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Factors influencing common diagnoses made during first-opinion small-animal consultations in the United Kingdom

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ABSTRACT

It is currently unclear how frequently a diagnosis is made during small-animal consultations or how much of a role making a diagnosis plays in veterinary decision-making. Understanding more about the diagnostic process will help direct future research towards areas relevant to practicing veterinary surgeons. The aim of this study was to determine the frequency with which a diagnosis was made, classify the types of diagnosis made (and the factors influencing these) and determine which specific diagnoses were made for health problems discussed during small-animal consultations.

Data were gathered during real-time direct observation of small-animal consultations in eight practices in the United Kingdom. Data collected included characteristics of the consultation (e.g. consultation type), patient (e.g. breed), and each problem discussed (e.g. new or pre-existing problem). Each problem discussed was classified into one of the following diagnosis types: definitive; working; presumed; open; previous. A three-level multivariable logistic-regression model was developed, with problem (Level 1) nested within patient (Level 2) nested within consulting veterinary surgeon (Level 3). Problems without a previous diagnosis, in cats and dogs only, were included in the model, which had a binary outcome variable of definitive diagnosis versus no definitive diagnosis.

Data were recorded for 1901 animals presented, and data on diagnosis were gathered for 3192 health problems. Previous diagnoses were the most common diagnosis type (n = 1116/3192; 35.0%), followed by open (n = 868/3192; 27.2%) then definitive (n = 660/3192; 20.7%). The variables remaining in the final model were patient age, problem history, consultation type, who raised the problem, and body system affected. New problems, problems in younger animals, and problems raised by the veterinary surgeon were more likely to result in a definitive diagnosis than pre-existing problems, problems in older animals, and problems raised by the owner. The most common diagnoses made were overweight/obese and periodontal disease (both n = 210; 6.6%).

Definitive diagnoses are rarely made during small-animal consultations, with much of the veterinary caseload involving management of ongoing problems or making decisions around new problems prior to a diagnosis being made. This needs to be taken into account when considering future research priorities, and it may be necessary to conduct research focused on the approach to common clinical presentations, rather than purely on the common diagnoses made. Examining how making a diagnosis affects the actions taken during the consultation may shed further light on the role of diagnosis in the clinical decision-making process.

1. Introduction

A diagnosis has been defined as 'the label given to a disease with certain clinical or pathologic characteristics applicable to a particular case' (Radostits et al., 2000) and are sought because they

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can influence the clinical work-up and outcome of cases, as well as being useful for billing and administrative purposes. In first-opinion veterinary practice, a definitive diagnosis may not always be reached, yet decisions on how to manage cases still have to be made. In medicine, it has been suggested that diagnoses are only useful where they influence decision-making, by changing the action taken, changing the eventual outcome of a case or providing a prognosis (Del Mar et al., 2006). Evidence on the diagnostic process in general practice is limited in human healthcare, particularly in terms of assessing the quality of the diagnosis made and the impact of making a diagnosis on patient outcomes (Foot et al., 2010).

It is currently unclear how making a diagnosis influences the decisions made during veterinary consultations. Understanding veterinary decision-making is vital to the process of evidence-based veterinary medicine (EVM), as the aim of EVM is to aid clinicians in making the best decisions for their patients (Dean et al., 2015). Determining how frequently a diagnosis is reached will further our understanding of the role of diagnosis in the decision-making process. In a previous study, Lund et al. (1999) found that a diagnostic code was assigned for only 36% of patient records, however this included transactions not involving a consultation, and so the rate of diagnosis in small-animal consultations remains unclear. Further research is needed to determine which factors influence whether a diagnosis is reached, such as the type of problem, the type of patient (e.g. species), which consulting veterinary surgeon is seen, and which practice is visited, as well as the common diagnoses made. Recent research by the Centre for Evidence-based Veterinary Medicine has suggested that consultations are highly complex with multiple different problems discussed (Robinson et al., 2015a), with the electronic patient record potentially limited in how much complexity it can capture (Jones-Diette, 2014). Examining the types of diagnoses made during small-animal consultations in detail, for all problems discussed, will allow future research and education to be targeted towards common decision-making points.

The primary aim of this study was to determine the frequency with which a diagnosis was made, classify the types of diagnosis made, and to determine the factors influencing these diagnoses during first-opinion small-animal consultations. The secondary aim was to determine which specific diagnoses were made for problems receiving a diagnosis during these consultations.

2. Materials and methods

2.1. Practice selection

A convenience sample of eight first-opinion veterinary practices was recruited (Robinson et al., 2015a). Practices recruited were those involved in a previous study (Dean et al., 2013), or those who had expressed interest in working with the Centre for Evidence-based Veterinary Medicine (CEVM). All eight practices approached agreed to take part in the study. Eight practices in total were chosen as this was considered to be the maximum number of practices which could feasibly be studied using the methods selected. Six practices were located in England (three in the Midlands and three in the South) and two practices were located in Scotland. Five practices treated small animals only, while three practices also treated farm and equine patients. Three practices were single branch only, while five practices had two or more branches. The median number of veterinary surgeons carrying out small-animal consultations per practice was 8 (range 3–20). The median years qualified of all veterinary surgeons observed was 14.3 (range 1–40 years). Of the 62 veterinary surgeons observed, 12 (19.4%) were certificate holders. Further details on the sample of practices involved in the study are reported in Robinson (2014).

2.2. Data-collection tool

2.2.1. Development of the tool

A data-collection tool was developed to allow the collection of complex data by real-time direct observation during small-animal consultations at participating practices. The tool consisted of a series of open and closed questions on a paper form and was used to gather data on various characteristics of the consultation, patient presented, and all problems discussed. Following initial development of the tool, pre-test and pilot studies were conducted between August 2010 and March 2011 to help identify any issues relating to design of the data-collection tool or feasibility of data collection. Pre-testing involved collection of data by the primary investigator (NR) and another author (RD) during a single morning each at two of the practices, in August 2010. A pilot study was then conducted between September 2010 and March 2011, with data collected by the primary investigator during a single day at each of the eight practices. An inter-rater reliability assessment of the tool was carried out in May 2012. Development, testing, and utilisation of the data-collection tool has been described in more detail previously (Robinson et al., 2015a).

2.2.2. Data collected

Data were collected on all problems discussed during the consultation. A problem was defined as 'any two-way discussion between owner/carer and vet regarding any aspect of the patient's health and wellbeing'. The reason for presentation (as stated by the owner or veterinary surgeon) or first problem raised where this was not stated, was considered to be the 'presenting problem'; each additional problem discussed was considered to be a 'non-presenting problem'. Each problem discussed was considered to be either a preventive-medicine problem if it related to the prevention of disease or injury (e.g. vaccination) or a specific health problem if it related to a health problem currently affecting the animal (e.g. vomiting and diarrhoea). All problems relating to preventive medicine were excluded from the analysis because a diagnosis was not relevant for these particular problems; however all specific health problems were included in analysis, including those raised during preventive-medicine consultations.

Data collected on characteristics of the consultation and patient included patient signalment; type of clinical examination performed (one selected from: None; Full; Focused); type of consultation (preventive-medicine consultation if the presenting problem related to preventive medicine, specific health-problem consultation if the presenting problem was a current health problem); whether the patient was weighed; total number of problems discussed during the consultation. Data on the individual breed of each patient presented were recorded, and were later condensed into a binary variable of purebred or crossbreed for analysis purposes. Data collected for each specific health problem included: problem history i.e. whether the problem was new or pre-existing; whether the problem was first raised by the veterinary surgeon or owner; the body system affected by the problem; whether there were any diagnostic tests performed for that problem; diagnosis type; specific diagnosis. Definitions were developed for consultation type, clinical examination type, problem history, body system affected, and diagnostic testing to ensure consistent categorisation (Appendix A). Further details around the development and coding of these variables have been discussed in previous publications (Robinson et al., 2015a,b, 2016).

2.2.3. Diagnosis type

Initially, a simple 'yes/no' closed field was included in the data-collection tool to record whether a diagnosis had been reached for each problem (including both presenting and non-presenting specific health problems). However, during the pre-test it was found

that this question was often difficult to answer, so a series of definitions for the type of diagnosis made (referred to as 'diagnosis type') were developed, then trialled during the pilot study. Only one diagnosis type could be selected for each problem from the following list: Previous (a diagnosis was made during a previous consultation or diagnostic work-up); Definitive (a diagnosis confirmed with a 'gold standard' test for that disease); Working (a diagnosis made provisionally whilst awaiting the results of a 'gold standard' test for that disease); Presumed (a diagnosis made based on clinical suspicion and other evidence where a 'gold standard' test has not been performed); Open (a diagnosis has not been made and/or multiple differential diagnoses are being considered at the end of the consultation). The diagnosis type made for each problem discussed was recorded using a closed field.

2.2.4. Specific diagnosis

Where a definitive, working, presumed or previous diagnosis was made, the disease diagnosed (e.g. hyperthyroidism) was also recorded (referred to as 'specific diagnosis'). Where an open diagnosis was made, this field was left blank. Whilst only one diagnosis type could be recorded for each problem, up to two specific diagnoses could be recorded (e.g. 'degenerative mitral valve disease' and 'congestive heart failure'), as it was found during the pilot study that a single specific diagnosis was sometimes insufficient.

All specific diagnoses were coded at the data entry stage by the primary investigator to ensure consistent terminology was used for the same disease, for example, feline lower urinary tract disease was always coded as this, rather than feline idiopathic cystitis or feline urologic syndrome. To ensure consistent coding, records were kept detailing how cases were coded, which could be referred back to when coding subsequent similar cases to ensure the same terminology was used. Where queries arose surrounding the categorisation and coding of data, discussions with colleagues in the Centre for Evidence-based Veterinary Medicine (CEVM) and veterinary surgeons in first-opinion practice were used to decide how data should be coded. A record was kept of these discussions to ensure similar cases were coded in the same way.

2.3. Data collection

Data were gathered during two separate one-week periods at each of the eight participating practices. The primary investigator observed consultations by a number of different vets during regular weekday consulting hours between April 2011 and June 2012. Where multiple veterinary surgeons were consulting simultaneously, selection of consultation stream to observe was based on convenience and feasibility (e.g. consultation room size), however an effort was made to ensure some time was spent observing each veterinary surgeon during the data-collection period.

2.4. Statistical analysis

Descriptive statistics were carried out using IBM® SPSS® Statistics 21. Pivot tables were used to generate frequency data for both diagnosis type and specific diagnosis. Where specific diagnoses are listed, the 10 most frequently recorded diagnoses are displayed. The chi-square test was used to compare categorical variables, for example species by diagnosis type. The Kruskal-Wallis test was used to compare numerical (non-parametric) and categorical variables, for example age distribution between diagnosis types. Statistical significance was initially set at the 0.05 level with a Bonferroni correction carried out to account for multiple testing (Petrie and Sabin, 2009).

A multi-level multivariable model was built to investigate factors which influenced whether a definitive diagnosis was reached during the consultation. Only data collected for dogs and cats were included in the model. Problems with 'Previous' diagnoses were excluded from the model, because the topic of interest was whether a new diagnosis was made during the consultation. A binary outcome variable for diagnosis type was used with definitive diagnosis coded as 1 and other diagnosis types (open, presumed and working) combined and coded as 0. The models were developed in MLwiN version 2.10. A three-level model was built with problem (Level 1) nested within patient (Level 2) nested within consulting veterinary surgeon (Level 3). Due to the small number of practices, practice was not included as a fourth level and was instead added into the model as a veterinary surgeon level explanatory variable. A single-level model and a two-level model (with problem nested within patient) were also built, with the three-level model selected as the final model as it showed the best model fit using Deviance information criterion (DIC). However inclusion of the two additional levels had relatively little impact on the magnitude of coefficients for variables retained within the model.

Explanatory variables added into the model consisted of characteristics of the consultation, aspects of patient signalment and characteristics of the problems discussed which had a p value of <0.2 on initial chi-square and Kruskall-Wallis analysis. Cross-tabulations were performed for all explanatory variables prior to building the model, and examined for evidence of strong collinearity. All variables added into the model were categorical with the exception of patient age, which was centred around the grand mean upon addition to the model. The Box-Tidwell test was conducted to test the assumption that the logit of the outcome variable had a linear relationship to patient age (Hosmer and Lemeshow, 1989). An interaction term between patient age and its natural log was added to the model and examined for significance (as significance would suggest a non-linear relationship). Problem number was added as a categorical variable, with categories consisting of 1 problem, 2 problems, 3 problems, and 4 or more problems, to avoid making assumptions about linearity. Body system was added to the model as a categorical variable with the ten most frequently affected body systems as separate dummy variables. The remaining body systems, which often had very small numbers, were grouped into a single reference category which was called 'Other'. Forward selection was initially used to build the model, with variables added one at a time. Iterative generalised least squares (IGLS) were used for initial parameter estimates with significance calculated using the Wald test (Hox, 2010). Markov-chain Monte Carlo (MCMC) simulations with 50,000 iterations and a burn-in length of 5000 were then used for final parameter estimates, using IGLS estimates as starting values and with diffuse prior distributions specified for model parameters. MCMC estimation was used because it produces more reliable estimates (Browne and Draper, 2006) particularly where there are smaller sample sizes within level 2 units (i.e. where only a small number of consultations were recorded for some veterinary surgeons). Deviance information criterion (DIC) was used as a measure of goodness-of-fit, with decreasing DIC representing improved model fit, and therefore the final model selected was that with the lowest DIC. Random-intercept models were fitted first then random-slope models examined for each variable. Two-way interaction terms were then evaluated for each possible pair of explanatory variables, including those not retained as main effects. Variance at the patient level (Level 2) and consulting-veterinary-surgeon level (Level 3) was estimated using the latent-variable approach (Goldstein et al., 2002). The model took the form:

$$\text{Definitive}_{ijk} \sim \text{Binomial}\,(n_{ijk}, \pi_{ijk})$$

$$\text{logit}(\pi_{ijk}) = \beta_{0jk} + \beta_1 \times 1_{ijk} + \beta_2 \times 2_{ijk} + \beta_3 \times 3_{ijk} + \beta_4 \times 4_{ijk} \ldots$$
$$+ \beta_k x k_{ijk}$$

$$\beta_{0jk} = \beta_0 + v_{0k} + u_{0jk}$$

Definitive$_{ijk}$ denotes the type of diagnosis made for the ith problem discussed for the jth patient presented to the kth veterinary surgeon, u_{0jk} is the random effect for patient j presented to veterinary surgeon k and v_{0k} is the random effect for veterinary surgeon k. $\beta_{1 \times} 1_{ijk}$, $\beta_{2 \times} 2_i$, and so on are the explanatory variables and their associated coefficients.

2.5. Ethical approval

Approval was obtained from the ethics committee at the School of Veterinary Medicine and Science, The University of Nottingham for the collection of data through direct observation, and subsequent analysis of this data. Details of how informed consent was obtained and data anonymised have been highlighted in a previous manuscript (Robinson et al., 2015a).

3. Results

3.1. Diagnosis type

Data were recorded for 1901 animals presented, with 4486 problems discussed, of which 3206 problems related to a specific health problem (rather than preventive medicine) and so were included in the analysis. Data were missing for 14 problems, 11 of which were presenting problems relating to elective euthanasia consultations. This left 3192/3206 problems (99.6%) for which data on diagnosis type were available, of which 1200/3192 were presenting problems and 1992/3192 were non-presenting problems.

Overall, previous diagnoses were the most common diagnosis type (n = 1116/3192; 35.0%), followed by open diagnoses (n = 868/3192; 27.2%) then definitive diagnoses (n = 660/3192; 20.7%). The Bonferroni correction resulted in an adjusted significance level of p = 0.003. Diagnosis type did not vary significantly with sex (p = 0.886) or breed (p = 0.004) but did vary significantly with a number of other consultation characteristics, patient characteristics, and problem characteristics (Table 1). The majority of pre-existing problems (n = 1116/1511; 73.9%) already had a previous diagnosis, however most of those which did not still had an open diagnosis at the end of the consultation i.e. the problem remained undiagnosed. Problems which had a previous diagnosis were more likely to be raised by the veterinary surgeon rather than the owner and were more likely to be the presenting problem rather than a non-presenting problem. Problems with a previous diagnosis were also more likely to receive a focused or no clinical examination as opposed to a full clinical examination. Problems raised by the owner more frequently resulted in a presumed or open diagnosis than problems which were raised by the veterinary surgeon. In rabbits and other species, definitive diagnoses were made less frequently and presumed diagnoses more frequently than in cats and dogs. Diagnosis type also varied significantly with age (p < 0.001) and number of problems discussed (p < 0.001).

Diagnosis type made also varied significantly depending upon body system affected (p < 0.001; Table 2). Definitive diagnoses were made most frequently for dental (n = 169/262; 64.5%) problems. Definitive diagnoses were never made during the consultation for neurological, endocrine or renal problems.

Data for 1958 problems (1352 problems affecting 780 dogs and 606 problems affecting 371 cats) were included in the multilevel model. There was no evidence of any strong collinearity between any of the explanatory variables, including those subsequently excluded from the final model. No random slopes or interaction terms were retained within the model. The interaction term between patient age and its natural log was not significant when added to the model, so the assumption of linearity was not violated. Body system dummy variables for Musculoskeletal,

Behaviour, Neurological, Respiratory, and Cardiovascular problems were not significant, so a new body system variable was coded with these non-significant body systems now included in the 'Other' reference category. Skin, Dental, Eyes, Gastrointestinal, and Non-specific body systems were all significant, so remained as separate dummy variables, and the model was checked to ensure this did not result in a change in model fit. The variables remaining in the final model were patient age, problem history, consultation type, who had raised the problem and body system affected. Younger animals appeared to be more likely to receive a definitive diagnosis than older animals. Problems which were new problems, problems discussed during a preventive-medicine consultation or raised by the veterinary surgeon were more likely to result in a definitive diagnosis than problems which were pre-existing, discussed during a specific health-problem consultation, or raised by the owner (Table 3). Skin, dental, eye, gastrointestinal, and non-specific problems were more likely to receive a definitive diagnosis than problems affecting other body systems. Variables not remaining in the model were problem type, species, breed, neutering status, number of problems discussed, clinical examination type, whether the patient was weighed, and whether diagnostic tests were performed. The proportion of unexplained variation attributable to patient (Level 2) and veterinary surgeon (Level 3) differences combined was 3.18%.

3.2. Specific diagnosis

As with diagnosis type, data on specific diagnoses were available for 3192 specific health problems (problems relating to preventive medicine were excluded). Of these, one specific diagnosis was listed for 2036 problems (63.8%) and two specific diagnoses were listed for 288 problems (9.0%). As expected, the 868 problems for which no specific diagnosis was listed were problems for which an open diagnosis was recorded.

Overweight/obese and periodontal disease were the most common diagnoses made overall (both n = 210; 6.6%). Both overweight/obese and dental disease (periodontal disease in dogs and cats, dental malocclusion in rabbits) were common diagnoses in all species (Table 4). However, a number of species-specific diseases are also seen, e.g. iFLUTD (idiopathic feline lower urinary tract disease) in cats (n = 24/877; 2.7%) and E. cuniculi infection in rabbits (n = 4/103; 3.9%).

4. Discussion

A definitive diagnosis was reached during the observed consultations for only a small proportion of problems. Veterinary surgeons spent much of their time dealing with problems where a definitive diagnosis was not reached by the end of the consultation, or for which a diagnosis had already been made prior to the consultation. Given this, future research and veterinary curricula could also focus on the approach to common clinical presentations, rather than simply common diagnoses.

Over a third of problems discussed during the veterinary consultation already had a diagnosis prior to the consultation. This suggests that much of the veterinary caseload consists of managing ongoing health problems, which is further supported by the common diagnoses found, which included chronic health problems such as osteoarthritis, atopic dermatitis and feline hyperthyroidism. While the majority of pre-existing problems already had a diagnosis prior to the consultation, most of those that did not had an open diagnosis recorded. This suggests that there is a subset of ongoing health problems for which a diagnosis has not been reached, which potentially presents a challenge for veterinary surgeons making decisions about these cases. Interestingly, previ-

Table 1
Consultation, patient, and problem characteristics for which diagnosis type reached for all problems varied significantly. Data were recorded for 3192 specific health problems discussed during real-time direct observation of consultations conducted by 62 veterinary surgeons in 8 practices between April 2011 and June 2012. Previous diagnoses were recorded for problems which had received a diagnosis prior to the consultation, and other diagnosis types were recorded based on the diagnosis reached during the consultation, ranging from most certainty (definitive diagnosis) to least certainty (open diagnosis).

| Variable | Categories | Diagnosis type | | | | | |
		Previous (n = 1116) n (%)	Definitive (n = 660) n (%)	Working (n = 70) n (%)	Presumed (n = 478) n (%)	Open(n = 868) n (%)	p
Problem type	Presenting	549 (45.8)	152 (12.7)	53 (4.4)	195 (16.3)	251 (20.9)	<0.001
	Non-presenting	567 (28.5)	508 (25.5)	17 (0.9)	283 (14.2)	617 (31.0)	
Problem history	New	0 (0.0)	633 (37.8)	42 (2.5)	428 (25.6)	570 (34.1)	<0.001
	Pre-existing	1116 (73.9)	27 (1.8)	28 (1.9)	50 (3.3)	290 (19.2)	
Consultation type	Preventive	227 (24.2)	318 (33.9)	5 (0.5)	126 (13.4)	261 (27.9)	<0.001
	Health problem	888 (39.4)	342 (15.2)	65 (2.9)	352 (15.6)	607 (26.9)	
Species	Dog	796 (37.1)	444 (20.7)	36 (1.7)	329 (15.3)	543 (25.3)	<0.001
	Cat	271 (30.9)	189 (21.6)	32 (3.6)	110 (12.5)	275 (31.4)	
	Rabbit	39 (37.9)	17 (16.5)	0 (0.0)	21 (20.4)	26 (25.2)	
	Other	10 (15.6)	10 (15.6)	2 (3.1)	18 (28.1)	24 (37.5)	
Neutering status	Entire	367 (30.9)	244 (20.6)	31 (2.6)	209 (17.6)	336 (28.3)	<0.001
	Neutered	716 (38.1)	387 (20.6)	37 (2.0)	244 (13.0)	495 (26.3)	
Clinical exam	None	83 (55.7)	8 (5.4)	10 (6.7)	10 (6.7)	38 (25.5)	<0.001
	Focused	404 (46.6)	156 (18.0)	20 (2.3)	122 (14.1)	165 (19.0)	
	Full	626 (28.8)	496 (22.8)	40 (1.8)	346 (15.9)	663 (30.5)	
Weighing	Yes	641 (42.4)	222 (14.7)	30 (2.0)	214 (14.2)	404 (26.7)	<0.001
	No	472 (28.2)	437 (26.1)	40 (2.4)	263 (15.7)	461 (27.6)	
Raised by	Vet	593 (49.7)	286 (24.0)	26 (2.2)	66 (5.5)	223 (18.7)	<0.001
	Owner	518 (26.0)	372 (18.7)	44 (2.2)	411 (20.7)	644 (32.4)	
Diagnostic tests performed	Yes	306 (34.1)	122 (13.6)	69 (7.7)	136 (15.1)	265 (29.5)	<0.001
	No	790 (35.0)	534 (23.7)	1 (0.4)	334 (14.8)	596 (26.4)	

Table 2
Diagnoses types made for problems affecting each body system. Data were recorded for 3192 specific health problems discussed during real-time direct observation of consultations conducted by 62 veterinary surgeons in 8 practices between April 2011 and June 2012. Previous diagnoses were recorded for problems which had received a diagnosis prior to the consultation, and other diagnosis types were recorded based on the diagnosis reached during the consultation, ranging from most certainty (definitive diagnosis) to least certainty (open diagnosis).

| | | Diagnosis type | | | | | | | | | |
| | | Previous | | Definitive | | Working | | Presumed | | Open | |
	Total n	n	%	n	%	n	%	n	%	n	%
Skin	809	332	41.0	176	21.8	7	0.9	123	15.2	171	21.1
Gastrointestinal	357	127	35.6	37	10.4	9	2.5	79	22.1	105	29.4
Musculoskeletal	271	154	56.8	5	1.8	10	3.7	66	24.4	36	13.3
Dental	262	82	31.3	169	64.5	0	0.0	9	3.4	2	0.8
Eyes	219	102	46.6	50	22.8	0	0.0	32	14.6	35	16.0
Respiratory	126	34	27.0	4	3.2	11	8.7	29	23	48	38.1
Cardiovascular	120	30	25.0	0	0.0	3	2.5	6	5.0	81	67.5
Behavioural	116	3	2.6	9	7.8	0	0.0	22	19.0	82	70.7
Neurological	114	42	36.8	0	0.0	2	1.8	31	27.2	39	34.2
Reproductive	91	30	33.0	24	26.1	6	6.8	18	19.8	13	14.3
Endocrine	82	65	79.3	0	0.0	14	17.1	2	2.4	1	1.2
Urinary	82	31	37.8	3	3.7	4	4.9	27	32.9	17	20.7
Renal	42	28	66.7	0	0.0	3	7.1	2	4.8	9	21.4
Haemopoetic	13	10	76.9	1	7.7	0	0.0	2	15.4	0	0.0
Non-specific	601	91	15.1	192	31.9	3	0.5	42	7.0	273	45.4

ous diagnoses were often the presenting problem, suggesting that these types of problems may be a common reason for animals to be presented to the veterinary surgeon, for example for a recheck or monitoring of an ongoing condition. They were, however, less likely to be associated with a full clinical examination, which may be due to time constraints of the consultation (Robinson et al., 2014), or it may be that veterinary surgeons perceive the full clinical examination to be predominantly useful for general health checks and detecting new problems, rather than monitoring ongoing problems. Previous work supports this suggestion, as full clinical examinations were more likely to be conducted and new problems more likely to be discussed during preventive-medicine consulta-

tions than during specific health-problem consultations (Robinson et al., 2016). There appeared to be less certainty around diagnoses in rabbits and other exotic species, which perhaps reflects the availability of or familiarity with diagnostic testing in these other species. Previous research has suggested that veterinary surgeons feel they have less information available to them on rabbits and other exotic small-animal species such as guinea pigs, than dogs and cats (Nielsen et al., 2014).

Even when accounting for other variables, specific health problems discussed during preventive-medicine consultations were more likely to receive a definitive diagnosis than those discussed during specific-health problem consultations. This is consistent

Table 3
Explanatory variables remaining in the final three-level logistic-regression model, which included data from 1958 problems affecting 780 dogs and 371 cats presented during real-time direct observation of consultations conducted by 60 veterinary surgeons in 8 practices between April 2011 and June 2012. The outcome variable for the model was binary with definitive diagnosis coded as 1 and other diagnosis types (working, presumed or open) coded as 0.

Parameter		Median	95% credible interval		Odds ratio
			Lower	Upper	
Intercept (B_0)		−2.693	−3.084	−2.335	
Age (gm)[a]		−0.075	−0.102	−0.050	0.927
Problem history	New problem	Reference			
	Pre-existing problem	−2.153	−2.691	−1.675	0.116
Consultation type	Specific health problem	Reference			
	Preventive medicine	0.351	0.083	0.622	1.420
Raised by	Owner	Reference			
	Veterinary surgeon	0.853	0.549	1.145	2.347
Body system	Other	Reference			
	Skin	1.959	1.557	2.375	7.092
	Dental	5.843	4.904	6.991	344.812
	Eyes	2.375	1.841	2.930	10.75
	Gastrointestinal	0.966	0.434	1.492	2.627
	Non-specific	1.952	1.563	2.374	7.043

[a] Age was centred around the grand mean.

Table 4
The most frequently recorded specific diagnoses for all problems (presenting and non-presenting), and comparatively within the three main species identified. Data were recorded for 3192 specific health problems discussed during real-time direct observation of consultations conducted by 62 veterinary surgeons in 8 practices between April 2011 and June 2012.

Species	Total n	Diagnosis	n	%[a]	Species	Total n	Diagnosis	n	%[a]
All	3192	Overweight/obese	210	6.6	Cat	877	Periodontal disease	87	9.9
		Periodontal disease	210	6.6			Overweight/obese	54	6.2
		Normal at present[b]	152	4.8			Hyperthyroidism	38	4.3
		Osteoarthritis	126	3.9			Wound	31	3.5
		Otitis externa	108	3.4			Normal at present[b]	25	2.9
		Wound	92	2.9			Abscess	24	2.7
		Atopic dermatitis	82	2.6			iFLUTD[c]	24	2.7
		Pyoderma	54	1.7			Chronic kidney disease	21	2.4
		Conjunctivitis	46	1.4			Cystitis	19	2.2
		Hyperthyroidism	38	1.2			Osteoarthritis	19	2.2
Dog	2148	Overweight/obese	143	6.7	Rabbit	103	Dental malocclussion	15	14.6
		Periodontal disease	123	5.7			Overweight/obese	10	9.7
		Osteoarthritis	107	5.0			Gastrointestinal stasis	9	8.7
		Normal at present[b]	106	4.9			Normal at present[b]	8	7.8
		Otitis externa	101	4.7			Cheyletiellosis	7	6.8
		Atopic dermatitis	78	3.6			Dacrocystitis	7	6.8
		Wound	57	2.7			Abscess	6	5.8
		Pyoderma	46	2.1			E. cuniculi infection[d]	4	3.9
		Anal gland impaction inimpaction	36	1.7			URT infection[e]	3	2.9
		Dietary indiscretion	36	1.7			Wound	2	1.9

[a] Percentages shown are based on the total number of problems for each problem type or species (shown in the Total n column).
[b] Normal at present: The health problem relates to normal behaviour or anatomy (all problems which resulted in this diagnosis were raised by the owner).
[c] iFLUTD: idiopathic Feline Lower Urinary Tract Disease.
[d] E. cuniculi infection: Infection with Encephalitozoon cuniculi.
[e] URT infection: Upper respiratory tract infection.

with previous findings that preventive-medicine consultations appear to be fundamentally different to specific health-problem consultations (Robinson et al., 2016). Across all types of consultations, problems relating to dental, skin, eye, gastrointestinal, and non-specific categories (a large proportion of which were overweight/obese) were more likely to receive a definitive diagnosis. This is perhaps not surprising given that many of these problems are often easier to visualise and diagnose on clinical examination without the need for a complex diagnostic work-up. Ease of diagnosing certain conditions on clinical examination alone may also explain why problems raised by the veterinary surgeon are more likely to lead to a definitive diagnosis. For example overweight/obese or dental disease are rarely the reason an owner presents their animal to the veterinary surgeon (Robinson et al., 2015b), but as they can be easily and definitively diagnosed on clinical examination, they may account for a large proportion of problems raised by the veterinary surgeon (Robinson et al., 2015b).

The conditions for which specific diagnoses were made show similarities to the results of other studies which have looked at caseload in first-opinion practice, with otitis externa being amongst the most common specific diagnoses (Lund et al., 1999; Robotham and Green, 2004; Hill et al., 2006). Dental disease and obesity were amongst the most common diagnoses made, which has implications for veterinary practice, particularly as these conditions may be preventable or easily detected on clinical examination. Veterinary practices could use weight or dental clinics to detect and manage these conditions at an early stage, potentially avoiding more in-depth interventions such as dental extractions. Early management could also help in the prevention of conditions secondary to or management of conditions exacerbated by weight and dental problems, such as diabetes mellitus, osteoarthritis, dental abscesses, and dacrocystitis. The common diagnoses highlighted in each species could be used to formulate research priorities and direct veterinary curricula towards diseases commonly encountered in first-opinion

practice. However, as definitive diagnoses were not made during the consultation for most problems, it would appear that veterinary surgeons in first-opinion practice frequently have to make decisions about cases prior to reaching definitive diagnoses. Future research and veterinary curricula could also focus on common clinical presentations (reported in Robinson et al., 2015b) rather than just specific diagnoses, thereby directing research towards common decision-making points.

Some of the limitations of this study have been discussed in more depth in previous manuscripts (Robinson et al., 2015a,b, 2016). The practices involved in the study were a convenience sample of practices and so it is unclear how representative these are of all UK practices. Practice did not remain as an explanatory variable in the final model, however as there were not enough practices for practice to form a separate level in the model, the possibility of a practice influence on diagnosis cannot be ruled out. The data were collected by observation and so were heavily dependent upon what the veterinary surgeon discussed with the owner during the consultation. For example if a veterinary surgeon has a clinical suspicion or 'gut feeling', in the current study it would only be recorded if it was discussed with the owner. Another limitation is that diagnoses, particularly those which are presumptive, may be inaccurate. In human healthcare, it has been estimated that the incidence of diagnostic errors is 5–15% (Ely et al., 2012) although it is currently unclear how frequently diagnostic errors occur in first-opinion veterinary practice. However, the data collected reflects the reality of first-opinion practice, where a definitive diagnosis may often not be reached yet decisions still need to be made as to how to proceed with a case. Patients and problems receiving a definitive diagnosis during the consultation appear to be different from those who do not which has implications for veterinary clinical trials, many of which require a definitive diagnosis using a gold standard test for inclusion in the trial. A further limitation is that conditions which are difficult to diagnose or present with vague clinical signs (e.g. some endocrine diseases) are likely under-represented, while those which are easy to diagnose, e.g. overweight/obese and periodontal disease, may be over-represented.

Categorising diagnosis, even using a detailed series of definitions such as those used during this study, proved to be complex and challenging. Even when keeping a record of how previous problems had been recorded, often decisions regarding how a diagnosis should be categorised were not straightforward. This leads us to the following questions: What is a diagnosis? Is a diagnosis necessary, and if so, what level of diagnosis? Del Mar et al. (2006) suggested that a diagnosis was a label given to a disease and that the boundaries surrounding a particular diagnosis were arbitrary. They concluded that the function of a diagnosis was to aid the practitioner in the decision-making process by assisting them in selecting the most appropriate treatment, advice, and prognosis for their patients. However they also noted that there may be circumstances within medicine where a diagnosis is not necessary in order to do this. In order to consider whether a definitive diagnosis is necessary in veterinary medicine, we need further information on how making a diagnosis affects decision-making and influences the outcome of the consultation. This will be considered in a separate manuscript. Given the limited existing evidence base, future research should aim to investigate the diagnostic process further, and qualitative methods would be particularly useful to explore veterinary surgeons' approaches to and experiences of making a diagnosis.

5. Conclusions

Definitive diagnoses are rarely made during small-animal consultations, with much of the veterinary caseload involving man-

agement of ongoing problems or making decisions around new problems prior to a diagnosis being made. Future research priorities may need to include questions focused on clinical signs or presentation, rather than simply diagnoses, in order to assist veterinary surgeons during decision-making. Examining the actions taken at the conclusion of the consultation and how making a diagnosis affects this may shed further light on when reaching a diagnosis is necessary.

Conflict of interests

Acknowledgements

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.prevetmed.2016.07.014.

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