01	0.90 (0.88-0.92)	<0.01
			Sex	Female	-	-	1.00	-
				Male	-0.03	0.01	0.97 (0.95-0.99)	0.01
			Vaccination	Not vaccinated	-	-	1.00	-
			status	Vaccinated	-0.08	0.01	0.93 (0.90-0.95)	<0.01
			Insurance	Not insured	-	-	1.00	-
			status	Insured	-0.14	0.02	0.87 (0.84-0.90)	<0.01
			Genetic	Retriever	-	-	1.00	-
			breed	Ancient / spitz	0.25	0.05	1.28 (1.17-1.40)	<0.01
			group ^e	Crossbreed	0.06	0.02	1.06 (1.03-1.10)	<0.01
				Herding	0.14	0.03	1.15 (1.09-1.22)	<0.01
				Mastiff-like	0.15	0.02	1.16 (1.11-1.21)	<0.01
				Scent hound	0.10	0.04	1.11 (1.03-1.19)	<0.01
				Sight hound	0.31	0.04	1.36 (1.25-1.48)	<0.01
				Small terrier	0.16	0.02	1.18 (1.13-1.22)	<0.01
				Spaniel	0.16	0.02	1.17 (1.13-1.22)	<0.01
				Toy	-0.00	0.03	1.00 (0.94-1.05)	0.92
				Unclassified	0.11	0.02	1.12 (1.07-1.16)	<0.01
				Unknown	0.09	0.05	1.09 (0.99-1.21)	0.075
				Working dog	0.19	0.03	1.21 (1.15-1.27)	<0.01
			Practice type	Companion animal	-	-	1.00	-
				Mixed	0.14	0.07	1.15 (1.01-1.30)	0.04
				Companion & equine	-0.05	0.15	0.95 (0.71-1.27)	0.73
				Companion & large	0.13	0.14	1.14 (0.86-1.50)	0.37
			Accreditation	None	-	-	1.00	-
			status	1+ accredited site	-0.24	0.08	0.79 (0.68-0.92)	<0.01
			Referral	No	-	-	1.00	-
			interest	Yes	-0.10	0.05	0.91 (0.82-1.00)	0.06
Continuous factors								
			Age (years)	Age - linear	-1.12	0.01	0.89 (0.87-0.91)	<0.01
				Age - quadratic	-0.09	0.01	0.92 (0.90-0.93)	<0.01
				Age - cubic	0.05	0.01	1.05 (1.04-1.07)	<0.01
Interaction terms								
			Insurance	Insured : Age	0.08	0.02	1.09 (1.04-1.14)	<0.01
			Status : Age	Insured : Age -	0.03	0.01	1.03 (1.00-1.06)	0.03
			(years)	Insured : Age - cubic	-0.03	0.01	0.97 (0.95-1.00)	0.02

425 ^a Standard deviation
 426 ^b Standard error
 427 ^c Odds ratio
 428 ^d 95% Confidence interval
 429 ^e Vonholdt et al., 2010

430 **Table 3:** Results from a multivariable mixed effect logistic regression model assessing the
 431 association between a range of categorical animal, owner, practitioner and practice-related
 432 factors and the probability of prescribing a systemic HPCIA in dogs ($n = 3,971/281,543$ sick
 433 consultations). Significant ($P < 0.05$) results are displayed in bold.

Random effect	Variance	SD ^a	Variable	Category	β	SE ^b	OR ^c (CI ^d)	P
Animal	3.04	1.74	Intercept	England	-4.77	0.11	0.01 (0.01-0.01)	-
Site	0.13	0.36		Scotland	-4.91	0.21	0.01 (0.01-0.01)	-
Practice	0.44	0.66		Wales	-4.88	0.22	0.01 (0.01-0.01)	-
Categorical factors								
Main presenting complaint			Gastroenteric		-	-	1.00	-
			Kidney disease		0.11	0.18	1.12 (0.78-1.60)	0.55
			Other unwell		-0.33	0.06	0.72 (0.64-0.80)	<0.01
			Pruritus		-0.23	0.07	0.79 (0.70-0.90)	<0.01
			Respiratory		0.29	0.09	1.33 (1.13-1.57)	<0.01
			Trauma		-1.16	0.08	0.31 (0.27-0.37)	<0.01
			Tumour		-0.92	0.11	0.40 (0.32-0.49)	<0.01
Vaccination status			Not vaccinated		-	-	1.00	-
			Vaccinated		-0.10	0.04	0.91 (0.83-0.99)	0.03
Insurance status			Not insured		-	-	1.00	-
			Insured		0.15	0.05	1.16 (1.07-1.27)	<0.01
Genetic breed group ^e			Retriever		-	-	1.00	-
			Ancient / spitz		0.12	0.22	1.13 (0.73-1.74)	0.60
			Crossbreed		0.24	0.08	1.27 (1.09-1.48)	<0.01
			Herding		0.04	0.12	1.04 (0.82-1.32)	0.73
			Mastiff-like		0.16	0.10	1.17 (0.97-1.43)	0.11
			Scent hound		0.67	0.13	1.96 (1.52-2.52)	<0.01
			Sight hound		0.43	0.17	1.54 (1.10-2.15)	0.01
			Small terrier		0.67	0.08	1.96 (1.67-2.29)	<0.01
			Spaniel		0.45	0.08	1.57 (1.33-1.84)	<0.01
			Toy		0.94	0.10	2.56 (2.10-3.12)	<0.01
			Unclassified		0.39	0.09	1.47 (1.24-1.74)	<0.01
		Unknown		0.23	0.22	1.25 (0.81-1.94)	0.31	
		Working dog		0.45	0.11	1.56 (1.27-1.93)	<0.01	
Continuous factors								
Age (years)			Age - linear		0.19	0.04	1.21 (1.12-1.31)	<0.01
			Age - quadratic		-0.06	0.03	0.95 (0.90-0.99)	0.03
			Age - cubic		0.04	0.02	1.04 (1.01-1.08)	0.01

434 ^a Standard deviation

435 ^b Standard error

436 ^c Odds ratio

437 ^d 95% Confidence interval

438 ^e Vonholdt et al., 2010

439 **Table 4:** Results from a multivariable mixed effect logistic regression model assessing the
 440 association between a range of categorical animal, owner, practitioner and practice-related
 441 factors and the probability of prescribing a topical antimicrobial in dogs ($n = 40,030/281,543$
 442 sick consultations). Significant ($P < 0.05$) results are displayed in bold.

Random effect	Variance	SD ^a	Variable	Category	β	SE ^b	OR ^c (CI ^d)	P
Animal	0.55	0.74	Intercept	England	-4.01	0.07	0.02 (0.02-0.02)	-
Site	0.02	0.14		Scotland	-3.88	0.09	0.02 (0.02-0.02)	-
Practice	0.02	0.16		Wales	-4.06	0.09	0.02 (0.01-0.02)	-
Categorical factors								
Main presenting complaint				Gastroenteric	-	-	1.00	-
				Kidney disease	0.71	0.22	2.03 (1.31-3.15)	<0.01
				Other unwell	2.41	0.07	11.18 (9.78-12.79)	<0.01
				Pruritus	3.24	0.07	25.64 (22.39-29.35)	<0.01
				Respiratory	0.63	0.11	1.88 (1.50-2.34)	<0.01
				Trauma	1.35	0.07	3.87 (3.36-4.46)	<0.01
				Tumour	1.15	0.08	3.16 (2.68-3.73)	<0.01
Sex				Female	-	-	1.00	-
				Male	0.07	0.01	1.08 (1.05-1.10)	<0.01
Microchip status				Not microchipped	-	-	1.00	-
				Microchipped	0.03	0.01	1.03 (1.00-1.06)	0.02
Vaccination status				Not vaccinated	-	-	1.00	-
				Vaccinated	0.08	0.02	1.08 (1.05-1.11)	<0.01
Insurance status				Not insured	-	-	1.00	-
				Insured	-0.10	0.02	0.90 (0.88-0.93)	<0.01
Genetic breed group ^e				Retriever	-	-	1.00	-
				Ancient / spitz	-0.14	0.06	0.87 (0.77-0.97)	0.02
				Crossbreed	-0.21	0.02	0.81 (0.78-0.84)	<0.01
				Herdling	-0.57	0.04	0.57 (0.53-0.61)	<0.01
				Mastiff-like	-0.03	0.03	0.97 (0.93-1.03)	0.32
				Scent hound	-0.25	0.04	0.78 (0.71-0.85)	<0.01
				Sight hound	-0.92	0.07	0.40 (0.34-0.46)	<0.01
				Small terrier	-0.29	0.03	0.75 (0.71-0.79)	<0.01
				Spaniel	0.04	0.02	1.04 (1.00-1.09)	0.08
				Toy	-0.14	0.03	0.87 (0.82-0.93)	<0.01
				Unclassified	-0.06	0.03	0.94 (0.89-0.99)	0.011
				Unknown	-0.31	0.06	0.74 (0.65-0.83)	<0.01
				Working dog	-0.21	0.03	0.81 (0.76-0.87)	<0.01
Hospital status				None	-	-	1.00	-
				1+ hospital site	0.06	0.04	1.07 (0.98-1.16)	0.15
Employed RCVS AVP ^f				None	-	-	1.00	-
				1+ AVP	0.08	0.04	1.08 (0.99-1.17)	0.08
Employed RCVS specialists ^f				None	-	-	1.00	-
				1+ specialist	-0.27	0.09	0.77 (0.64-0.92)	<0.01
Continuous factors								
Age (years)				Age - linear	-0.10	0.09	0.91 (0.76-1.09)	0.30
				Age - quadratic	0.04	0.04	1.04 (0.98-1.13)	0.39
				Age - cubic	0.04	0.04	1.04 (0.96-1.13)	0.30
Interaction terms								
Main presenting complaint : Age (years)				Kidney disease : Age	-0.33	0.27	0.72 (0.42-1.22)	0.22
				Other unwell : Age	-0.30	0.10	0.74 (0.61-0.89)	<0.01
				Pruritus : Age	0.08	0.10	1.08 (0.89-1.31)	0.42
				Respiratory : Age	-0.01	0.15	0.90 (0.66-1.21)	0.47
				Trauma : Age	0.01	0.10	1.01 (0.82-1.23)	0.95
				Tumour : Age	-0.15	0.12	0.86 (0.69-1.08)	0.20
				Kidney disease : Age - quadratic	0.04	0.15	1.04 (0.77-1.40)	0.79
				Other unwell : Age - quadratic	-0.11	0.05	0.90 (0.82-0.98)	0.02
				Pruritus : Age - quadratic	-0.00	0.05	1.00 (0.91-1.09)	0.96
				Respiratory : Age - quadratic	-0.12	0.08	0.89 (0.76-1.03)	0.11
				Trauma : Age - quadratic	-0.02	0.05	0.98 (0.89-1.08)	0.68
				Tumour : Age - quadratic	0.14	0.06	1.15 (1.02-1.29)	0.02
				Kidney disease : Age - cubic	-0.01	0.11	0.99 (0.79-1.24)	0.94
				Other unwell : Age - cubic	-0.04	0.04	0.97 (0.89-1.05)	0.39
				Pruritus : Age - cubic	-0.06	0.04	0.94 (0.87-1.02)	0.15
				Respiratory : Age - cubic	-0.01	0.07	0.99 (0.86-1.13)	0.84
				Trauma : Age - cubic	-0.03	0.05	0.97 (0.89-1.06)	0.56
			Tumour : Age - cubic	-0.02	0.05	0.98 (0.88-1.08)	0.64	

443 ^a Standard deviation

444 ^b Standard error

445 ^c Odds ratio

446 ^d 95% Confidence interval

447 ^e Vonholdt et al., 2010

448 ^f Royal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner and / or specialist status

449 **Table 5:** Results from a multivariable mixed effect logistic regression model assessing the
 450 association between a range of categorical animal, owner, practitioner and practice-related
 451 factors and the probability of prescribing a systemic antimicrobial in cats ($n = 36,521/111,139$
 452 sick consultations). Significant ($P < 0.05$) results are displayed in bold.

Random effect	Variance	SD ^a	Variable	Category	β	SE ^b	OR ^c (CI ^d)	P
Animal	0.50	0.70	Intercept	England	-0.81	0.06	0.45 (0.39-0.50)	-
Site	0.06	0.25		Scotland	-0.77	0.10	0.46 (0.38-0.57)	-
Practice	0.08	0.28		Wales	-0.55	0.12	0.58 (0.46-0.72)	-
Categorical factors								
Main presenting complaint				Gastroenteric	-	-	1.00	-
				Kidney disease	-0.20	0.07	0.82 (0.71-0.94)	0.01
				Other unwell	-0.23	0.04	0.79 (0.73-0.85)	<0.01
				Pruritus	-0.37	0.05	0.69 (0.63-0.76)	<0.01
				Respiratory	0.91	0.06	2.48 (2.23-2.77)	<0.01
				Trauma	0.59	0.04	1.80 (1.65-1.97)	<0.01
				Tumour	-0.56	0.07	0.57 (0.50-0.65)	<0.01
Sex				Female	-	-	1.00	-
				Male	0.03	0.05	1.03 (0.93-1.14)	0.59
Vaccination status				Not vaccinated	-	-	1.00	-
				Vaccinated	-0.09	0.02	0.92 (0.89-0.95)	<0.01
Insurance status				Not insured	-	-	1.00	-
				Insured	-0.19	0.02	0.82 (0.79-0.86)	<0.01
Genetic breed group ^e				West Europe	-	-	1.00	-
				Asian	0.20	0.05	1.22 (1.10-1.36)	<0.01
				Crossbreed	0.14	0.03	1.16 (1.08-1.23)	<0.01
				Mediterranean	0.36	0.26	1.43 (0.86-2.38)	0.17
				Unclassified	0.11	0.06	1.11 (0.99-1.24)	0.07
Practice type				Unknown	0.13	0.05	1.14 (1.03-1.26)	0.01
				Companion animal	-	-	1.00	-
				Mixed	0.18	0.08	1.20 (1.03-1.39)	0.02
				Companion & equine	-0.01	0.18	1.00 (0.70-1.41)	0.98
				Companion & large	0.10	0.17	1.10 (0.80-1.53)	0.56
Referral interest				No	-	-	1.00	-
				Yes	-0.08	0.06	0.92 (0.82-1.04)	0.18
Employed RCVS AVP ^f				None	-	-	1.00	-
				1+ AVP	-0.10	0.07	0.90 (0.79-1.04)	0.16
Continuous factors								
Age (years)				Age - linear	-0.38	0.02	0.69 (0.66-0.72)	<0.01
				Age - quadratic	-0.08	0.01	0.90 (0.90-0.95)	<0.01
				Age - cubic	0.10	0.01	1.08 (1.08-1.12)	<0.01
Cats per km ² ^g				Cats per km² - linear	-0.02	0.01	0.98 (0.97-1.00)	0.02
Interaction terms								
Sex : Age (years)				Male : Age	-0.10	0.03	0.91 (0.85-0.97)	<0.01
				Male : Age -	-0.10	0.02	0.91 (0.88-0.94)	<0.01
Sex : Main presenting complaint				Male : Age - cubic	0.03	0.02	1.03 (1.00-1.06)	0.11
				Male : Kidney	-0.26	0.11	0.77 (0.62-0.96)	0.02
				Male : Other unwell	0.17	0.05	1.19 (1.07-1.32)	<0.01
				Male : Pruritus	0.10	0.07	1.10 (0.96-1.26)	0.16
				Male : Respiratory	0.06	0.08	1.06 (0.91-1.23)	0.44
				Male : Trauma	0.48	0.06	1.62 (1.44-1.82)	<0.01
			Male : Tumour	0.15	0.10	1.16 (0.96-1.40)	0.12	

453 ^a Standard deviation

454 ^b Standard error

455 ^c Odds ratio

456 ^d 95% Confidence interval

457 ^e Lipinski et al, 2008

458 ^f Royal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner and / or specialist status

459 ^g Aegerter et al., 2017

460 **Table 6:** Results from a multivariable mixed effect logistic regression model assessing the
 461 association between a range of categorical animal, owner, practitioner and practice-related
 462 factors and the probability of prescribing a systemic HPCIA in cats ($n = 19,018/111,139$ sick
 463 consultations). Significant ($P < 0.05$) results are displayed in bold.

Random effect	Variance	SD ^a	Variable	Category	β	SE ^b	OR ^c (CI ^d)	P
Animal	0.68	0.82	Intercept	England	-2.79	0.21	0.06 (0.04-0.09)	-
Site	0.13	0.36		Scotland	-2.74	0.24	0.07 (0.04-0.10)	-
Practice	0.44	0.66		Wales	-2.55	0.24	0.08 (0.05-0.12)	-
Categorical factors								
Main presenting complaint				Gastroenteric	-	-	1.00	-
				Kidney disease	0.55	0.25	1.74 (1.08-2.82)	0.02
				Other unwell	0.59	0.12	1.80 (1.43-2.26)	<0.01
				Pruritus	1.08	0.13	2.95 (2.28-3.81)	<0.01
				Respiratory	1.50	0.14	4.47 (3.41-5.85)	<0.01
				Trauma	1.06	0.12	2.89 (2.27-3.67)	<0.01
				Tumour	0.38	0.18	1.46 (1.04-2.03)	0.03
Sex				Female	-	-	1.00	-
				Male	0.12	0.03	1.13 (1.07-1.19)	<0.01
Vaccination status				Not vaccinated	-	-	1.00	-
				Vaccinated	-0.06	0.02	0.95 (0.91-0.98)	<0.01
Insurance status				Not insured	-	-	1.00	-
				Insured	-0.14	0.03	0.87 (0.83-0.92)	<0.01
Owner urban status				Urban	-	-	1.00	-
				Rural	0.05	0.03	1.05 (1.00-1.11)	0.06
Genetic breed group ^e				West Europe	-	-	1.00	-
				Asian	0.21	0.07	1.23 (1.08-1.40)	<0.01
				Crossbreed	0.14	0.04	1.16 (1.06-1.26)	<0.01
				Mediterranean	0.11	0.32	1.12 (0.59-2.11)	0.73
				Unclassified	0.14	0.07	1.15 (1.00-1.33)	0.06
				Unknown	0.12	0.06	1.12 (0.99-1.27)	0.07
Accreditation status				Not accredited	-	-	1.00	-
				1+ accredited site	0.10	0.22	1.10 (0.72-1.69)	0.65
Continuous factors								
Age (years)				Age - linear	-0.23	0.03	0.80 (0.76-0.85)	<0.01
				Age - quadratic	-0.13	0.02	0.88 (0.85-0.90)	<0.01
				Age - cubic	0.13	0.01	1.14 (1.11-1.17)	<0.01
Interaction terms								
Main presenting complaint : Accreditation				Kidney disease : accredited site	0.23	0.26	1.26 (0.76-2.08)	0.37
				Other unwell : accredited site	0.21	0.13	1.23 (0.96-1.58)	0.10
				Pruritus : accredited site	0.00	0.14	1.00 (0.76-1.32)	1.00
				Respiratory : accredited site	0.23	0.15	1.26 (0.94-1.69)	0.12
				Trauma : accredited site	0.64	0.13	1.90 (1.46-2.47)	<0.01
				Tumour : accredited site	0.19	0.19	1.21 (0.83-1.75)	0.32
Sex : Age (years)				Male : Age - linear	-0.06	0.04	0.95 (0.87-1.02)	0.17
				Male : Age - quadratic	-0.09	0.02	0.91 (0.87-0.95)	<0.01
				Male : Age - cubic	0.02	0.02	1.02 (0.98-1.06)	0.32

464 ^a Standard deviation
 465 ^b Standard error
 466 ^c Odds ratio
 467 ^d 95% Confidence interval
 468 ^e Lipinski et al, 2008

469 **Table 7:** Results from a multivariable mixed effect logistic regression model assessing the
 470 association between a range of categorical animal, owner, practitioner and practice-related
 471 factors and the probability of prescribing a topical antimicrobial in cats ($n = 6,769/111,139$ sick
 472 consultations). Significant ($P < 0.05$) results are displayed in bold.

Random effect	Variance	SD ^a	Variable	Category	β	SE ^b	OR ^c (CI ^d)	P
Animal	0.82	0.90	Intercept	England	-3.98	0.17	0.02 (0.01-0.03)	-
Site	0.02	0.15		Scotland	-3.94	0.19	0.02 (0.01-0.03)	-
Practice	0.03	0.16		Wales	-3.91	0.19	0.02 (0.01-0.03)	-
Categorical factors								
Main presenting complaint				Gastroenteric	-	-	1.00	-
				Kidney disease	-0.98	0.50	0.38 (0.14-1.00)	0.05
				Other unwell	1.79	0.16	5.96 (4.37-8.12)	<0.01
				Pruritus	2.13	0.16	8.37 (6.09-11.51)	<0.01
				Respiratory	1.21	0.18	3.36 (2.35-4.82)	<0.01
				Trauma	1.34	0.17	3.82 (2.76-5.28)	<0.01
Sex				Tumour	0.38	0.25	1.46 (0.90-2.36)	0.12
				Female	-	-	1.00	-
				Male	0.05	0.03	1.05 (1.00-1.11)	0.06
Neutered status				Not neutered	-	-	1.00	-
				Neutered	-0.06	0.04	0.94 (0.88-1.01)	0.09
Insurance status				Not insured	-	-	1.00	-
				Insured	-0.13	0.04	0.88 (0.82-0.95)	<0.01
Genetic breed group ^e				West Europe	-	-	1.00	-
				Asian	-0.14	0.09	0.87 (0.73-1.03)	0.09
				Crossbreed	-0.50	0.05	0.61 (0.55-0.67)	<0.01
				Mediterranean	-0.40	0.50	0.67 (0.25-1.78)	0.42
				Unclassified	-0.24	0.09	0.79 (0.66-0.95)	0.01
				Unknown	-0.43	0.08	0.65 (0.56-0.77)	<0.01
Referral interest				No	-	-	1.00	-
				Yes	0.08	0.05	1.08 (0.98-1.19)	0.11
Continuous factors								
Age (years)				Age - linear	0.08	0.26	1.09 (0.65-1.82)	0.75
				Age - quadratic	-0.12	0.14	0.89 (0.68-1.17)	0.40
				Age - cubic	-0.14	0.14	0.87 (0.66-1.15)	0.34
Interaction terms								
Main presenting complaint : Age (years)				Kidney disease : Age	1.14	0.68	3.11 (0.82-11.84)	0.10
				Other unwell : Age	-0.61	0.27	0.54 (0.32-0.91)	0.02
				Pruritus : Age	0.18	0.27	1.19 (0.70-2.03)	0.52
				Respiratory : Age	-0.34	0.31	0.71 (0.39-1.29)	0.26
				Trauma : Age	0.07	0.28	1.07 (0.62-1.85)	0.81
				Tumour : Age	-0.07	0.38	0.93 (0.44-1.95)	0.85
				Kidney disease : Age - quadratic	0.52	0.32	1.69 (0.89-3.18)	0.11
				Other unwell : Age - quadratic	0.16	0.14	1.17 (0.89-1.53)	0.26
				Pruritus : Age - quadratic	0.42	0.14	1.52 (1.15-2.02)	<0.01
				Respiratory : Age - quadratic	0.26	0.16	1.29 (0.95-1.77)	0.11
				Trauma : Age - quadratic	0.22	0.15	1.24 (0.93-1.65)	0.14
				Tumour : Age - quadratic	0.16	0.20	1.18 (0.80-1.73)	0.41
				Kidney disease : Age - cubic	-0.51	0.33	0.60 (0.31-1.16)	0.13
				Other unwell : Age - cubic	0.14	0.14	1.15 (0.87-1.52)	0.33
				Pruritus : Age - cubic	0.04	0.15	1.04 (0.78-1.38)	0.81
				Respiratory : Age - cubic	-0.03	0.16	0.97 (0.70-1.33)	0.84
				Trauma : Age - cubic	0.06	0.15	1.06 (0.79-1.42)	0.70
				Tumour : Age - cubic	0.10	0.19	1.10 (0.75-1.61)	0.62

473 ^a Standard deviation

474 ^b Standard error

475 ^c Odds ratio

476 ^d 95% Confidence interval

477 ^e Lipinski et al, 2008

478 **Figure legends**

479 **Figure 1:** Results from two multivariable mixed effect logistic regression models, modelling
480 predicted probability of systemic antimicrobial prescription in sick (a) dogs and (b) cats against
481 age of the animal at time of consultation, in years. For dogs an interaction term considering
482 current insurance status has been included, in cats an interaction term considering sex has been
483 included. Lines refer to predicted probability, with shading relating to 95% confidence intervals
484 to such predictions. Points and triangles are plotted to show original data points expressing the
485 percentage of animals of each relevant age group (rounded to 0.5-year groups) that were
486 prescribed a systemic antimicrobial in the dataset analysed.

487

488 **Figure 2:** Results from two multivariable mixed effect logistic regression models, modelling
489 predicted probability of systemic highest priority critically important antimicrobial (HPCIA)
490 prescription in sick (a) dogs and (b) cats against age of the animal at time of consultation, in
491 years. For cats an interaction term considering sex has been included. Lines refer to predicted
492 probability, with shading relating to 95% confidence intervals to such predictions. Points and
493 triangles are plotted to show original data points expressing the percentage of animals of each
494 relevant age group (rounded to 0.5-year groups) that were prescribed a systemic HPCIA in the
495 dataset analysed.

496

497 **Figure 3:** Results from two multivariable mixed effect logistic regression models, modelling
498 predicted probability of topical antimicrobial prescription in sick (a) dogs and (b) cats against
499 age of the animal at time of consultation, in years. For both species an interaction term
500 considering main presenting complaint has been included. Lines refer to predicted probability,
501 with shading relating to 95% confidence intervals to such predictions. Points are plotted to
502 show original data points expressing the percentage of animals of each relevant age group

503 (rounded to 0.5-year groups) that were prescribed a topical antimicrobial in the dataset
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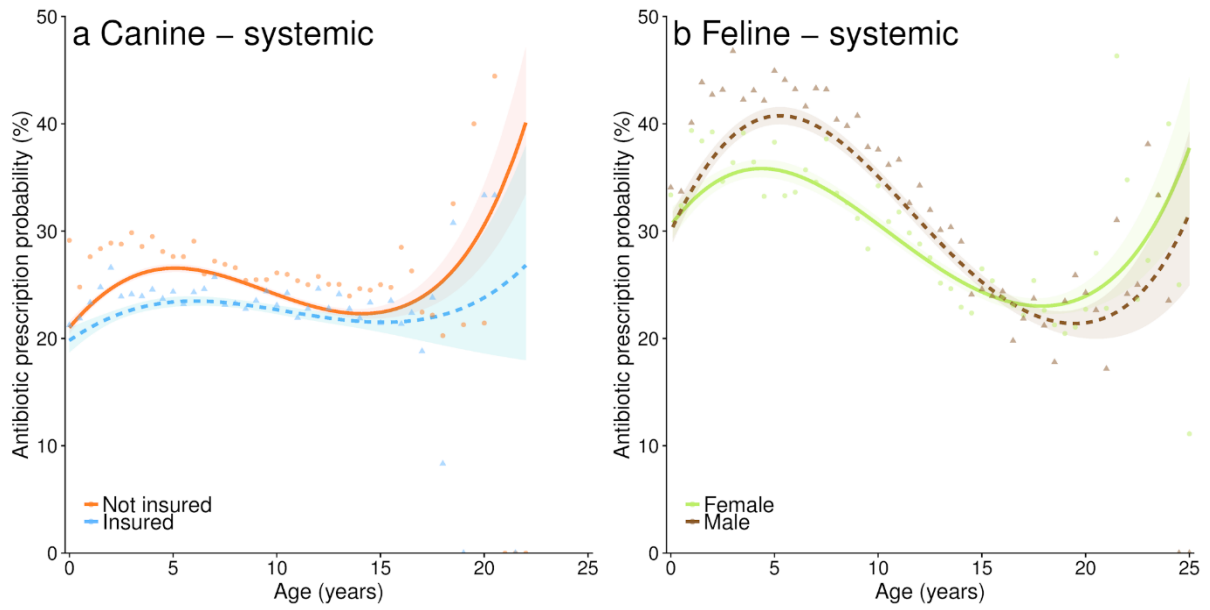
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638

639 **Figures**

640 **Figure 1**

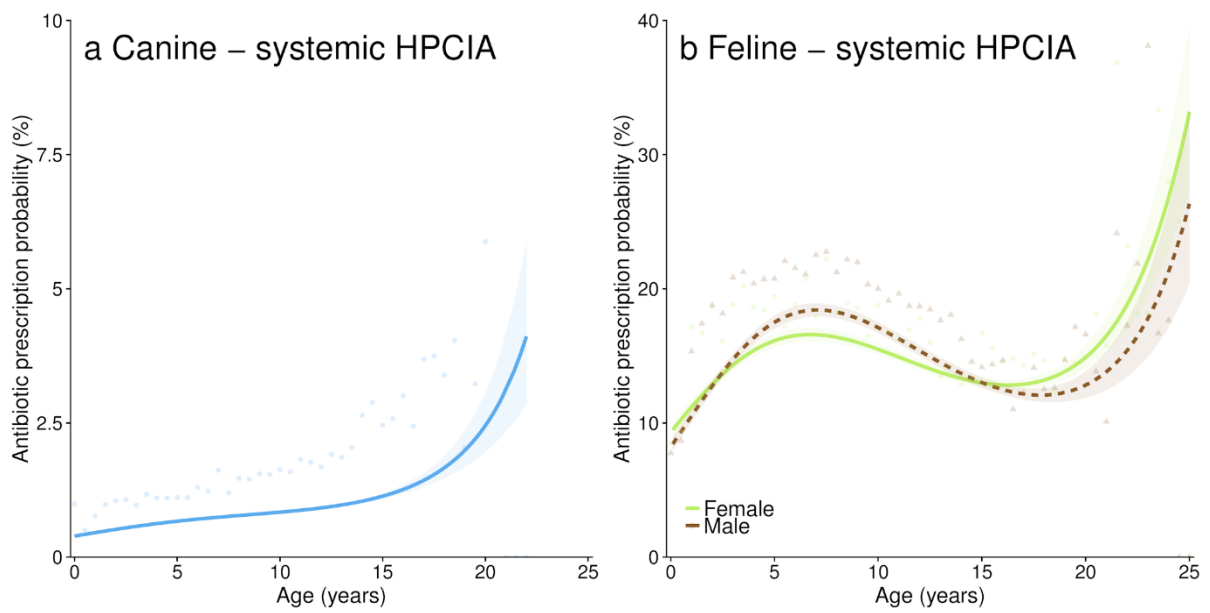


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643 **Figure 2**

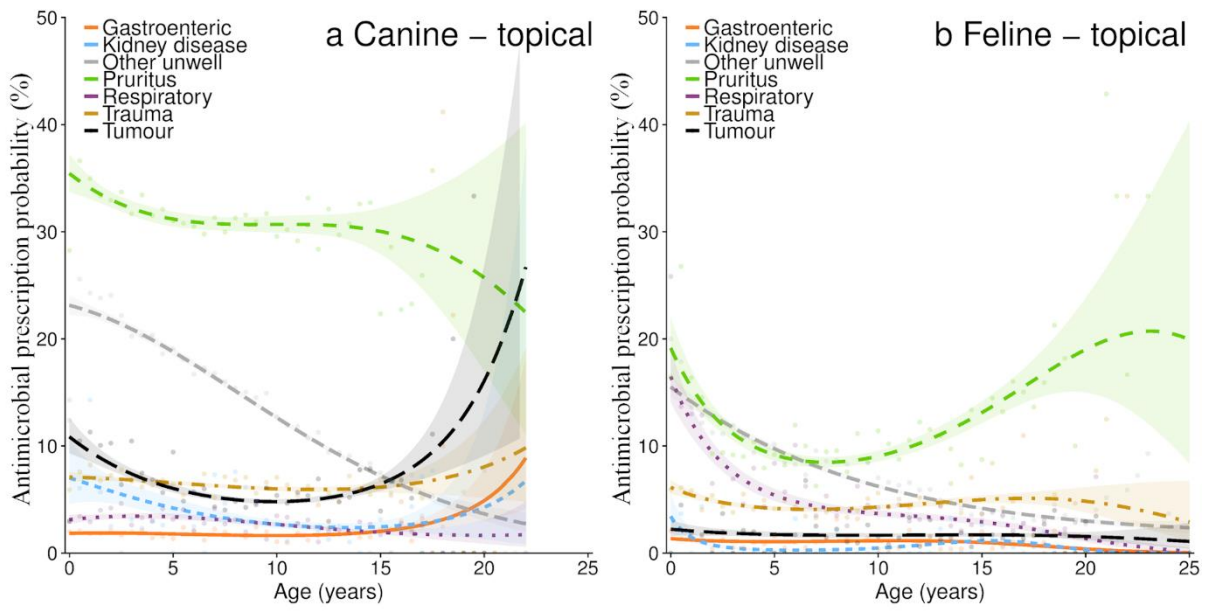
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647 **Figure 3**



648

649

Supplementary material

Table S1

Summary of antimicrobial agents authorised for use in dogs and/or cats in the United Kingdom. Information source: Veterinary Medicines Directorate (<https://www.vmd.defra.gov.uk/ProductInformationDatabase/>), accessed 1 April 2016.

Antimicrobial class	Antimicrobial agent
Aminoglycoside	Framycetin sulphate Gentamicin Neomycin Streptomycin sulphate
Amphenicol	Florfenicol
Beta-lactam	
	<i>Amoxicillin</i> Amoxicillin
	<i>Ampicillin</i> Ampicillin
	<i>Clavulanic acid potentiated amoxicillin</i> Amoxicillin-clavulanic acid
	<i>Cloxacillin</i> Cloxacillin
	<i>1st generation cephalosporin</i> Cefalexin
	<i>3rd generation cephalosporin</i> Cefovecin
	<i>Penicillin</i> Benzathine benzyl penicillin
	<i>Penicillin</i> Procaine benzylpenicillin
Fluoroquinolone	Enrofloxacin Orbifloxacin Marbofloxacin Pradofloxacin
Fusidic acid	Fusidic acid
Lincosamide	Clindamycin Lincomycin
Nitroimidazole	Metronidazole
Nitroimidazole-macrolide	Metronidazole-spiramycin
Potentiated sulphonamide	Sulfadiazine-trimethoprim
Polymyxin	Polymyxin B sulphate
Tetracycline	Doxycycline Oxytetracycline

Table S2

Descriptive demographic summary of sick canine and feline consultations utilised for analyses of factors associated with antimicrobial prescription, focusing on the percentage of consultations contributed by a range of genetically similar breed groups, as defined by Vonholdt et al. (2010) for dog breeds, and Lipinski et al. (2008) for cat breeds.

Breeds	% of consults (CI ^a)	Breeds	% of consults (CI ^a)
Dog breed group		Cat breed group	
Ancient / spitz	1.3 (1.2-1.4)	Asian	3.5 (3.3-3.8)
Crossbreed	22.1 (21.4-22.8)	Crossbreed	87.6 (86.3-88.8)
Herding	4.7 (4.4-5.1)	Mediterranean	0.1 (0.1-0.1)
Mastiff-like	9.5 (9.1-9.9)	West Europe	6.4 (5.3-7.5)
Retriever	14.5 (13.8-15.2)	Unclassified	2.5 (2.3-2.7)
Scent hound	2.6 (2.5-2.8)	Unknown / missing	4.0 (3.1-4.8)
Sight hound	1.6 (1.5-1.8)		
Small terriers	12.8 (12.4-13.2)		
Spaniel	13.7 (13.3-14.1)		
Toy	4.7 (4.4-5.0)		
Working dog	5.2 (5.0-5.4)		
Unclassified	11.3 (10.9-11.6)		
Unknown / missing	1.2 (1.0-1.4)		

^a95% Confidence interval

Table S3

Descriptive summary of the percentage of total sick canine consultations where an animal was prescribed at least one antimicrobial (systemic, topical or systemic highest priority critically important (HPCIA) compared against animal breed, including breeds where in excess of 2,500 consultations were recorded.

Genetic breed group	Dog breed	n consults	Systemic		Topical		Systemic HPCIA	
			% ^b	95% CI ^c	%	95% CI	%	95% CI
Crossbreed	Crossbreed	59,010	24.9	23.9-25.8	13.3	12.9-13.7	1.2	0.9-1.4
Herding	Border collie	9,821	26.7	25.2-28.2	8.1	7.5-8.7	1.0	0.6-1.5
	Border terrier	5,225	24.3	22.6-26.1	16.0	14.7-17.3	1.4	0.9-1.8
Mastiff-like	Boxer	4,780	22.6	21.0-24.2	17.7	16.4-19.1	0.7	0.4-0.9
	Bulldog	2,530	32.7	30.5-34.9	23.3	21.3-25.3	1.1	0.6-1.6
	Staffordshire bull terrier	9,719	24.8	23.6-26.0	15.6	14.8-16.5	0.7	0.5-1.0
Retriever	Golden retriever	6,223	26.3	24.4-28.1	15.1	13.9-16.4	1.0	0.7-1.4
	Labrador retriever	30,977	22.7	21.6-23.8	15.2	14.5-15.9	1.0	0.7-1.2
Scent hound	Dachshund	3,065	25.1	22.7-27.4	9.6	8.4-10.9	2.7	1.8-3.5
Small terrier	Jack russell terrier	14,869	26.1	24.9-27.4	16.7	15.8-17.7	1.4	1.1-1.8
	West highland white terrier	11,040	28.9	27.5-30.3	10.8	10.0-11.7	2.9	2.4-3.5
	Yorkshire terrier	6,328	27.6	25.9-29.2	11.0	10.4-11.6	3.2	2.6-3.8
Spaniel	Cavalier King Charles	7,586	22.5	21.1-24.0	14.0	13.1-14.9	1.3	0.9-1.7
	Cocker spaniel	15,312	27.8	26.5-29.2	18.1	17.2-18.9	1.7	1.4-2.1
	English springer spaniel	6,774	26.3	24.8-27.9	14.1	13.1-15.2	1.3	0.9-1.7
	Springer spaniel	4,073	27.4	25.6-29.2	15.5	14.1-16.8	1.4	0.9-1.9
Toy	Chihuahua	2,583	26.5	24.3-28.8	7.9	6.8-9.0	2.3	1.5-3.1
	Pug	2,679	24.7	22.6-26.7	21.5	19.9-23.1	1.8	1.1-2.4
	Shih tzu	5,938	23.4	21.8-25.0	17.3	16.2-18.5	2.0	1.6-2.5
Unclassified	Bichon frise	3,314	25.8	24.2-27.4	18.7	17.1-20.4	1.4	0.9-1.8
	Lhasa apso	3,060	26.5	24.3-28.7	17.3	15.5-19.1	2.4	1.7-3.1
Unknown	Unknown	3,182	24.3	22.5-26.1	12.1	10.8-13.3	0.9	0.5-1.3
Working dog	German shepherd dog	6,695	28.4	27.0-29.8	13.5	12.5-14.4	1.1	0.7-1.6
	Schnauzer	3,376	27.2	25.2-29.1	12.3	11.0-13.5	1.2	0.7-1.8

^a Vonholdt et al., 2010

^b Percentage of consultations where at least one antimicrobial was prescribed

^c 95% Confidence Interval

^d Highest priority critically important antimicrobial

Table S4

Descriptive summary of the percentage of total sick canine consultations prescribed a systemic antimicrobial. Also included are parameter estimates from a series of univariable mixed effect logistic regression models assessing the association between a range of animal, owner, practitioner and practice-related factors and the probability of prescribing a systemic antimicrobial. Random effects include animal, site, and practice.

Variable	Category	% of prescribing consults (CI ^a)	β	SE ^b	OR ^c	CI	P
Categorical factors							
Country	England (Intercept)	25.7 (24.7-26.7)	-1.16	0.03	0.31	0.30-0.33	
	Scotland	26.8 (24.9-28.7)	0.04	0.05	1.04	0.94-1.16	0.45
	Wales	24.7 (22.3-27.1)	-0.02	0.07	0.98	0.86-1.12	0.76
Main presenting complaint	Gastroenteric (Intercept)	40.2 (41.0-44.8)	-0.46	0.03	0.63	0.59-0.67	
	Other unwell	22.0 (21.3-22.8)	-0.93	0.02	0.34	0.38-0.41	<0.01
	Kidney disease	30.1 (27.4-32.8)	-0.39	0.06	0.68	0.61-0.76	<0.01
	Pruritus	27.0 (25.7-28.4)	-0.65	0.02	0.52	0.51-0.54	<0.01
	Respiratory	42.9 (41.0-44.8)	0.11	0.03	1.12	1.06-1.17	<0.01
	Trauma	22.5 (21.5-23.6)	-0.86	0.02	0.42	0.41-0.44	<0.01
	Tumour	18.4 (17.5-19.3)	-1.17	0.03	0.31	0.30-0.33	<0.01
Sex	Female (Intercept)	25.9 (24.9-26.8)	-1.15	0.03	0.32	0.30-0.33	
	Male	25.6 (24.7-26.4)	-0.01	0.01	0.99	0.97-1.01	0.19
Neuter	Un-neutered (Intercept)	27.4 (26.5-28.2)	-1.08	0.03	0.34	0.32-0.36	
	Neutered	24.8 (24.0-25.7)	-0.12	0.01	0.89	0.87-0.91	<0.01
Microchip status	Un-microchipped (Intercept)	26.4 (25.5-27.3)	-1.14	0.03	0.32	0.30-0.34	
	Microchipped	25.2 (24.3-26.1)	-0.03	0.01	0.97	0.95-0.99	0.01
Vaccination status	Un-vaccinated (Intercept)	27.3 (26.4-28.2)	-1.10	0.03	0.33	0.32-0.35	
	Vaccinated	25.1 (24.2-26.0)	-0.09	0.01	0.92	0.90-0.94	<0.01
Insurance status	Un-insured (Intercept)	26.7 (25.9-27.6)	-1.11	0.03	0.33	0.31-0.35	
	Insured	23.7 (22.7-24.7)	-0.14	0.01	0.87	0.85-0.89	<0.01
Owner urban status	Urban (Intercept)	25.5 (24.5-26.4)	-1.16	0.03	0.31	0.30-0.33	
	Rural	26.2 (25.0-27.3)	0.01	0.01	1.01	0.98-1.03	0.71
Genetic breed group ^d	Retriever (Intercept)	23.4 (22.3-24.5)	-1.28	0.03	0.28	0.26-0.29	
	Crossbreed	24.9 (23.9-25.8)	0.08	0.02	1.08	1.05-1.12	<0.01
	Ancient / spitz	28.8 (26.7-30.8)	0.27	0.05	1.32	1.20-1.44	<0.01
	Herding	26.5 (25.2-27.8)	0.14	0.03	1.15	1.09-1.22	<0.01
	Mastiff-like	26.2 (25.2-27.1)	0.16	0.02	1.17	1.12-1.22	<0.01
	Scent hound	25.6 (24.0-27.1)	0.13	0.04	1.13	1.06-1.21	<0.01
	Sight hound	29.5 (27.6-31.5)	0.30	0.04	1.35	1.25-1.47	<0.01
	Small terrier	27.3 (26.2-28.4)	0.20	0.02	1.22	1.17-1.27	<0.01
	Spaniel	26.5 (25.4-27.5)	0.16	0.02	1.17	1.13-1.22	<0.01
	Toy	24.7 (23.4-25.9)	0.06	0.03	1.06	1.01-1.12	0.03
	Unclassified	26.0 (25.0-27.0)	0.13	0.02	1.14	1.09-1.19	<0.01
	Unknown	24.3 (22.6-26.1)	0.12	0.05	1.13	1.03-1.24	0.01
	Working dog	27.4 (26.4-28.4)	0.21	0.03	1.24	1.18-1.30	<0.01
	Practice type	Small animal (Intercept)	25.4 (24.3-26.4)	-1.19	0.03	0.31	0.29-0.32
Mixed		26.6 (25.0-28.3)	0.16	0.07	1.18	1.03-1.34	0.02
Small & equine		23.1 (20.2-25.9)	-0.04	0.15	0.96	0.71-1.30	0.79
Small & large		28.7 (26.2-31.2)	0.16	0.14	1.17	0.89-1.55	0.27
Accreditation	Not accredited (Intercept)	28.4 (26.3-30.5)	-0.93	0.07	0.40	0.35-0.46	
	1+ accredited site	25.2 (24.3-26.1)	-0.27	0.07	0.77	0.66-0.89	<0.01
Hospital status	No hospital site (Intercept)	26.2 (25.2-27.2)	-1.14	0.03	0.32	0.30-0.34	
	1+ hospital site	23.9 (22.7-25.1)	-0.09	0.06	0.91	0.81-1.04	0.16
Referral interest	No (Intercept)	26.0 (25.1-26.9)	-1.12	0.03	0.33	0.31-0.35	
	Yes	25.1 (23.2-26.9)	-0.11	0.05	0.89	0.80-0.99	0.04
Employed RCVS AVP ^e	None (Intercept)	26.3 (25.3-27.2)	-1.13	0.03	0.32	0.31-0.34	
	1+ AVP	24.0 (22.2-25.8)	-0.14	0.06	0.87	0.77-0.98	0.02
Employed RCVS specialist ^e	None (Intercept)	25.8 (25.0-26.7)	-1.15	0.03	0.32	0.30-0.33	
	1+ specialist	22.0 (19.1-24.8)	-0.18	0.15	0.84	0.63-1.11	0.21
Continuous factors							
Age (years)	Intercept		-1.14	0.03	0.32	0.31-0.34	
	Age - linear		-0.10	0.01	0.90	0.88-0.92	<0.01
	Age - quadratic		-0.03	0.01	0.97	0.96-0.99	<0.01
	Age - cubic		0.02	0.01	1.02	1.02-1.03	<0.01
rIMD ^f	Intercept		-1.16	0.03	0.31	0.30-0.33	
	rIMD		-0.02	0.01	0.98	0.97-1.00	0.04
Dogs per household ^g	Intercept		-1.16	0.03	0.31	0.30-0.33	
	Dogs per household		-0.01	0.01	0.99	0.98-1.01	0.24
Dogs per km ² ^g	Intercept		-1.16	0.03	0.31	0.30-0.33	
	Dogs per km		-0.01	0.01	1.00	0.98-1.01	0.34

^a95% Confidence Interval^bStandard Error^cOdds Ratio

^d Vonholdt et al., 2010

^e Royal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner (AVP) and / or specialist status

^f Rescaled Indices of Multiple Deprivation (rIMD) quintile, 1 = most deprived

^g Aegerter et al., 2017

Table S5

Descriptive summary of the percentage of total sick canine consultations prescribed a systemic highest priority critically important antimicrobial (HPCIA). Also included are parameter estimates from a series of univariable mixed effect logistic regression models assessing the association between a range of animal, owner, practitioner and practice-related factors and the probability of prescribing a systemic HPCIA. Random effects include animal, site, and practice.

Variable	Category	% of prescribing consults (CI ^a)	β	SE ^b	OR ^c	CI	P
Categorical factors							
Country	England (Intercept)	1.4 (1.2-1.7)	-4.80	0.07	0.01	0.01-0.01	1
	Scotland	1.4 (0.9-1.8)	-0.15	0.19	0.86	0.59-1.24	0.42
	Wales	1.1 (0.7-1.6)	-0.11	0.20	0.90	0.61-1.32	0.59
Main presenting complaint	Gastroenteric (Intercept)	1.7 (0.8-2.7)	-4.54	0.08	0.01	0.01-0.01	
	Kidney disease	2.2 (1.5-2.8)	0.31	0.18	1.36	0.95-1.95	0.09
	Other unwell	1.5 (1.3-1.8)	-0.21	0.06	0.81	0.73-0.91	<0.01
	Pruritus	1.6 (1.3-1.8)	-0.18	0.07	0.84	0.74-0.95	<0.01
	Respiratory	2.8 (2.4-3.3)	0.44	0.08	1.55	1.31-1.82	<0.01
	Trauma	0.5 (0.4-0.7)	-1.13	0.08	0.32	0.27-0.38	<0.01
	Tumour	0.8 (0.6-1.0)	-0.80	0.11	0.45	0.37-0.56	<0.01
Sex	Female (Intercept)	1.4 (1.2-1.7)	-4.80	0.07	0.01	0.01-0.01	
	Male	1.4 (1.2-1.6)	-0.03	0.04	0.97	0.90-1.05	0.47
Neuter status	Un-neutered (Intercept)	1.4 (1.2-1.6)	-4.82	0.07	0.01	0.01-0.01	
	Neutered	1.4 (1.2-1.7)	0.00	0.04	1.00	0.92-1.09	0.94
Microchip status	Un-microchipped (Intercept)	1.5 (1.3-1.7)	-4.75	0.07	0.01	0.01-0.01	
	Microchipped	1.4 (1.1-1.6)	-0.12	0.04	0.88	0.82-0.96	<0.01
Vaccination status	Un-vaccinated (Intercept)	1.5 (1.3-1.7)	-4.73	0.07	0.01	0.01-0.01	
	Vaccinated	1.4 (1.2-1.6)	-0.13	0.04	0.88	0.81-0.96	<0.01
Insurance status	Un-insured (Intercept)	1.3 (1.1-1.6)	-4.86	0.07	0.01	0.01-0.01	
	Insured	1.5 (1.3-1.8)	0.13	0.04	1.13	1.04-1.23	<0.01
Owner urban status	Urban (Intercept)	1.3 (1.1-1.5)	-4.83	0.07	0.01	0.01-0.01	
	Rural	1.6 (1.3-2.0)	0.03	0.05	1.04	0.95-1.14	0.49
Genetic breed group ^d	Retriever (Intercept)	1.0 (0.7-1.2)	-5.19	0.09	0.01	0.01-0.01	
	Crossbreed	1.2 (0.9-1.4)	0.06	0.22	1.07	0.69-1.64	0.78
	Ancient / spitz	0.9 (0.5-1.3)	0.24	0.08	1.27	1.09-1.47	<0.01
	Herding	1.2 (0.7-1.6)	0.08	0.12	1.09	0.86-1.37	0.50
	Mastiff-like	1.0 (0.8-1.1)	0.09	0.10	1.09	0.90-1.33	0.37
	Scent hound	1.9 (1.4-2.4)	0.67	0.13	1.95	1.52-2.51	<0.01
	Sight hound	1.4 (0.9-1.8)	0.34	0.17	1.41	1.01-1.97	0.04
	Small terrier	2.3 (1.9-2.6)	0.80	0.08	2.23	1.91-2.61	<0.01
	Spaniel	1.5 (1.3-1.8)	0.45	0.08	1.58	1.34-1.80	<0.01
	Toy	2.2 (1.8-2.6)	0.90	0.10	2.45	2.02-2.99	<0.01
	Unclassified	1.5 (1.2-1.8)	0.43	0.09	1.53	1.29-1.81	<0.01
	Unknown	0.9 (0.5-1.3)	0.18	0.22	1.20	0.77-1.85	0.43
	Working dog	1.4 (1.1-1.8)	0.45	0.11	1.57	1.27-1.93	<0.01
	Practice type	Small animal (Intercept)	1.3 (1.1-1.5)	-4.85	0.07	0.01	0.01-0.01
Mixed		1.7 (1.0-2.3)	0.18	0.17	1.20	0.86-1.66	0.29
Small & equine		1.2 (0.7-1.6)	-0.10	0.40	0.91	0.42-1.98	0.80
Small & large		1.5 (1.0-1.9)	0.08	0.35	1.09	0.55-2.15	0.81
Accreditation	Not accredited (Intercept)	1.7 (1.1-2.4)	-4.65	0.18	0.01	0.01-0.01	
	1+ accredited site	1.4 (1.1-1.6)	-0.19	0.19	0.83	0.57-1.20	0.33
Hospital status	No hospital site (Intercept)	1.5 (1.3-1.8)	-4.78	0.07	0.01	0.01-0.01	
	1+ hospital site	1.0 (0.9-1.1)	-0.17	0.16	0.84	0.62-1.15	0.28
Referral interest	No (Intercept)	1.5 (1.2-1.7)	-4.80	0.08	0.01	0.01-0.01	
	Yes	1.2 (1.0-1.5)	-0.06	0.14	0.94	0.72-1.23	0.66
Employed RCVS AVP ^e	None (Intercept)	1.5 (1.2-1.7)	-4.79	0.07	0.01	0.01-0.01	
	1+ AVP	1.3 (1.0-1.5)	-0.13	0.16	0.87	0.64-1.19	0.39
Employed RCVS specialist ^e	None (Intercept)	1.4 (1.2-1.6)	-4.81	0.06	0.01	0.01-0.01	
	1+ specialist	0.8 (0.5-1.1)	-0.26	0.38	0.77	0.37-1.62	0.49
Continuous factors							
Age (years)	Intercept		-4.81	0.07	0.01	0.01-0.01	
	Age - linear		0.20	0.04	1.22	1.13-1.32	<0.01
	Age - quadratic		-0.03	0.03	0.97	0.93-1.02	0.23
	Age - cubic		0.04	0.02	1.04	1.01-1.08	0.01
rIMD ^f	Intercept		-4.82	0.06	0.01	0.01-0.01	
	rIMD		0.02	0.02	1.02	0.97-1.07	0.39
Dogs per household ^g	Intercept		-4.82	0.06	0.01	0.01-0.01	
	Dogs per household		0.02	0.03	1.03	0.97-1.09	0.40
Dogs per km ² ^g	Intercept		-4.82	0.06	0.01	0.01-0.01	
	Dogs per km		-0.02	0.02	0.98	0.94-1.02	0.31

^a95% Confidence Interval

^bStandard Error

^c Odds Ratio

^d Vonholdt et al., 2010

^e Royal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner (AVP) and / or specialist status

^f Rescaled Indices of Multiple Deprivation (rIMD) quintile, 1 = most deprived

^g Aegerter et al., 2017

Table S6

Descriptive summary of the percentage of total sick canine consultations prescribed a topical antimicrobial. Also included are parameter estimates from a series of univariable mixed effect logistic regression models assessing the association between a range of animal, owner, practitioner and practice-related factors and the probability of prescribing a topical antimicrobial. Random effects include animal, site, and practice.

Variable	Category	% of prescribing consults (CI ^a)	β	SE ^b	OR ^c	CI	P
Categorical factors							
Country	England (Intercept)	14.1 (13.9-14.6)	-1.82	0.02	0.16	0.16-0.17	
	Scotland	13.4 (11.9-14.9)	0.03	0.05	1.03	0.93-1.13	0.58
	Wales	14.7 (13.9-15.6)	-0.06	0.06	0.95	0.85-1.06	0.34
Main presenting complaint	Gastroenteric (Intercept)	1.8 (1.2-2.5)	-3.99	0.05	0.02	0.02-0.02	
	Kidney disease	3.2 (2.4-4.1)	0.61	0.14	1.84	1.41-2.41	<0.01
	Other unwell	15.5 (15.0-16.0)	2.28	0.04	9.79	8.99-10.65	<0.01
	Pruritus	31.7 (30.7-32.8)	3.23	0.04	25.30	23.23-27.55	<0.01
	Respiratory	2.9 (2.3-3.6)	0.48	0.07	1.61	1.40-1.85	<0.01
	Trauma	6.6 (6.2-7.0)	1.32	0.05	3.75	3.43-4.11	<0.01
	Tumour	5.9 (5.5-6.4)	1.22	0.05	3.38	3.04-3.76	<0.01
Sex	Female (Intercept)	13.6 (13.3-14.0)	-1.87	0.02	0.15	0.15-0.16	
	Male	14.8 (14.4-15.2)	0.10	0.01	1.11	1.08-1.13	<0.01
Neuter status	Un-neutered (Intercept)	15.0 (14.6-15.4)	-1.76	0.02	0.17	0.17-0.18	
	Neutered	13.8 (13.4-14.2)	-0.10	0.01	0.91	0.88-0.93	<0.01
Microchip status	Un-microchipped (Intercept)	13.4 (13.1-13.8)	-1.89	0.02	0.15	0.15-0.16	
	Microchipped	14.9 (14.5-15.3)	0.13	0.01	1.14	1.11-1.16	<0.01
Vaccination status	Un-vaccinated (Intercept)	13.2 (12.9-13.6)	-1.90	0.02	0.15	0.14-0.16	
	Vaccinated	14.6 (14.3-15.0)	0.11	0.01	1.12	1.09-1.15	<0.01
Insurance status	Un-insured (Intercept)	14.5 (14.2-14.9)	-1.80	0.02	0.17	0.16-0.17	
	Insured	13.6 (13.2-14.1)	-0.07	0.01	0.93	0.91-0.96	<0.01
Owner urban status	Urban (Intercept)	14.4 (14.0-14.8)	-1.81	0.02	0.16	0.16-0.17	
	Rural	14.0 (13.6-14.4)	-0.04	0.02	0.97	0.94-1.00	0.02
Genetic breed group ^d	Retriever (Intercept)	15.3 (14.7-16.0)	-1.72	0.02	0.18	0.17-0.19	
	Crossbreed	13.3 (12.9-13.7)	-0.01	0.06	0.99	0.89-1.11	0.92
	Ancient / spitz	15.0 (13.5-16.5)	-0.16	0.02	0.85	0.82-0.89	<0.01
	Herding	8.2 (7.7-8.7)	-0.70	0.04	0.50	0.46-0.54	<0.01
	Mastiff-like	17.0 (16.4-17.6)	0.11	0.03	1.11	1.06-1.17	<0.01
	Scent hound	13.3 (12.2-14.3)	-0.18	0.04	0.83	0.77-0.91	<0.01
	Sight hound	5.3 (4.4-6.2)	-1.17	0.07	0.31	0.27-0.36	<0.01
	Small terrier	12.8 (12.3-13.3)	-0.22	0.02	0.80	0.76-0.84	<0.01
	Spaniel	16.1 (15.5-16.6)	0.04	0.02	1.04	0.99-1.08	0.13
	Toy	15.5 (14.7-16.3)	-0.02	0.03	0.99	0.92-1.05	0.64
	Unclassified	15.5 (14.9-16.1)	0.01	0.02	1.01	0.96-1.06	0.73
	Unknown	12.1 (10.8-13.4)	-0.29	0.06	0.75	0.66-0.85	<0.01
	Working dog	13.7 (12.9-14.5)	-0.13	0.03	0.88	0.82-0.93	<0.01
	Practice type	Small animal (Intercept)	14.3 (13.9-14.8)	-1.81	0.02	0.16	0.16-0.17
Mixed		13.6 (12.9-14.3)	-0.08	0.04	0.92	0.85-1.00	0.05
Small & equine		16.2 (14.3-18.2)	0.17	0.09	1.19	0.99-1.42	0.06
Small & large		14.5 (13.6-15.4)	0.00	0.09	1.00	0.84-1.2	0.99
Not accredited (Intercept)		13.3 (12.3-14.4)	-1.90	0.05	0.15	0.14-0.16	
Accreditation	1+ accredited site	14.4 (14.0-14.7)	0.09	0.05	1.10	1.00-1.20	0.05
	1+ hospital site	15.0 (14.3-15.7)	0.07	0.04	1.07	0.99-1.15	0.09
Hospital status	No hospital site (Intercept)	14.0 (13.6-14.4)	-1.83	0.02	0.16	0.15-0.17	
	1+ hospital site	15.0 (14.3-15.7)	0.07	0.04	1.07	0.99-1.15	0.09
Referral interest	No (Intercept)	14.2 (13.9-14.6)	-1.83	0.02	0.16	0.16-0.17	
	Yes	14.2 (13.5-15.0)	0.03	0.03	1.03	0.96-1.10	0.47
Employed RCVS AVP ^e	None (Intercept)	13.9 (13.5-14.3)	-1.84	0.02	0.16	0.15-0.17	
	1+ AVP	15.3 (14.6-15.9)	0.08	0.04	1.08	1.01-1.16	0.03
Employed RCVS specialist ^e	None (Intercept)	14.3 (13.9-14.6)	-1.82	0.02	0.16	0.16-0.17	
	1+ specialist	12.0 (10.2-13.7)	-0.18	0.09	0.84	0.70-1.00+	0.05
Continuous factors							
Age (years)	Intercept		-1.74	0.02	0.20	0.17-0.18	
	Age - linear		-0.32	0.01	0.73	0.71-0.75	<0.01
	Age - quadratic		-0.12	0.01	0.89	0.88-0.90	<0.01
	Age - cubic		0.03	0.01	1.03	1.02-1.04	<0.01
rIMD ^f	Intercept		-1.82	0.02	0.16	0.16-0.17	<0.01
	rIMD		0.01	0.01	1.01	0.99-1.02	0.32
Dogs per household ^g	Intercept		-1.82	0.02	0.16	0.16-0.17	
	Dogs per household		-0.01	0.01	0.99	0.98-1.01	0.40
Dogs per km ² ^g	Intercept		-1.82	0.02	0.16	0.16-0.17	
	Dogs per km		0.00	0.01	1.00	0.99-1.01	0.98

^a95% Confidence Interval^bStandard Error^cOdds Ratio

^d Vonholdt et al., 2010

^e Royal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner (AVP) and / or specialist status

^f Rescaled Indices of Multiple Deprivation (rIMD) quintile, 1 = most deprived

^g Aegerter et al., 2017

Table S7

Descriptive summary of the percentage of total sick feline consultations where an animal was prescribed at least one antimicrobial (systemic, topical or systemic highest priority critically important (HPCIA) compared against animal breed, including breeds where in excess of 1,000 consultations were recorded.

Genetic breed group	Cat breed	n consults	Systemic		Topical		Systemic HPCIA	
			% ^b	95% CI ^c	%	95% CI	%	95% CI
Asian	Burmese	1,314	32.1	28.8-35.4	8.9	6.8-11.0	18.8	15.6-22.0
Asian	Siamese	1,814	35.3	31.9-38.7	5.0	3.9-6.2	17.6	14.8-20.4
Crossbreed	Crossbreed	93,599	32.9	31.9-33.8	5.7	5.5-5.9	17.2	16.1-18.4
Unclassified	Bengal	1,024	37.0	33.1-40.9	8.8	6.7-11.0	20.3	16.8-23.8
Unknown	Unknown	4,244	34.0	32.4-35.6	7.4	6.5-8.3	18.0	15.6-20.3
West Europe	British	2,707	29.1	26.1-32.2	9.5	7.3-11.6	14.6	12.2-17.0
West Europe	Persian	1,870	29.9	26.6-33.2	11.0	9.3-12.7	16.1	13.4-18.8

^a Lipinski et al., 2008

^b Percentage of consultations where at least one antimicrobial was prescribed

^c 95% Confidence Interval

^d Highest priority critically important antimicrobial

Table S8

Descriptive summary of the percentage of total sick feline consultations prescribed a systemic antimicrobial. Also included are parameter estimates from a series of univariable mixed effect logistic regression models assessing the association between a range of animal, owner, practitioner and practice-related factors and the probability of prescribing a systemic antimicrobial. Random effects include animal, site, and practice.

Variable	Category	% of prescribing consults (CI ^a)	β	SE ^b	OR ^c	CI	P
Categorical factors							
Country	England (Intercept)	32.5 (31.5-33.5)	-0.77	0.03	0.46	0.44-0.49	
	Scotland	37.0 (33.9-40.1)	0.06	0.09	1.06	0.90-1.26	0.47
	Wales	33.4 (29.9-37.0)	0.34	0.10	1.40	1.15-1.71	<0.01
Main presenting complaint	Gastroenteric (Intercept)	30.5 (28.1-32.9)	-0.83	0.04	0.44	0.41-0.47	
	Kidney disease	20.7 (18.8-22.6)	-0.47	0.05	0.62	0.56-0.69	<0.01
	Other unwell	27.2 (26.1-28.2)	-0.20	0.03	0.82	0.78-0.87	<0.01
	Pruritus	26.8 (24.9-28.7)	-0.23	0.03	0.79	0.74-0.85	<0.01
	Respiratory	53.0 (50.6-55.4)	0.91	0.04	2.49	2.32-2.69	<0.01
	Trauma	53.5 (52.3-54.7)	0.99	0.03	2.68	2.53-2.84	<0.01
	Tumour	20.7 (19.0-22.3)	-0.58	0.05	0.56	0.51-0.62	<0.01
Sex	Female (Intercept)	30.1 (29.1-31.1)	-0.88	0.03	0.42	0.39-0.44	
	Male	35.4 (34.4-36.4)	0.26	0.02	1.30	1.26-1.34	<0.01
Neuter	Un-neutered (Intercept)	33.1 (31.9-34.2)	-0.74	0.03	0.48	0.45-0.51	
	Neutered	32.8 (31.8-33.8)	-0.00	0.02	1.00	0.96-1.04	0.87
Microchip status	Un-microchipped (Intercept)	32.2 (31.3-33.2)	-0.80	0.03	0.45	0.43-0.48	
	Microchipped	33.9 (32.8-35.1)	0.14	0.02	1.15	1.12-1.19	<0.01
Vaccination status	Un-vaccinated (Intercept)	33.6 (32.6-34.6)	-0.73	0.03	0.48	0.46-0.51	
	Vaccinated	32.2 (31.2-33.2)	-0.03	0.02	0.97	0.94-1.00	0.05
Insurance status	Un-insured (Intercept)	33.8 (32.8-34.8)	-0.71	0.03	0.49	0.47-0.52	
	Insured	28.9 (27.7-30.1)	-0.20	0.02	0.82	0.79-0.86	<0.01
Owner urban status	Urban (Intercept)	32.1 (31.1-33.1)	-0.76	0.03	0.47	0.44-0.50	
	Rural	34.8 (33.3-36.2)	0.04	0.02	1.05	1.00-1.09	0.04
Genetic breed group ^d	West Europe (Intercept)	30.8 (29.1-32.4)	-0.88	0.04	0.41	0.38-0.45	
	Asian	33.1 (30.7-35.5)	0.14	0.05	1.15	1.04-1.27	0.01
	Crossbreed	32.9 (31.9-33.8)	0.14	0.03	1.16	1.0-1.23	<0.01
	Mediterranean	42.5 (27.5-57.4)	0.48	0.26	1.61	0.97-2.67	0.06
	Unclassified	34.7 (32.2-37.3)	0.22	0.06	1.25	1.11-1.39	<0.01
	Unknown	34.0 (32.4-35.6)	0.18	0.05	1.19	1.08-1.31	<0.01
Practice type	Small animal (Intercept)	32.2 (31.1-33.2)	-0.79	0.03	0.45	0.43-0.48	
	Mixed	35.4 (32.8-38.0)	0.24	0.08	1.27	1.10-1.47	<0.01
	Small & equine	28.7 (22.4-35.0)	-0.02	0.17	0.98	0.70-1.38	0.90
	Small & large	37.7 (32.7-42.7)	0.25	0.16	1.29	0.94-1.76	0.11
Accreditation	Not accredited (Intercept)	36.4 (34.2-38.6)	-0.54	0.08	0.58	0.50-0.68	
	1+ accredited site	32.2 (31.2-33.2)	-0.23	0.09	0.80	0.67-0.94	<0.01
Hospital status	No hospital site (Intercept)	33.3 (32.2-34.4)	-0.72	0.03	0.49	0.46-0.52	
	1+ hospital site	31.2 (29.5-32.9)	-0.13	0.07	0.88	0.76-1.01	0.07
Referral interest	No (Intercept)	33.2 (32.1-34.3)	-0.71	0.03	0.49	0.46-0.53	
	Yes	31.9 (30.1-33.8)	-0.11	0.06	0.90	0.79-1.01	0.08
Employed RCVS AVP ^e	None (Intercept)	33.4 (32.3-34.5)	-0.71	0.03	0.49	0.46-0.53	
	1+ AVP	31.3 (29.4-33.2)	-0.18	0.07	0.84	0.73-0.96	0.01
Employed RCVS specialist ^e	None (Intercept)	32.9 (32.0-33.9)	-0.74	0.03	0.48	0.45-0.51	
	1+ specialist	29.0 (24.7-33.4)	-0.14	0.17	0.87	0.62-1.21	0.41
Continuous factors							
Age (years)	Intercept		-0.64	0.03	0.53	0.50-0.56	
	Age - linear		-0.53	0.02	0.59	0.57-0.61	<0.01
	Age - quadratic		-0.13	0.01	0.87	0.86-0.89	<0.01
	Age - cubic		0.12	0.01	1.13	1.11-1.15	<0.01
rIMD ^f	Intercept		-0.74	0.03	0.48	0.45-0.50	
	IMD		-0.03	0.01	0.97	0.96-0.99	<0.01
Cats per household ^g	Intercept		-0.74	0.03	0.48	0.45-0.50	
	Cats per household		-0.00	0.01	1.00	0.97-1.02	0.73
Cats per km ^{2g}	Intercept		-0.74	0.03	0.48	0.45-0.50	
	Cats per km		-0.02	0.01	0.98	0.97-1.00	0.02

^a95% Confidence Interval

^bStandard Error

^cOdds Ratio

^dLipinski et al., 2008

^eRoyal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner (AVP) and / or specialist status

^fRescaled Indices of Multiple Deprivation (rIMD) quintile, 1 = most deprived

^gAegerter et al., 2017

Table S9

Descriptive summary of the percentage of total sick feline consultations prescribed a systemic highest priority critically important antimicrobial (HPCIA). Also included are parameter estimates from a series of univariable mixed effect logistic regression models assessing the association between a range of animal, owner, practitioner and practice-related factors and the probability of prescribing a systemic HPCIA. Random effects include animal, site, and practice.

Variable	Category	% of prescribing consults (CI ^a)	β	SE ^b	OR ^c	CI	P
Categorical factors							
Country	England (Intercept)	17.1 (16.0-18.1)	-1.71	0.06	0.18	0.16-0.20	
	Scotland	17.5 (9.8-25.3)	0.07	0.12	1.07	0.86-1.35	0.54
	Wales	18.0 (14.9-21.1)	0.18	0.17	1.20	0.86-1.68	0.29
Main presenting complaint	Gastroenteric (Intercept)	6.9 (5.9-7.9)	-2.71	0.07	0.07	0.06-0.08	
	Kidney disease	13.7 (11.9-15.5)	0.75	0.07	2.12	1.84-2.44	<0.01
	Other unwell	14.2 (13.2-15.2)	0.79	0.05	2.20	2.02-2.41	<0.01
	Pruritus	19.8 (18.1-21.5)	1.17	0.05	3.23	2.92-3.57	<0.01
	Respiratory	29.4 (26.9-31.9)	1.72	0.05	5.57	5.00-6.19	<0.01
	Trauma	27.1 (24.6-29.5)	1.68	0.05	5.35	4.88-5.87	<0.01
	Tumour	12.3 (11.0-13.7)	0.57	0.07	1.77	1.55-2.01	<0.01
Sex	Female (Intercept)	16.3 (15.2-17.4)	-1.76	0.06	0.17	0.15-0.19	
	Male	17.9 (16.7-19.1)	0.13	0.02	1.14	1.10-1.18	<0.01
Neuter	Un-neutered (Intercept)	16.3 (15.0-17.7)	-1.78	0.06	0.17	0.15-0.19	
	Neutered	17.3 (16.2-18.4)	0.10	0.03	1.11	1.06-1.16	<0.01
Microchip status	Un-microchipped (Intercept)	16.8 (15.7-17.9)	-1.73	0.06	0.18	0.16-0.20	
	Microchipped	17.6 (16.4-18.8)	0.08	0.02	1.09	1.05-1.13	<0.01
Vaccination status	Un-vaccinated (Intercept)	17.5 (16.3-18.7)	-1.67	0.06	0.19	0.17-0.21	
	Vaccinated	16.8 (15.7-17.8)	-0.05	0.02	0.95	0.91-0.98	<0.01
Insurance status	Un-insured (Intercept)	17.6 (16.5-18.8)	-1.67	0.06	0.19	0.17-0.21	
	Insured	15.0 (13.7-16.2)	-0.13	0.03	0.88	0.84-0.93	<0.01
Owner urban status	Urban (Intercept)	16.5 (15.4-17.6)	-1.71	0.06	0.18	0.16-0.20	
	Rural	18.7 (16.9-20.5)	0.06	0.03	1.06	1.01-1.11	0.03
Genetic breed group ^d	West Europe (Intercept)	15.3 (13.8-16.9)	-1.88	0.07	0.15	0.13-0.17	
	Asian	17.2 (15.2-19.3)	0.19	0.07	1.21	1.06-1.37	<0.01
	Crossbreed	17.2 (16.1-18.3)	0.20	0.04	1.23	1.13-1.33	<0.01
	Mediterranean	22.0 (7.1-36.9)	0.11	0.32	1.12	0.60-2.09	0.73
	Unclassified	16.6 (14.7-18.6)	0.15	0.07	1.16	1.01-1.34	0.04
Practice type	Unknown	18.0 (15.6-20.3)	0.14	0.06	1.15	1.02-1.30	0.02
	Small animal (Intercept)	16.5 (15.3-17.8)	-1.73	0.06	0.18	0.16-0.20	
	Mixed	18.8 (16.1-21.5)	0.10	0.16	1.11	0.81-1.50	0.52
	Small & equine	18.2 (12.7-23.7)	0.27	0.37	1.30	0.64-2.67	0.47
	Small & large	20.1 (14.4-25.9)	0.28	0.32	1.32	0.71-2.46	0.38
Accreditation	Not accredited (Intercept)	14.5 (10.5-18.4)	-1.93	0.16	0.15	0.11-0.20	
	1+ accredited site	17.7 (16.6-18.7)	0.27	0.17	1.31	0.93-1.83	0.12
Hospital status	No hospital site (Intercept)	17.0 (15.7-18.4)	-1.67	0.06	0.19	0.17-0.21	
	1+ hospital site	17.4 (15.6-19.1)	-0.14	0.15	0.87	0.65-1.16	0.34
Referral interest	No (Intercept)	17.5 (16.1-18.8)	-1.67	0.07	0.19	0.17-0.22	
	Yes	16.2 (14.3-18.2)	-0.08	0.12	0.92	0.72-1.17	0.50
Employed RCVS AVP ^e	None (Intercept)	17.3 (15.9-18.6)	-1.69	0.06	0.19	0.16-0.21	
	1+ AVP	16.8 (14.8-18.7)	-0.04	0.14	0.96	0.73-1.27	0.77
Employed RCVS specialist ^e	None (Intercept)	17.1 (16.0-18.2)	-1.70	0.06	0.18	0.16-0.21	
	1+ specialist	16.5 (12.5-20.5)	0.06	0.34	1.07	0.55-2.06	0.85
Continuous factors							
Age (years)	Intercept		-1.51	0.06	0.22	0.20-0.25	
	Age - linear		-0.38	0.02	0.68	0.66-0.71	<0.01
	Age - quadratic		-0.20	0.01	0.82	0.80-0.83	<0.01
	Age - cubic		0.17	0.01	1.18	1.16-1.20	<0.01
rIMD ^f	Intercept		-1.69	0.06	0.18	0.17-0.21	
	IMD		0.00	0.01	1.00	0.98-1.03	0.83
Cats per household ^g	Intercept		-1.69	0.06	0.18	0.17-0.21	
	Cats per household		0.01	0.02	1.01	0.98-1.04	0.54
Cats per km ² ^g	Intercept		-1.69	0.06	0.18	0.16-0.21	
	Cats per km		-0.01	0.01	0.99	1.00-1.01	0.28

^a95% Confidence Interval

^bStandard Error

^cOdds Ratio

^dLipinski et al., 2008

^eRoyal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner (AVP) and / or specialist status

^fRescaled Indices of Multiple Deprivation (rIMD) quintile, 1 = most deprived

^gAegerter et al., 2017

Table S10

Descriptive summary of the percentage of total sick feline consultations prescribed a topical antimicrobial. Also included are parameter estimates from a series of univariable mixed effect logistic regression models assessing the association between a range of animal, owner, practitioner and practice-related factors and the probability of prescribing a topical antimicrobial. Random effects include animal, site, and practice.

Variable	Category	% of prescribing consults (CI ^a)	β	SE ^a	OR ^b	CI ^c	P
Categorical factors							
Country	England (Intercept)	6.0 (5.8-6.3)	-2.77	0.02	0.06	0.06-0.07	
	Scotland	6.6 (5.5-7.7)	0.07	0.09	1.07	0.90-1.28	0.45
	Wales	6.6 (6.0-7.2)	0.14	0.09	1.15	0.97-1.36	0.11
Main presenting complaint	Gastroenteric (Intercept)	1.1 (0.6-1.6)	-4.47	0.10	0.01	0.01-0.01	
	Kidney disease	0.8 (0.5-1.1)	-0.34	0.23	0.72	0.46-1.11	0.14
	Other unwell	7.1 (6.8-7.4)	1.89	0.10	6.59	5.40-8.04	<0.01
	Pruritus	10.8 (10.0-11.7)	2.35	0.11	10.49	8.54-12.89	<0.01
	Respiratory	5.7 (4.9-6.4)	1.63	0.12	5.10	4.07-6.40	<0.01
	Trauma	4.6 (4.3-5.0)	1.43	0.11	4.20	3.41-5.17	<0.01
	Tumour	1.7 (1.3-2.1)	0.42	0.16	1.53	1.13-2.08	0.01
Sex	Female (Intercept)	6.0 (5.7-6.2)	-2.78	0.03	0.06	0.06-0.07	
	Male	6.2 (6.0-6.5)	0.04	0.03	1.05	0.99-1.10	0.11
Neuter status	Un-neutered (Intercept)	7.3 (6.8-7.7)	-2.57	0.04	0.08	0.07-0.08	
	Neutered	5.9 (5.6-6.1)	-0.23	0.03	0.79	0.74-0.85	<0.01
Microchip status	Un-microchipped (Intercept)	5.9 (5.7-6.2)	-2.79	0.03	0.06	0.06-0.07	
	Microchipped	6.4 (6.0-6.7)	0.09	0.03	1.09	1.03-1.16	<0.01
Vaccination status	Un-vaccinated (Intercept)	6.2 (5.9-6.5)	-2.74	0.03	0.06	0.06-0.07	
	Vaccinated	6.0 (5.8-6.3)	-0.02	0.03	0.98	0.93-1.03	0.42
Insurance status	Un-insured (Intercept)	6.3 (6.1-6.5)	-2.72	0.02	0.07	0.06-0.07	
	Insured	5.3 (4.9-5.8)	-0.19	0.04	0.83	0.77-0.89	<0.01
Owner urban status	Urban (Intercept)	6.0 (5.8-6.3)	-2.77	0.03	0.06	0.06-0.07	
	Rural	6.3 (5.9-6.7)	0.04	0.03	1.04	0.97-1.11	0.26
Genetic breed group ^d	West Europe (Intercept)	9.5 (8.4-10.6)	-2.28	0.05	0.10	0.09-0.11	
	Asian	6.9 (5.8-8.0)	-0.29	0.09	0.75	0.63-0.88	<0.01
	Crossbreed	5.7 (5.5-5.9)	-0.54	0.05	0.58	0.53-0.64	<0.01
	Mediterranean	5.5 (0.5-10.4)	-0.47	0.49	0.62	0.24-1.64	0.34
	Unclassified	8.3 (7.2-9.5)	-0.13	0.09	0.88	0.74-1.05	0.17
	Unknown	7.4 (6.4-8.3)	-0.29	0.08	0.75	0.64-0.88	<0.01
	Practice type	Small animal (Intercept)	6.0 (5.8-6.3)	-2.77	0.03	0.06	0.06-0.07
	Mixed	6.4 (5.9-7.0)	0.07	0.06	1.08	0.96-1.21	0.20
	Small & equine	5.7 (4.5-6.8)	-0.11	0.14	0.89	0.68-1.18	0.43
	Small & large	6.4 (5.5-7.3)	0.09	0.12	1.09	0.86-1.39	0.47
Accreditation	Not accredited (Intercept)	5.9 (5.2-6.5)	-2.77	0.06	0.06	0.06-0.07	
	1+ accredited site	6.2 (5.9-6.4)	0.02	0.07	1.02	0.90-1.16	0.74
Hospital status	No hospital site (Intercept)	6.0 (5.7-6.2)	-2.76	0.03	0.06	0.06-0.07	
	1+ hospital site	6.5 (6.1-6.9)	0.04	0.06	1.05	0.94-1.16	0.42
Referral interest	No (Intercept)	6.0 (5.8-6.3)	-2.78	0.03	0.06	0.06-0.07	
	Yes	6.3 (5.9-6.8)	0.08	0.05	1.08	0.98-1.19	0.10
Employed RCVS AVP ^e	None (Intercept)	6.1 (5.9-6.4)	-2.75	0.03	0.06	0.06-0.07	
	1+ AVP	6.0 (5.6-6.4)	-0.03	0.05	0.97	0.87-1.08	0.57
Employed RCVS specialist ^e	None (Intercept)	6.1 (5.9-6.3)	-2.75	0.02	0.06	0.06-0.07	
	1+ specialist	5.3 (4.1-6.6)	-0.13	0.14	0.88	0.66-1.16	0.36
Continuous factors							
Age (years)	Intercept		-2.86	0.03	0.06	0.05-0.06	
	Age - linear		-0.29	0.03	0.75	0.70-0.79	<0.01
	Age - quadratic		0.04	0.02	1.04	1.01-1.08	0.01
	Age - cubic		-0.04	0.02	0.96	0.93-0.99	0.01
rIMD ^f	Intercept		-2.76	0.02	0.06	0.06-0.07	
	IMD		-0.04	0.02	0.96	0.93-0.99	0.01
Cats per household ^g	Intercept		-2.75	0.02	0.06	0.06-0.07	
	Cats per household		0.01	0.02	1.01	0.97-1.04	0.72
Cats per km ^{2g}	Intercept		-2.75	0.02	0.06	0.06-0.07	
	Cats per km		0.01	0.01	1.01	0.98-1.03	0.72

^a95% Confidence Interval

^bStandard Error

^cOdds Ratio

^dLipinski et al., 2008

^eRoyal College of Veterinary Surgeons (RCVS) Advanced Veterinary Practitioner (AVP) and / or specialist status

^fRescaled Indices of Multiple Deprivation (rIMD) quintile, 1 = most deprived

