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ORIGINAL ARTICLE

Antibiotic use in first opinion equine practice in the United Kingdom: Serial point prevalence surveys in 17 practices

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Summary

Background: Monitoring antibiotic use (AMU) is a key component of antimicrobial stewardship. Published data on AMU in first opinion equine practice are limited.

Objectives: To document AMU in first opinion equine practices.

Study design: Repeated point prevalence surveys.

Methods: AMU was recorded one day every month for 12 consecutive months in 17 equine practices.

Results: Two hundred and fifty-two horses were prescribed antibiotics across 2273 consultations (excluding routine appointments) (11.1%; 95% CI 9.8%–12.4%). Median number of consultations per practice was 121 (IQR 112–159; range 27–303). Across 17 practices, the proportion of horses receiving antibiotics varied by practice from 0% to 26.4%. Commonest indications for AMU included cellulitis (66; 26.8%), wounds (46; 18.7%), surgical prophylaxis (36; 14.6%), respiratory infection (27; 11.0%) and skin infection (20; 8.1%). Commonest antibiotics prescribed were potentiated sulphonamides (109; 43.6%), oxytetracycline (58; 23.2%), procaine penicillin (40; 16.0%) and doxycycline (36; 14.4%). 45.0% of oxytetracycline use was for surgical prophylaxis. 44.8% of procaine penicillin use was for cellulitis. 28.6% of 'other antimicrobial' use was for pyrexia of unknown origin. Use of antibiotics differed significantly depending on the underlying diagnosis ($p < 0.001$). Median antibiotic dose rates were: potentiated sulphonamides 30 mg/kg (IQR 27–75; range 10–75; $n = 96$); procaine penicillin 19 mg/kg (IQR 15–23; range 7–30; $n = 35$); oxytetracycline 6 mg/kg (IQR 5–6; range 4–30; $n = 55$); doxycycline 10 mg/kg (IQR 10–20; range 7–30; $n = 34$).

Main limitations: Weight of horses were often estimated. Duration of antibiotic courses was not recorded.

Conclusions: Antibiotics were prescribed in 11% of nonroutine consultations. Commonest indication for AMU was cellulitis. Potentiated sulphonamides, oxytetracycline and procaine penicillin were the commonest prescribed drugs. Critically important antibiotic use was infrequent. Dose rates varied, but median values were generally appropriate.

KEYWORDS

horse, antibiotics, antibiotic resistance, antibiotic stewardship, antibiotic use, point prevalence survey

INTRODUCTION

Antimicrobial (antibiotic) resistance (AMR) is a major health hazard that has been identified by the World Health Organization (WHO) as one of the top ten global health threats (World Health Organization, 2015). Disease caused by resistant bacteria results in increased severity, prolonged hospitalisation and increased mortality risk, raising the social and economic costs of the disease (World Health Organization, 2021). In simplistic terms, AMR means that in the future the available antimicrobial agents might not be effective in the treatment of many life-threatening bacterial infections in both humans and domestic animals. The development of AMR is part of normal bacterial evolution (Lloyd & Page, 2018); however, antimicrobial use (AMU) in humans and animals promotes the development and spread of AMR (Tang et al., 2017). The close association between animals, including horses, and people provides opportunities for the transfer of resistance determinants between these species (Parkhill, 2022). There have been several recent published studies that highlight the development and importance of AMR in horses (Chalder et al., 2020; Fonseca et al., 2020; Isgren et al., 2021; Marshall & Marsella, 2023; Mercer & Davis, 2019). The term 'antimicrobial stewardship' (AMS) is used to describe the multiple approaches needed to sustain the efficacy of antimicrobial drugs in the face of the increasing development and spread of AMR in bacterial pathogens (Prescott, 2020). Antimicrobial stewardship involves a dynamic and multifaceted approach of continuous improvement based on reducing, improving, monitoring and evaluating the use of antimicrobials so as to preserve their future efficacy and to protect human and animal health (Prescott, 2020; Weese et al., 2013). The American Veterinary Medical Association identified 5 core principles of AMS, including commitment to stewardship, selection and use of antimicrobial drugs judiciously and evaluation of antimicrobial drug use in practices (American Veterinary Medical Association, 2015). Measurement of AMU is an essential step in improving prescribing practices. Antibiotic drug use data are used to describe baseline practices, identify opportunities for improvement, guide goal setting and measure progress (Hsieh et al., 2022). Several veterinary AMS programmes with different interventions have now been shown to have a positive influence on antimicrobial use in small animal practice (Singleton et al., 2021).

There have been few published studies documenting AMU in horses. The Veterinary Antimicrobial Resistance and Sales Surveillance (VARSS) report, which is published annually by the Veterinary Medicines Directorate (VMD) in the United Kingdom, uses information provided by veterinary pharmaceutical companies to report sales data for animals (UK-VARSS, 2022). However, these data do not include the use of antibiotic preparations licensed for use in a different species (including humans) or extemporaneous preparations, which are commonly used in horses (Tallon et al., 2023). The VARSS report also provides no data on the indications for AMU. Other previously published studies of AMU in horses include practitioner survey data (Hughes et al., 2013; Wilson et al., 2022), evaluation of electronic patient records (Allen et al., 2022; Bollig et al., 2022; Ross et al., 2016; Rule et al., 2021; Tallon et al., 2023) and analysis of practice antimicrobial sales data (Mair & Parkin, 2022). In addition, antibiotic use in the specific case of limb wounds in one UK referral hospital has been documented (Ross et al., 2016).

The objectives of this study were to record AMU in a group of first opinion ambulatory equine practices in the United Kingdom. This was achieved by aggregating data from monthly single-day point prevalence surveys over the course of 1 year. The study aimed to provide detailed and accurate data about the most commonly used drugs, the indications and the dose rates of prescribed antibiotics in equine general first opinion practices.

MATERIALS AND METHODS

Systemic AMU was recorded on one day every month for 12 months (August 2021 to July 2022) in 17 first opinion equine practices, all part of the CVS Equine Group. Sixteen practices were located in England and one in Wales. The day of the week selected for data collection was rotated each month, avoiding data collection at weekends or on public holidays. The day of data collection was determined prospectively, and clinicians were aware of the study and the days selected. On each selected day, the number of nonroutine consultations (i.e. consultations for ill-health and excluding routine consultations such as for vaccinations or routine dental examinations) were recorded. For every horse prescribed an antibiotic on the selected days (including repeat prescriptions), demographic data (age, breed, sex), weight (estimated by the attending veterinarian), clinical diagnosis, details of antimicrobial susceptibility testing (AST) if performed, and antimicrobial drugs prescribed (including name of antimicrobial drug(s), dose and dose rate, route and frequency of administration) were recorded.

Data were entered and organised in Microsoft Excel for Mac version 16.66.1 and analyses were performed using Excel and Stata 17.0. Descriptive data were presented, and missing data were excluded. Categorical data were presented showing the count and percentage. Quantitative data were assessed for normality using the Shapiro–Wilk test and graphically. Normally distributed data were summarised using the mean (standard deviation [SD]) and non-normally distributed data using the median (interquartile range [IQR] and range). Univariable categorical comparisons were made using chi-squared tests. Prevalence and corresponding 95% confidence intervals (CI) derived from the standard errors were reported.

RESULTS

Overall, 252 horses were prescribed antibiotics in 2273 nonroutine consultations (11.1%; 95% CI 9.8%–12.4%). The median number of consultations per practice was 121 (IQR 112–159; range 27–303). Across the 17 first opinion practices, the proportion of horses receiving antibiotics varied by practice from 0.0% (practice 15) to 26.4% (practice 4) (Table 1). The median practice prevalence of

TABLE 1 The total number of nonroutine consultations and prevalence of antimicrobial prescriptions in 17 first opinion equine practices.

Practice ID	Number of consultations	Number of antibiotic prescriptions	Prevalence	95% CI
4	121	32	0.26	0.19–0.34
5	144	36	0.25	0.18–0.32
13	81	19	0.23	0.14–0.33
8	63	9	0.14	0.06–0.23
10	206	26	0.13	0.08–0.17
16	112	14	0.13	0.06–0.19
3	116	13	0.11	0.05–0.17
1	133	14	0.11	0.05–0.16
11	159	15	0.09	0.05–0.14
2	169	15	0.09	0.05–0.13
9	174	15	0.09	0.04–0.13
14	104	7	0.07	0.02–0.12
6	303	20	0.07	0.04–0.09
12	122	8	0.07	0.02–0.11
17	120	5	0.04	0.01–0.08
7	119	4	0.03	0.00–0.07
15	27	0	0.00	0.00–0.00

TABLE 2 Seasonal prevalence of antimicrobial prescriptions in 17 first opinion equine practices.

Season	Prevalence	95% CI
Autumn	0.08	0.06–0.10
Winter	0.12	0.09–0.14
Spring	0.13	0.10–0.15
Summer	0.12	0.09–0.15

antibiotic prescriptions was 9.4% (95% CI 6.6%–12.6%). The seasonal prevalence of antimicrobial prescriptions across the year is shown in Table 2 and Figure 1. There was no demonstrable pattern to antibiotic prescriptions over the study 12 months.

The most common breeds receiving antibiotics were: Thoroughbreds/crosses (75; 31.3%), Warmbloods/crosses (40; 16.7%), cobs/crosses (38; 15.8%), sport horses/crosses (30; 12.5%) and ponies/crosses (27; 11.3%). The horses prescribed antibiotics included 84 females (34.6%), 131 geldings (53.9%) and 28 entire males (11.5%). The median age was 10 years (IQR 5–16; range 0.7–32). The median estimated weight was 500 kg (IQR 450–550; range 37–650 kg).

The most frequent diagnostic categories for horses prescribed antibiotics were cellulitis (66; 26.8%), wounds (46; 18.7%), surgical prophylaxis (36; 14.6%), respiratory disease (27; 11.0%) and skin disease (20; 8.1%) (Figure 2). Skin wounds and wounds potentially involving bone and/or synovial cavities accounted for 23.2% of antibiotic prescriptions. The most commonly prescribed antibiotics were potentiated sulphonamides (trimethoprim/sulphadiazine) (109; 43.6%), oxytetracycline (58; 23.2%), procaine penicillin (40; 16.0%) and doxycycline (36; 14.4%). Metronidazole, ceftiofur, enrofloxacin and gentamicin each accounted for less than 1% of antibiotic prescriptions (Figure 3). A single dose of an antibiotic followed by dosing with a different second antibiotic was administered in 39 cases (15.7%). The route of administration of the antibiotics in the 252 horses were per os (141; 56.6%), intravenous (63; 25.3%) and intramuscular (45; 18.1%).

The distribution of the different antimicrobial drugs used to treat different conditions is shown in Figure 4. Surgical prophylaxis accounted for 45.0% of oxytetracycline use. Cellulitis accounted for 44.8% of procaine penicillin use. Pyrexia of unknown origin accounted for 28.6% of 'other antimicrobials' (excluding trimethoprim/sulphadiazine, oxytetracycline, procaine penicillin and doxycycline) use. The use of each antibiotic differed significantly depending on the underlying diagnosis ($p < 0.001$). Antibiotic susceptibility testing results were obtained prior to antimicrobial prescription in only 4 cases (2%).

The median antibiotic dose rates are shown In Table 3.

A second antimicrobial was prescribed in 51 cases, and 36% of the cases where a second antimicrobial was used were cellulitis cases (Figure 5).

DISCUSSION

Our study successfully used a repeated point prevalence survey method to record antibiotic use in first opinion equine practice. The most prescribed antibiotics were potentiated sulphonamides, oxytetracycline, procaine penicillin and doxycycline. To the authors' knowledge, this is the largest study to record accurate AMU data in first opinion equine practice using serial point prevalence surveys. Similar methodology could be readily applied to future studies of antibiotic use in all species. Another benefit of the repeated point prevalence approach is the relatively limited imposition on staff around data collection compared to longer collection timeframes. Bollig et al. (2022)

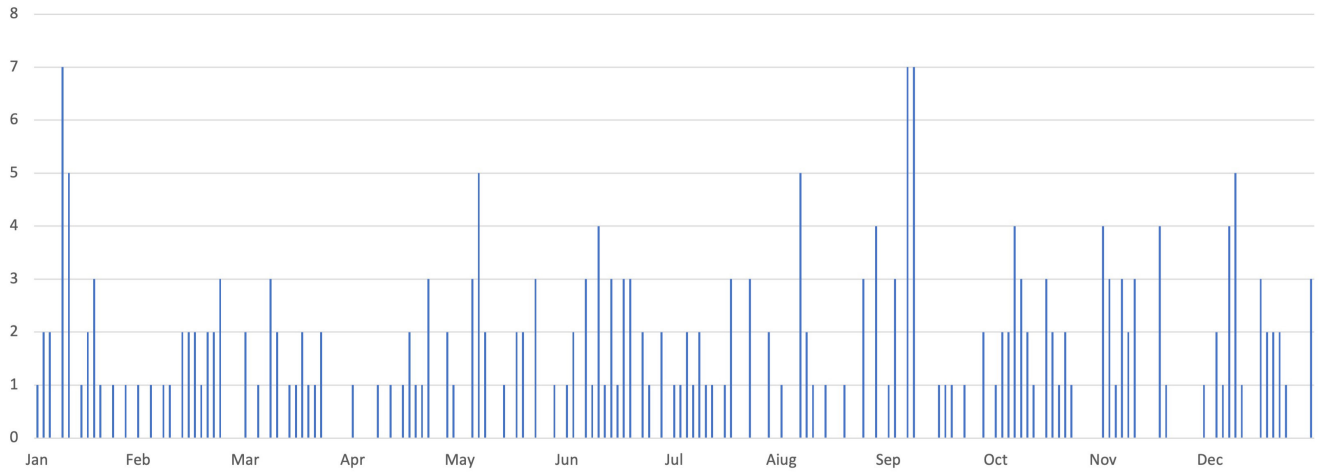

FIGURE 1 Numbers of antibiotic prescriptions for each of 17 practices every month for 12 months.

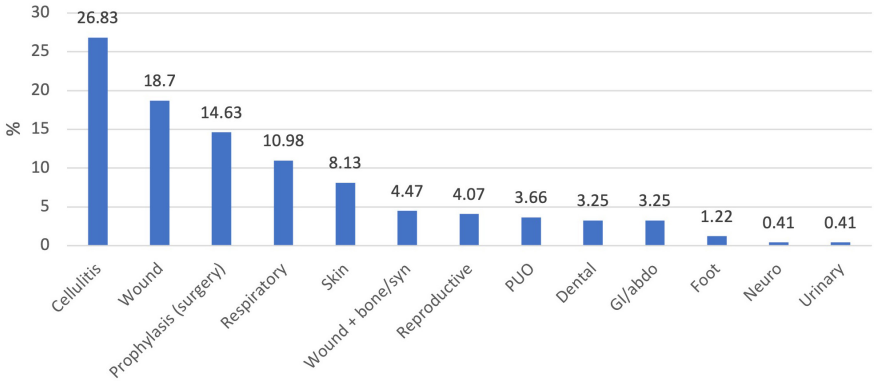

FIGURE 2 Frequencies of disease categories of 252 horses prescribed antimicrobials in 17 first opinion practices.

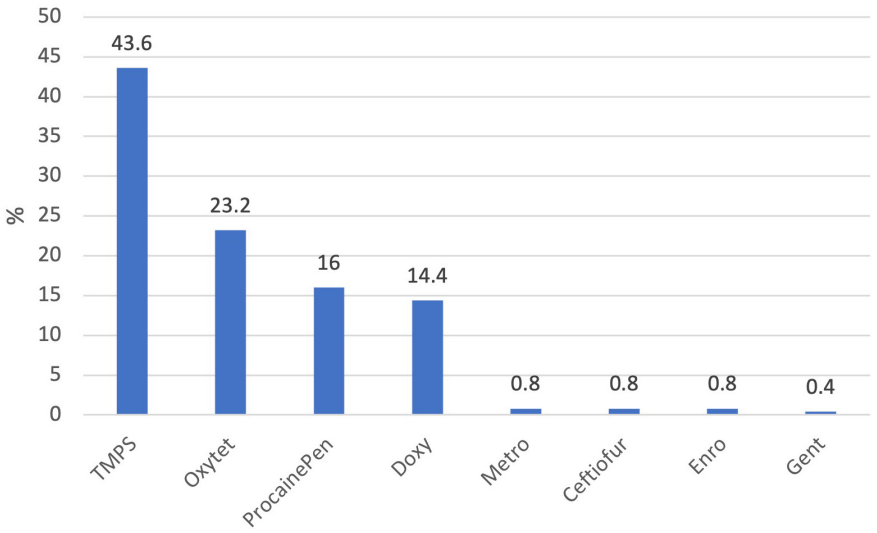

FIGURE 3 Frequencies of individual antimicrobial prescriptions in 252 horses.

reported a point prevalence study and collected antibiotic prescription data from electronic patient records from dogs, cats and horses in veterinary practices in Minnesota and Dakota, USA, but this was limited to 1 day per quarter for 1 year, and included only 3 exclusively equine practices and 3 mixed small animal/equine practices. We are not aware of other published studies using a point prevalence methodology in equine practice. Surveillance of AMU is essential for benchmarking performance and identifying opportunities for

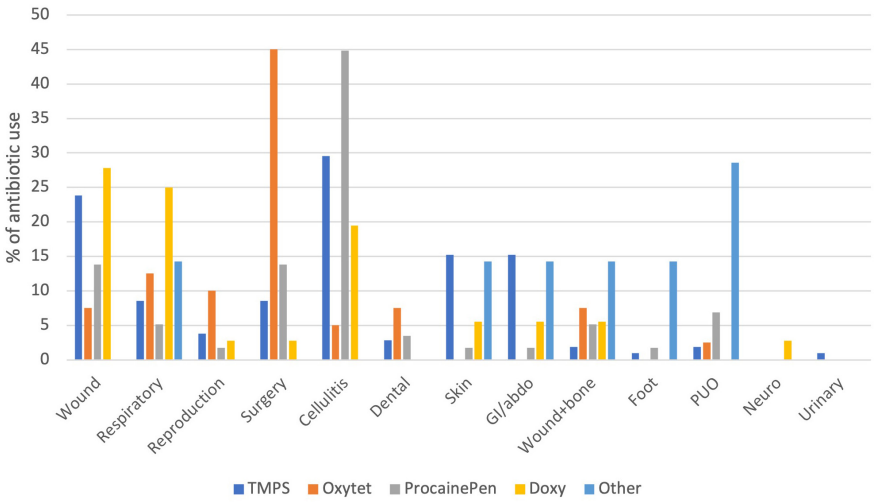

FIGURE 4 Distribution of individual antimicrobial drug use in different conditions in 252 horses.

TABLE 3 Median dose rates of the four most commonly prescribed antibiotics.

Antibiotic	Median dose mg/kg	IQR mg/kg	Range mg/kg	Number
Trimethoprim/sulphadiazine	30	27–75	10–75	96
Procaine penicillin	19	15–23	7–30	35
Oxytetracycline	6	5–6	4–30	55
Doxycycline	10	10–20	7–30	34

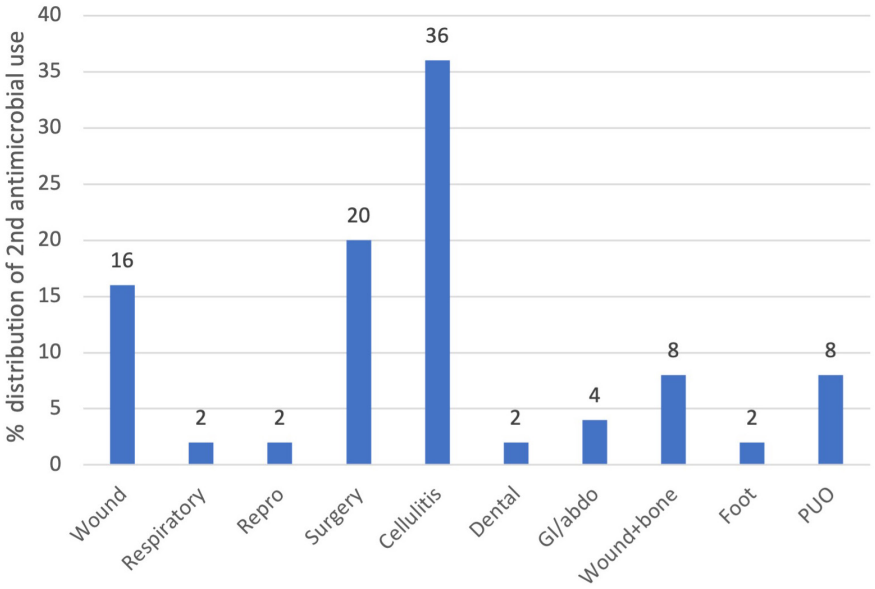

FIGURE 5 Frequencies of disease categories of 51 horses prescribed two antimicrobials.

improvement (Allen et al., 2022). This study has provided novel data on AMU in first opinion equine veterinary practices in the United Kingdom that can be used to inform AMS programmes and set priorities for surveillance. The optimum way of reporting antibiotic usage remains unclear, but the point prevalence survey methodology used in this study provided valuable patient-level surveillance data, including the indications, choice, dosing and routes of AMU. The main limitation of point prevalence surveys is inherent to the method used, namely the interpretation of single point data. However, this methodology has been widely used in human healthcare, for example to identify priorities for quality improvement strategies to reduce hospital acquired infections (Davey et al., 2010).

Antibiotics were prescribed in 11.1% of nonroutine consultations in this study. This compares with 8.5% of 39,483 total visits in a retrospective, observational study using electronic patient records in an ambulatory equine practice of a university veterinary practice in the mid-Atlantic United States (Rule et al., 2021); however, the latter study included both routine and nonroutine consultations, with 'healthy visits' accounting for 41.7% of all visits. Antimicrobial prescriptions were recorded in 30.2% of emergency visits and 7.9% of nonemergency visits in that study. The study of Bollig et al. (2022) from the United States recorded only 202 equine consultations (including routine consultations and hospitalised patients), of which 33 (16.3%) were prescribed antibiotics (9 of which were topical preparations); of 183 outpatient consultations, only 14 (7.7%) were prescribed antibiotics.

Allen et al. (2022) used electronic patient records of horses in 39 UK veterinary practices to record the use of antibiotics licensed for systemic use during 2018. Antimicrobials were prescribed to 12,538 (19.5%) equids in that study, which was a higher proportion than in our study. However, it is difficult to compare different studies that use different methodologies, and like our results, the proportion of equids receiving systemic antimicrobials in the study of Allen et al. (2022) varied considerably in different practices from 3.0% to 33.5%. However, the study included 6 equine hospitals, and equids attended by an equine veterinary hospital had 1.9 times the odds of systemic AMU compared with those attended by a veterinary practice without hospital status. Differences between practices likely reflect differences in underlying case demographics, caseload, provision of and adherence to practice guidelines and individual clinician habits (Allen et al., 2022). The results of our study, as well as others, suggest that antibiotics are prescribed less frequently in horses in first opinion practice than in small animals. For example, the frequency of antimicrobial use in first opinion small animal consultations in the United Kingdom was reported to be 25% in dogs and 21% in cats in one study (Buckland et al., 2016).

The most prescribed antibiotics in our study were potentiated sulphonamides (43.6%), oxytetracycline (23.2%), procaine penicillin (16.0%) and doxycycline (14.4%). Potentiated sulphonamides have been identified as the most commonly prescribed antimicrobial drugs in other studies documenting antimicrobial use in horses in the United Kingdom (Allen et al., 2022; Hughes et al., 2013; Mair & Parkin, 2022; Tallon et al., 2023; Wilson et al., 2022). For example, in the study of Tallon et al. (2023), potentiated sulphonamides represented 79% of all used antibiotics by weight, and in the study of Allen et al. (2022) potentiated sulphonamides were given to 50.2% of the equids receiving antibiotics. The frequent choice of potentiated sulphonamides in equine practice is likely, at least partially, to be due to its broad spectrum, ease of administration and relatively low cost. In the study by Allen et al. (2022), Category B antimicrobials (based on the European Medicines Agency classification (European Medicines Agency, 2019)) were prescribed to 1.9% of veterinary-attended equids, with third-generation cephalosporins and quinolones the most frequently prescribed antimicrobial classes in this group. These results are similar to our study, where antimicrobials classified under the European Medicines Agency as Category B (enrofloxacin and ceftiofur) were each used in less than 1% of prescriptions. Since this study was performed, cefazolin (a first generation cephalosporin) has become available in the United Kingdom, as a 'special' product, which may be used in the place of ceftiofur in some cases in the future. Other drugs considered to be important for human healthcare include aminoglycosides and aminopenicillins, but none of these drugs were used in the present study. Bacteriological culture and AST were performed in only one horse prior to prescription of one of these drugs. This contravenes guidelines and recommendations, produced by the World Organisation for Animal Health (OIE), World Health Organization and British Equine Veterinary Association, which suggest that highest priority critically important antimicrobials should only be used with supporting culture and sensitivity testing (BEVA, 2019). However, it is acknowledged that it is not always possible to obtain samples for culture and sensitivity in cases such as PUO and cellulitis.

In the study of Rule et al. (2021) from the United States, aminoglycosides were the most frequently prescribed antimicrobials (20.3%), followed by potentiated sulphonamides (20.2%) and tetracyclines (18.3%). However, that study included topical (e.g. ocular) and local (e.g. intrasynovial, intrauterine, etc.) administration of antimicrobials, with the commonest indications for AMU being ocular conditions; these results cannot, therefore, be directly compared with our study of systemic antimicrobial use only. In the study of Bollig et al. (2022), also in the United States, the most commonly prescribed antibiotic in horses was ceftiofur, a third-generation cephalosporin that is considered a highest priority critically important antimicrobial. Ceftiofur's broad spectrum activity and safety profile make it a versatile agent for the treatment of horses, including the treatment of respiratory infections, skin infections, abscesses, urinary tract diseases and sepsis (Hardefeldt et al., 2021; Ryan et al., 2023). Ceftiofur crystalline free acid, that is available in the United States, provides a long-acting intramuscular option; however, this formulation is not available in the United Kingdom. As stated previously, the recent introduction of cefazolin in the United Kingdom under the 'specials' import scheme might alter the perceived need to use ceftiofur in cases supported by bacteriological culture and AST.

The most common specific indications for systemic AMU in our study were cellulitis (26.8%), wounds (18.7%), surgical prophylaxis (14.6%), respiratory infection (11.0%) and skin infection (8.1%). These results are somewhat different to the results of the study of Allen et al. (2022) where integumentary disorders (40.5% of antimicrobial courses), surgical prophylaxis (29.0%) and musculoskeletal conditions (22.8%) were the commonest reasons for AMU. However, this latter study included local use of antimicrobials licensed for systemic use, which likely explains some of the differences in the results, for example the higher frequency of AMU for musculoskeletal conditions reported by Allen et al. (2022); antimicrobial drugs are commonly employed locally in the uterus, eyes, joints, tendon sheaths, etc, in equine practice,

often unassociated with systemic use, and these uses were not recorded in the present study. Our results were also different from those of Bollig et al. (2022), where ocular, respiratory, skin and orthopaedic diseases were the commonest indications for antibiotic use, but this included topical and local as well as systemic treatments, and included hospitalised horses.

Only 4 prescriptions in our study followed bacterial culture and AST. The ability to perform diagnostics in the field is often limited by cost, logistics, facilities and other factors. Therefore, a definitive diagnosis is not always made, and empirical treatment is commonly pursued. Veterinarians have previously identified cost of culture and sensitivity testing and lack of rapid diagnostic tests as barriers to appropriate AMU (Rule et al., 2021). The finding that bacteriological culture was not commonly used to support antimicrobial selection in our study agrees with the results of other published studies (Hughes et al., 2013; Rule et al., 2021; Welsh et al., 2017).

This study documented dose rates for the antimicrobials which has not been accomplished in other published studies of antimicrobial use in horses in first opinion equine practice. Tallon et al. (2023) recorded antibiotic usage in 14 equine veterinary practices (both hospital and ambulatory practices) using one specific practice management software over a 10-year period (2012–2021). No distinction between systemic administration and local administration of the antibiotics was possible in this study. The study of Tallon et al. (2023) study used an average weight to calculate dose rates, but this will have led to inaccuracies in the results since weights of animals are not consistently recorded in the electronic patient records. Estimating the weight of each horse prescribed an antibiotic in the current study allowed more accurate dose rates calculations for the antibiotics to be recorded. The median dose rate recorded for the trimethoprim/sulphadiazine (39 mg/kg) and doxycycline (10 mg/kg) matched the recommended dose rates listed in the BEVA Protect-ME toolkit (BEVA, 2019). However, the median dose rates for oxytetracycline (6 mg/kg) and procaine penicillin (19 mg/kg) were lower than current recommendations (6.6 and 22 mg/kg, respectively) (Hardefeldt et al., 2021). Wide variations in dose rates in individual patients were also identified, which highlights an issue that requires further work and improvement. Inappropriate dose rates of antimicrobials are a known factor that contributes to the development of AMR (Lloyd & Page, 2018).

There were several limitations of this study. The point prevalence surveys required manual input of data from the veterinary practices. Ultimately, automated data input from electronic patient records should permit easier collection of AMU in equine practices, but this requires accurate recording of clinical and demographic data, which is currently limited in most practice management system records. The further development of equine veterinary disease surveillance initiatives such as EVSNET (https://www.liverpool.ac.uk/evsnet/), Equine VetCompass (https://www.rvc.ac.uk/vetcompass/research-projects-and-opportunities/projects/vetcompass-equine) and VetTeamAMR (https://knowledge.rcvs.org.uk/quick-links-to-journals/vetteam-amr/) should ultimately provide increased opportunities to record and monitor AMU at the individual practice level.

The collaborating veterinary practices in our study represented a convenience sample of UK equine practices (all practices were part of the CVS Equine Group) which may have introduced some selection bias, due to availability of different drug preparations within the corporate group; however, this was considered to be negligible. In addition, the duration of antimicrobial therapy was not recorded in this study; this is likely to be another important factor that may contribute to the development of AMR. The primary goal of the study was to understand antibiotic prescribing rates and common indications in first opinion equine veterinary practices. Given the study design, clinical outcomes could not be determined from this data set. Additionally, while indications for prescriptions of antibiotics were recorded, diagnosis was not recorded for animals that did not receive a prescription of antibiotics. This precluded us from reporting on the rates of antibiotic prescribing for specific conditions; this should be a goal of future studies. Finally, the results of this study cannot be extrapolated to all equine first opinion practices in view of the highly variable populations of horses in different practices.

Despite the limitations of this study, our results are useful in establishing baseline rates that can subsequently be used to assess the success of antimicrobial stewardship initiatives. Documenting antimicrobial use is a fundamental step towards gauging appropriateness of use and developing stewardship policies. Analysis of AMU data also allows for comparison of antimicrobial prescribing patterns between practices, which can be used to assess stewardship strategies.

AUTHOR CONTRIBUTIONS

Charlotte Sinclair: Conceptualization; data curation; investigation; methodology; project administration; writing – original draft. **Imogen Schofield:** Data curation; methodology; project administration; visualization; writing – original draft. **Tim S Mair:** Conceptualization; data curation; formal analysis; investigation; methodology; project administration; supervision; validation; writing – original draft.

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CONFLICT OF INTEREST STATEMENT

No conflicts of interest have been declared.

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ETHICS STATEMENT

Approval was granted by the CVS Ethics Panel.

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