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Prevalence, survival analysis and multimorbidity of chronic diseases in the general veterinarian-attended horse population of the UK

Claire E. Welsh[a,*], Marco Duz[b], Timothy D.H. Parkin[a], John F. Marshall[a]

[a] Equine Clinical Sciences Division, Weipers Centre Equine Hospital, School of Veterinary Medicine, University of Glasgow, UK
[b] School of Veterinary Medicine and Science, University of Nottingham, UK

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ABSTRACT

The average age of the global human population is increasing, leading to increased interest in the effects of chronic disease and multimorbidity on health resources and patient welfare. It has been posited that the average age of the general veterinarian-attended horse population of the UK is also increasing, and therefore it could be assumed that chronic diseases and multimorbidity would pose an increasing risk here also. However, evidence for this trend in ageing is very limited, and the current prevalence of many chronic diseases, and of multimorbidity, is unknown. Using text mining of first-opinion electronic medical records from seven veterinary practices around the UK, Kaplan-Meier and Cox proportional hazard modelling, we were able to estimate the apparent prevalence among veterinarian-attended horses of nine chronic diseases, and to assess their relative effects on median life expectancy following diagnosis. With these methods we found evidence of increasing population age. Multimorbidity affected 1.2% of the study population, and had a significant effect upon survival times, with co-occurrence of two diseases, and three or more diseases, leading to 6.6 and 21.3 times the hazard ratio compared to no chronic disease, respectively. Laminitis was involved in 74% of cases of multimorbidity. The population of horses attended by UK veterinarians appears to be aging, and chronic diseases and their co-occurrence are common features, and as such warrant further investigation.

1. Introduction

The non-racing, mixed breed horse population of the UK has been relatively neglected to date in terms of research into disease burden and population structure (Mellor et al., 1999; Hotchkiss et al., 2007; Ireland et al., 2013; Wylie et al., 2013). There may be as many as one million horses in the UK, yet little is known about the health and longevity of the vast majority (British Equestrian Trade Association, 2011). Reasons for this include the lack of a central database of mandatory horse passport details since withdrawal of funding from the National Equine Database in 2012, and the fragmented nature of first-opinion equine veterinary services (Boden et al., 2013). Collation of health and disease data occurs on a small scale periodically, but relies upon either owner-reporting of health problems or voluntary submission of laboratory samples, which, although informative and helpful, are both subject to significant bias if results were to be extrapolated to the general equine population (Slater, 2014; Animal Health Trust (AHT) et al., 2015). Chronic or recurrent disease is undoubtedly a feature of this population, but the extent to which it affects longevity and welfare is unknown.

Multimorbidity is defined as the co-occurrence of multiple disease conditions within an individual without reference to an index condition (Islam et al., 2014). The study of multimorbidity in medical research is currently popular, as recognition of the greater strain multimorbidity places upon health services, and its detrimental effect on patient welfare and longevity are growing (Islam et al., 2014; Pache et al., 2015). Understanding multimorbidity patterns can help uncover commonalities in aetiology or risk factors between previously unlinked conditions, and could improve patient care by shifting treatment emphasis from individual diseases to co-occurring groups of disease, especially where treatment regimens for co-occurring diseases are discordant. The average human lifespan in the UK continues to rise, and with it, the proportion of people living with multiple chronic diseases (Pache et al., 2015; Wohland et al., 2015). It has been often cited that the average age of horses in the UK is also increasing, but this assumption is based upon limited studies, and methodologies less robust than those used by UK human health authorities (Brosnahan and Paradis, 2003).

This study aimed to use first-opinion medical records to quantify the burden of a number of common chronic diseases within

* Corresponding author.
E-mail address: Claire.Welsh@Glasgow.ac.uk (C.E. Welsh).

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a sample of the general veterinary-attended horse population in the UK, and to estimate their effects upon survival. The apparent prevalence of comorbidity (co-occurrence of two diseases) and multimorbidity (co-occurrence of more than two diseases) were also sought, as were the effects of co- and multimorbid states on survival. A secondary aim was to implement demographic methodologies to ascertain whether the population under study was ageing over time, as has been previously postulated. These results will constitute the first such analyses on this large and diverse population, and will serve as benchmarks for future studies of the effects of chronic disease and multimorbidity in horses.

2. Materials and methods

2.1. Data

Free-text first-opinion equine medical records spanning twenty-six years (1987–2013) were collected from a convenience sample of seven first opinion equine veterinary practices around the UK, and reformatted into comma-separated values format (n = 1001375 records). Records included the following database; unique numerical identification number, date of entry into the system (date of record), sex, date of birth, breed, practice, and a field containing free-text medical records with prescription information. Records missing the date of birth or record entry were excluded, as were records of non-equine consultations, and records entered after 2012. Sex was converted into four categories; unknown, female, male, neutered male. Breed was converted into the following groups; Arab/Arab cross, Cob/Cob cross, Draught/Draught cross, Native/Native cross, pony/pony cross, Thoroughbred/Thoroughbred cross, Warmblood/Warmblood cross, Welsh/Welsh cross, other and unknown. Descriptions of each veterinary practice are contained in Table 1. All data cleaning was conducted in R statistical environment (R Core Development Team, 2015).

2.2. Text mining

Nine chronic (or recurrent) conditions were chosen for study *a priori*, after discussion with experienced equine clinicians; neoplasia, pituitary pars intermedia dysfunction (PPID), equine metabolic syndrome (EMS), grass sickness, laminitis, navicular syndrome, osteoarthritis, recurrent airway obstruction (RAO), and sarcoids. These were chosen as diseases that can be diagnosed in first opinion practice, which are chronic or recurrent in nature and are commonly incurable. They were also considered to have names that would be unlikely to appear in medical records unless the animal in question was thought to be suffering from them. Commercially available text mining software (WordStat v7.0, Provalis Research Inc.) was used to construct dictionaries that would allow identification of records where each disease was mentioned, in an iterative process modified from the approach detailed by Lam et al. (Lam et al., 2007) and validated by Anholt et al. (2014). 'Diagnosis' of disease in this context was defined as inclusion of these key words or phrases, without requirement of additional information such as test results. 'Diagnoses' were therefore reflective of the thought process and professional opinion of the veterinarian regarding the case at hand, as opposed to an accurate and verbose description of the diagnostic criteria of the case (which were commonly missing). Additionally, a dictionary was constructed to identify records of death (natural or euthanasia) (see Appendix A). These criteria were chosen in order to identify the real-world decisions (e.g. euthanasia) taken following delivery of a veterinarian's clinical judgement in each case. Dictionary construction was performed on the full dataset to maximise coverage, and negations were added to a list of excluded words and phrases as necessary. Internal validation was conducted through manually checking the 'keyword-in-context' output for each disease; and altering the dictionary and/or excluded words list as necessary. Data were subsequently exported with one column per disease (containing binary data indicating presence/absence of disease) in place of free text records; plus a binary column indicating presence/absence of death at each record.

2.3. Life expectancy following initial veterinary care episode

Period life tables were constructed for three-year periods near the beginning and end of the study (1995–1997, and 2010–2012), for records from five practices (two practices were excluded due to significantly lower ages at the time of death [Practice 4], and high annual proportion of deaths [Practice 7]). Life expectancy (following first recorded veterinary episode) with 95% confidence intervals was calculated (Chiang, 1968, 1978).

2.4. Univariable and multivariable modelling of chronic diseases

Survival analyses were conducted using R packages 'survMisc' and 'survival' (Dardis, 2015; Therneau, 2015). For each horse that had at least one record of chronic disease, the time from diagnosis to its last record in the data was computed, and the presence of a record of death was recorded as 0/1. Similarly, for those horses that were not diagnosed with any of the selected diseases, the time from their first entry in the data, to their last, was computed, and whether they were recorded as having died was noted. Kaplan-Meier survival analysis was performed to estimate median survival time following diagnosis, or following entry into the dataset (in the case of no chronic disease). Univariable Cox proportional hazard models were constructed to assess the significance of the effect of disease, sex, breed, practice, and age at the time of diagnosis (years) upon survival. Variables were retained for potential inclusion in the multivariable model if the p-value <0.25, and the likelihood ratio test (LRT) p-value compared with the null model was <0.05. Categorical variables were re-grouped based on similarity of exponentiated coefficients and Wald significance, as required. A forward stepwise manual model building procedure was implemented, with significant variables included in order of highest to lowest log-likelihood (Dohoo, 2009). Variables were retained in the multivariable model if LRT p-value <0.05. All pairwise interactions between retained variables were investigated for significance and their effect on existing coefficients. Proportional hazards assump-

Table 1
Descriptive details of a convenience sample of seven first-opinion veterinary practices serving horses, that contributed data to the current study.

Practice	Number of veterinarians	Location	Provide own out-of-hours	RCVS Accredited	Species covered	Number of branches
1	11	Scotland	Yes	Yes	Mixed	2
2	21	Central England	Yes	Yes	Equine	1
3	17	Northern England	Yes	Yes	Mixed	5
4	14	Central England	Yes	No	Mixed	4
5	11	Southern England	Yes	No	Equine	1
6	4	Northern England	Yes	Yes	Large	1
7	8	Northern England	Yes	No	Mixed	2

RCVS Royal College of Veterinary Surgeons.