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ORIGINAL RESEARCH

'Knowledge, attitudes and practices' survey of Austrian veterinarians' antibiotic use in clinical practice

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Abstract

Background: Antimicrobial resistance (AMR) is a critical global health issue, with antimicrobial use (AMU) in veterinary medicine playing a relevant role in its emergence. This study aimed to evaluate the knowledge, attitudes and practices of Austrian veterinarians regarding AMU and AMR.

Methods: An online survey was conducted in 2022. Veterinary respondents were grouped according to their type of practice (companion animals, i.e., pets and horses; farm; mixed practice).

Results: Knowledge gaps were identified, particularly among companion animal veterinarians, with only 31% correctly recognising cefovecin as a critically important antimicrobial and 16% incorrectly stating it was a first-choice drug. However, treating groups of animals with orally administered antibiotics was correctly classed as having the highest influence on AMR by 75% of 165 respondents. With respect to deciding to use antibiotics, all practitioners considered a clinical examination to be important or very important, while cost considerations and owner expectations were classed by companion animal practitioners as being significantly less important than among farm and mixed practitioners. Of all 180 veterinarians, 47% reported using antimicrobial susceptibility testing always or regularly (approximately 20%–50% of antibiotic treatments).

Limitations: The small sample size may have introduced confirmation bias, as practitioners with a particular interest in AMU and AMR may have been more likely to respond to the survey.

Conclusion: The findings confirm the need for additional training to improve prudent AMU and awareness of antimicrobial stewardship in clinical practice across all veterinary sectors in Austria. Future efforts should prioritise the knowledge gaps among companion animal practitioners, in particular.

INTRODUCTION

The threat of antimicrobial resistance (AMR) remains a true silent pandemic, which has the potential to negatively affect human and animal health. A recent modelling study estimated 1.9 million deaths attributable to AMR and 8.2 million deaths associated with AMR could occur in 2050.[1] The link between antimicrobial use (AMU) and AMR in both human and veterinary medicine is complex and not always linear. Nevertheless, certain AMU has been shown to directly affect AMR, such as when the use of quinolones in poultry was introduced in the Netherlands and a subsequent increase in ciprofloxacin-resistant *Campylobacter* isolated from humans was noted.[2] For this reason, there is high-level agreement between a variety of international agencies, such as the World Health Organization (WHO), World Organisation for Animal Health (WOAH), United Nations Environment Programme, and the Food and Agriculture Organization of the United Nations, that AMU in both humans and animals is a contributing factor to global AMR and all One Health aspects need to be considered when combating this health concern.[3]

According to the most recent European ESVAC report, Austrian sales of veterinary antibiotics for

use in food-producing animals have continuously fallen, from 50.2 mg/population correction unit (PCU) in 2018 to 36.2 mg/PCU in 2022.[4] While not as low as in Scandinavia, the Austrian values have always been substantially lower than those of neighbouring countries (e.g., Italy [157.5 mg/PCU] and Germany [69.9 mg/PCU] in 2022).[4] In the first report of the new EU monitoring system (ESUAvet), Austria was reported to have sales of 22.0 mg/PCU for non-food-producing animals (primarily dogs and cats) in 2023.[5] Again, this value was lower than values reported for Italy (29.9 mg/PCU) and Germany (33.5 mg/PCU), although it must be noted that this new monitoring system is not yet complete with respect to data availability.[5]

The limited veterinary AMU in Austria may derive from the fact that AMU monitoring in food-producing animals has been mandatory for over a decade. In Austria, veterinarians treating farm animals have been required to report any antibiotics dispensed for use in these species since 2015.[6] Antibiotics can also only be dispensed by the herd veterinarian to farmers trained in medicine use as part of their membership in the Austrian Animal Health Service. Antibiotics administered by farm veterinarians directly were previously excluded from the reporting requirement. However, it is now mandatory in the EU to report all AMU in cattle, pigs and poultry.[7,8] Furthermore, in accordance with both Austrian and EU legislation, from 2027, all equine AMU will be required to be reported and from 2030 all AMU in cats and dogs.[7,8] It is important to note that both previous and current Austrian legislation on antimicrobial use includes antibacterial substances only and, for this reason, this knowledge, attitudes and practices (KAP) survey focused solely on the use of antibiotics and not that of antiparasitic or antiviral drugs.

Regardless of the legal framework in place, to ensure the prudent use of antimicrobial substances, it is vital that both veterinarians and medics have an adequate level of knowledge about antibiotics. Antimicrobial stewardship programmes will only be successful if prescribers understand why changes to their AMU are necessary. For this reason, the current study aimed to use a KAP survey method, commonly used in healthcare research to assess the status quo of clinical practice,[9] to evaluate these aspects with respect to what is known, believed and done in the context of veterinary AMU and AMR among Austrian veterinarians.

MATERIALS AND METHODS

Survey

The survey was constructed by C. L. F., A. K. and K. F. Both C. L. F. and A. K. are veterinarians, while K. F. is a data expert in veterinary antibiotic monitoring. Questions were selected based on the literature and the authors' experience in clinical practice (C. L. F.), antimicrobial stewardship programmes (all) and veterinary education (C. L. F. and A. K.). The survey was created using the online software Sogolytics, was tested on three veterinarians in clinical practice and questions were adapted/rewritten accordingly. The final survey comprised 45 questions, including 30 multiple-choice questions, seven text questions, seven Likert scale questions and one ranking question. Questions were grouped into the three areas of knowledge, attitudes and practice, as well as the demographics of the participants.

Questions in the area of 'knowledge' included whether the respondents had attended continuing professional development (CPD) training in the area of AMU or antibiotic resistance in the last 5 years, how they would classify different antibiotics, and how modes of drug administration could influence AMR.

To be able to analyse the veterinarians' opinions towards various aspects of AMU, the participants were asked to rate statements in the 'attitudes' section using a Likert scale. Responses ranged from completely agree to disagree completely. Four Likert responses were chosen, so that participants could not continuously choose a central 'neutral' response.

In the 'practice' section, questions were asked about, for example, the veterinarians' use of antimicrobial susceptibility testing (AST), their use of antibiotic guidelines and how they attempted to reduce their use of antibiotics in their daily clinical work.

A translated summary of the German survey is provided in Table S1. Table S1 also includes details of whether questions were single or multiple answer, as well as to which KAP area they belonged.

Distribution

The link to the online survey was distributed via the email list of the Austrian Chamber of Veterinarians (ÖTK, equivalent to the RCVS in the UK) to all licensed veterinarians in the country. Furthermore, the survey link was published on private Facebook groups for German-speaking veterinarians and leaflets with a QR code to the survey were distributed at the largest companion animal conference in Austria (annual meeting of the VÖK—[Austrian Association for Small Animal Veterinarians]), as well as at smaller local meetings of the Austrian Animal Health Service (*Tiergesundheitsdienst*) for farm animal practitioners. The link was shared internally via email with all veterinarians employed in the clinical departments at the University of Veterinary Medicine in Vienna and also through specialist veterinary associations. Reminders were sent once.

The survey was available online from September to December 2022.

Data cleaning

Following closure of the online survey, data were exported from the Sogolytics online platform

TABLE 1 Respondents' length of time in clinical practice, by practice type.

	Companion animals ($n = 100$)	Farm ($n = 55$)	Mixed practice ($n = 25$)
0–2 years	13.0% (13)	10.9% (6)	16.0% (4)
3–5 years	5.0% (5)	9.1% (5)	4.0% (1)
6–10 years	9.0% (9)	14.6% (8)	4.0% (1)
11–15 years	14.0% (14)	5.5% (3)	12.0% (3)
16–20 years	14.0% (14)	12.7% (7)	8.0% (2)
>20 years	45.0% (45)	47.3% (26)	56.0% (14)

into Microsoft Excel (Microsoft Corporation). The questions were grouped into KAP categories. The respondents were also grouped into 'companion animals' (small animal and/or equine practitioners), 'farm' and 'mixed practice'. With respect to veterinarians who responded with 'mixed practice' as their practice type, they were moved to either 'companion animal' or 'farm' if either of these species' groups made up more than 80% of their clinical work. If the various species treated were all under 80% per species, then the response remained in the 'mixed practice' category (e.g., farm 20%; small animals 55%; equine 25% = 'mixed practice' compared to farm 85%; small animals 10%; equine 5% = 'farm').

Statistical analysis

The Pearson chi-square test was used to test for significant differences. If the result of the test yielded a p-value < 0.05, this difference was considered statistically significant. All calculations were carried out using the statistical software GNU R (version 4.3.2).[10]

RESULTS

Respondents' demographics

In total, 183 veterinarians responded to the survey. During the data cleaning process, responses from three participants were removed from the dataset for the following reasons: not in clinical practice [1]; not practicing veterinary medicine in Austria [1]; did not answer any questions or answered 'x'/'no answer given' [1]. A further respondent had not completed the entire survey but had answered more than 75% of the questions and was therefore included in the dataset. After data cleaning, 180 respondents remained in the dataset.

Of these, 55.6% (100/180) worked in companion animal (small animal and/or equine) practice, 30.6% (55/180) in the farm sector and 13.9% (25/180) in mixed practice. In all three groups, around half of the respondents had been in clinical practice for more than 20 years, namely, 45% (45/100) of those in companion animal practice, 47.3% (26/55) in farm practice and 56.0% (14/25) in mixed practice (Table 1). This is comparable to the distribution by age of all veterinarians licensed to practice in Austria according to the official veterinary register, where 46.2% of veterinarians are aged more than 50 years (K. Fuchs, personal communication, 2023).

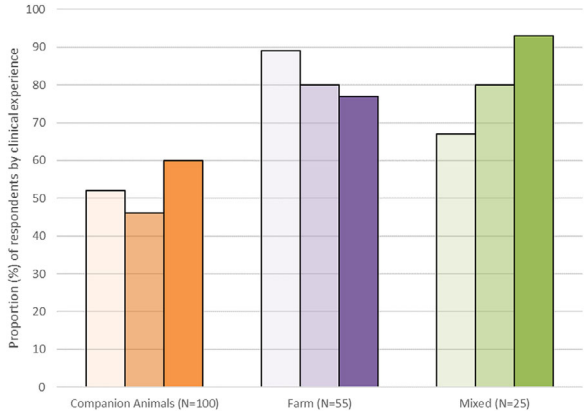


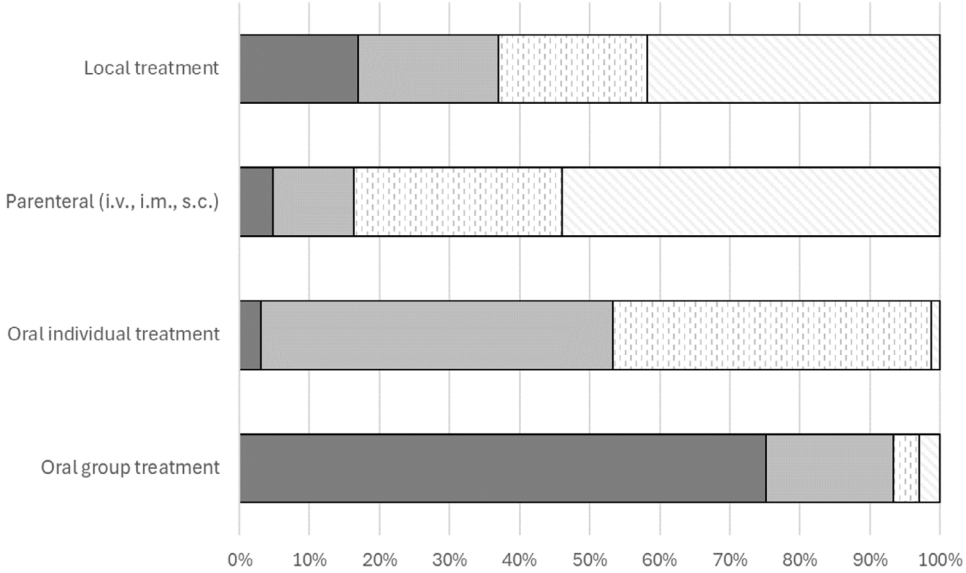
FIGURE 1 Proportion of veterinarians in each clinical experience group who attended continuing professional development on antibiotics in the past 5 years (divided by practice type). Lightest shading: 0–10 years in clinical practice; mid-shade: 11–20 years; darkest shade: more than 20 years.

As their highest veterinary qualification, the majority (53.3%; 96/180) of the respondents had obtained their undergraduate degree, which entitled them to practice as veterinarians, followed by a research doctorate in veterinary medicine (Dr.med.vet.) (39.4%; 71/180).

Knowledge

A total of 66.7% (120/180) of all respondents stated that they had attended any kind of CPD courses on antibiotics in the past 5 years, with 8.8% (16/180) of the study population not answering this question. However, when these responses were divided by practice type, there was a statistically significant difference ($p < 0.05$) between groups, with 81.8% (45/55) of farm practitioners and 84.0% (21/25) of mixed practitioners attending such events, compared to just over half of companion animal practitioners (54.0%; 54/100) (Figure 1).

The respondents were asked to rank antibiotic administration methods with respect to their influence on AMR, with 1 having the highest influence and 4 having the lowest. Results were classified



	Oral group treatment	Oral individual treatment	Parenteral (i.v., i.m., s.c.)	Local treatment
Highest influence	124	5	8	28
Some influence	30	83	19	33
Slight influence	6	75	49	35
Least influence	5	2	89	69

FIGURE 2 Respondents' ranking of antibiotic administration methods and their influence on antimicrobial resistance, with 1 being the highest impact and 4 being the lowest impact. *Note*: Fifteen people did not respond, as this question was not mandatory.

according to the suggested European Medicines Agency (EMA) ranking of administration methods published in 2019.[11] Oral treatment of groups of animals was correctly classed as having the highest influence on AMR by 75.2% of 165 respondents (median rank: 1), followed by oral treatment of individual animals being ranked second by 50.3% (median rank: 2), parenteral treatment was ranked third by 29.7% (median rank: 3) and local treatment (e.g., eye drops, creams) correctly ranked to have the least impact on AMR by 41.8% (median rank: 4) (Figure 2).

With respect to the critically important antimicrobial classifications of the WHO (highest priority critically important antimicrobials [HPCIA]), the EMA (category B) and the WOAH (veterinary critically important antimicrobials[(VCIA)] https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20008823, the vast majority of all respondents in all species groups had no recognition of these terms (Figure 3). HPCIA and category B were the most recognised classifications. Farm and mixed practitioners were more likely to recognise these terms than companion animal practitioners, although 26% of the latter had heard of the most recent EMA category B antibiotics (Figure 3). Although these classifications were introduced from the mid-to-late 2000s onwards, older veterinarians who had been in practice longer than 20 years actually had the highest levels of recognition for all three organisational terms to classify antibiotics, even among companion animal practitioners (Figure 3). The general German terms 'reserve antibiotics' (recognised by 97% of respondents) and 'critical antibiotics' (63% of respondents) were more frequently recognised compared to official classifications. However, these terms have no official definition or designation with respect to antibiotic classes and are used to generally refer to antibiotics that should be 'reserved' for human medicine or to treat resistant infections.

With respect to the EMA categorisation of specific antibiotics,[11] exemplary results are shown in Table 2. To assist the respondents in their decision making, one or two common brand names for each antibiotic were also given. Carbapenems (EMA category A: avoid), which are not licensed for use in veterinary medicine, were not recognised (43%; 77/180) or not used in the animal species (36%; 65/180) by the majority of veterinarians (Table 2). Approximately one quarter of companion animal practitioners classified carbapenem as a critically important antimicrobial and none of the respondents in any practice group stated that they would use it as a first-line drug.

In category B (restrict use), 34% (61/180) correctly identified enrofloxacin according to the EMA classification as a critically important fluoroquinolone, which should be reserved for human use (Table 2). However, 19% (19/100) of companion animal practitioners stated that enrofloxacin was a first-line antibiotic, compared to just 5% (3/55) of farm and 8% (2/25) of mixed practitioners. Some (third/fourth generation) cephalosporins are only licensed for use in certain animal species. When divided into the practitioner types most likely to be familiar with these critically important cephalosporins, most veterinarians placed ceftiofur (for farm animals) and cefovecin (for pets) in either the critically important or the second-line group.

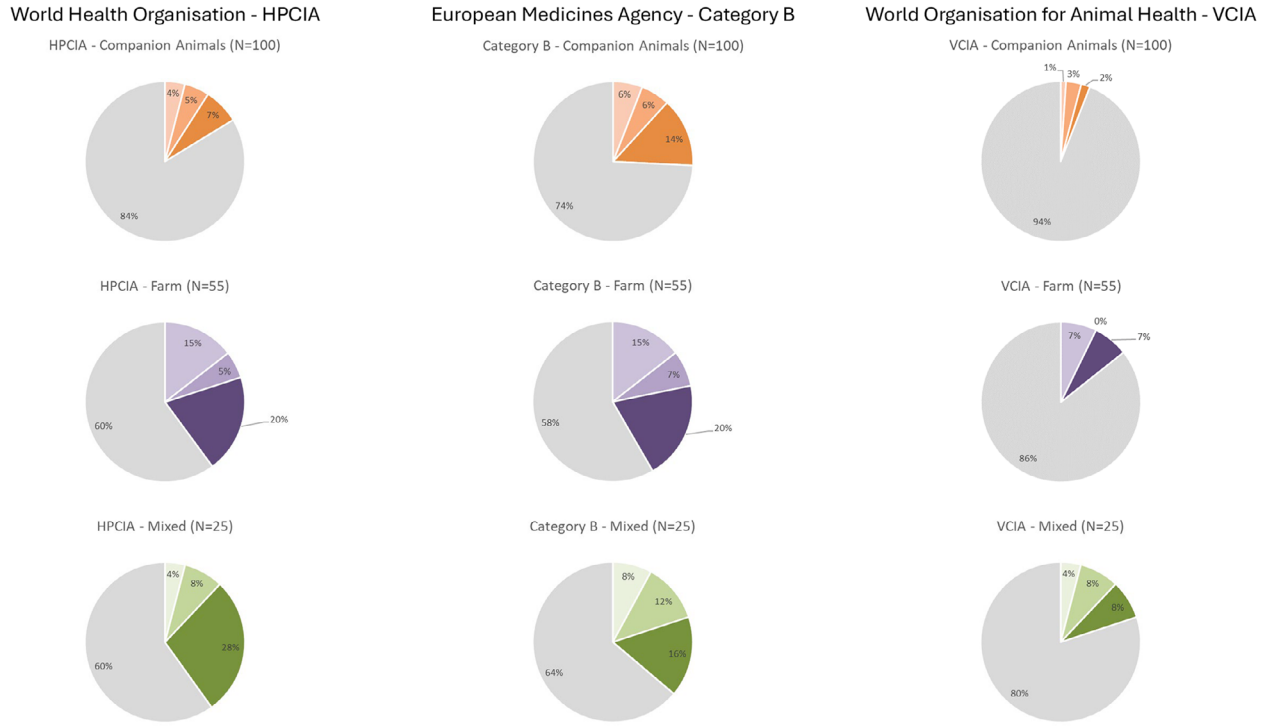


FIGURE 3 Respondents' recognition of official antimicrobial classifications by practice type and length of time in clinical practice (the darker the colour, the longer in practice from 0–10 years, 11–20 years and >20 years; grey colour denotes no recognition of the term). HPCIA, highest priority critically important antimicrobials; VCIA, veterinary critically important antimicrobials.

Ceftiofur was correctly identified according to the EMA classification as critically important by 40% (26/55) of mixed and 47% (10/25) of farm veterinarians, while cefovecin was correctly identified by 31% (31/100) of companion animal practitioners (Table 2). However, in contradiction to the EMA classification, 16% (16/100) of companion animal practitioners classed cefovecin as a first-choice antibiotic, while only 6% (3/55) of farm veterinarians classified ceftiofur as such.

Of all respondents, 38% (69/180) correctly identified tylosin (EMA category C: cautious use) according to the EMA classification as a second-choice antimicrobial (Table 2). In accordance with the EMA classification, 86% (154/180) correctly identified amoxicillin (EMA category D: prudent use) as a first-line antibiotic, with no statistically significant difference found between groups (Table 2). It is important to note that, while amoxicillin is classed by the EMA as category D and is therefore considered a first-choice antibiotic, penicillins with a narrow spectrum of activity are available. However, in the current study, amoxicillin was included in the survey to ensure the maximum level of recognition among practitioners treating a variety of animal species.

Attitudes

When asking respondents for their opinions with respect to AMU and AMR, a four-point Likert scale was used. Most practitioners disagreed (39%) or completely disagreed (36%) that AMR in veterinary medicine is exaggerated as a problem (Figure 4). Whether veterinary medicine played a crucial role in AMR risk to humans was more controversial, with 41% of respondents agreeing and 35% disagreeing with this statement. Almost all (97%) veterinarians were in agreement that antimicrobial susceptibility tests should always be used for problematic cases/recurrent infections (with over 70% agreeing completely), and 90% agreed that critically important antimicrobials should not be used as a first-line drug in veterinary medicine (almost 60% in complete agreement with this statement) (Figure 4).

When asked for their opinion on the use of antibiotics as growth promoters, the vast majority of farm and mixed practitioners were aware that the use of antibiotics as growth promoters is no longer permitted in Austria (>80% in each practice group), although 5% and 4% of these groups (respectively) stated that they did not know. No farm practitioners stated that antibiotics were routinely used for growth promotion in Austria. However, 19% of companion animal practitioners responded that growth promoters were used routinely in Austria in their opinion, while 40% of this group stated that they did not know whether antibiotics were used for this purpose.

Practices

The most important aspects for all veterinarian respondents with respect to decision making in antibiotic treatment was the clinical examination of the animal (79%; 143/180 stated that this was a very important aspect), followed by clinical experience

TABLE 2 Knowledge of prudent use categories, using specific antibiotics as examples, by total population and practice type.

	First choice	Second choice (ideally after culture/AST)	Critically important antibiotic (reserve for use in human medicine)	Not used in the animal species I treat	Do not recognise this antibiotic
Category A (not licensed for use in veterinary medicine): carbapenem					
Whole population ($N = 180$)	0%	4%	17%	**43%**	36%
Companion animals ($N = 100$)	0%	5%	26%	**40%**	29%
Farm ($N = 55$)	0%	2%	5%	**55%**	38%
Mixed ($N = 25$)	0%	8%	4%	28%	**60%**
Category B (restrict use): enrofloxacin (fluoroquinolone)					
Whole population ($N = 180$)	13%	**51%**	34%	2%	0%
Companion animals ($N = 100$)	19%	**64%**	15%	2%	0%
Farm ($N = 55$)	5%	33%	**60%**	2%	0%
Mixed ($N = 25$)	8%	36%	**52%**	4%	0%
Category B (restrict use, only licensed in farm animals): ceftiofur (third-generation cephalosporin)					
Whole population ($N = 180$)	3%	30%	**31%**	22%	14%
Companion animals ($N = 100$)	3%	21%	19%	**32%**	25%
Farm ($N = 55$)	6%	36%	**47%**	11%	0%
Mixed ($N = 25$)	0%	**52%**	40%	4%	4%
Category B (restrict use, only licensed in pets): cefovecin (third-generation cephalosporin)					
Whole population ($N = 180$)	9%	**28%**	27%	27%	9%
Companion animals ($N = 100$)	16%	**41%**	31%	11%	1%
Farm ($N = 55$)	0%	9%	13%	**58%**	20%
Mixed ($N = 25$)	4%	16%	**44%**	20%	16%
Category C (cautious use): tylosin (macrolide)					
Whole population ($N = 180$)	18%	**38%**	10%	32%	2%
Companion animals ($N = 100$)	9%	36%	10%	**43%**	2%
Farm ($N = 55$)	29%	**44%**	13%	14%	0%
Mixed ($N = 25$)	28%	**36%**	8%	24%	4%
Category D (prudent use): amoxicillin (penicillin)					
Whole population ($N = 180$)	**86%**	8%	0%	6%	0%
Companion animals ($N = 100$)	**85%**	6%	0%	9%	0%
Farm ($N = 55$)	**87%**	9%	0%	4%	0%
Mixed ($N = 25$)	**84%**	16%	0%	0%	0%

Note: Green background colour shows the correct category according to the European Medicines Agency classification. Bold % values denote the highest proportion for each practice type or the whole study population.
Abbreviation: AST, antimicrobial susceptibility testing.

(70%; 126/180) and a confirmed diagnosis (58%; 104/180) (Figure 5). No respondents in any group stated that they considered the clinical examination was not important. There was a statistically significant difference ($p < 0.05$) between practitioner groups with respect to companion animal and farm veterinarians versus mixed practitioners, where 58% of companion animal and 69% of farm practitioners considered a confirmed diagnosis to be very important for decision making compared to just 32% of mixed practitioners (64% of whom considered a confirmed diagnosis to be important but not very important). Veterinary practitioners with more than 11 years of clinical experience found that this experience was very important for their decision-making processes compared to colleagues with less experience (namely 79% of both the 11–20-year and 79% of the >20-year groups compared to 48% with 0–10 years of experience, $p < 0.05$).

Statistically significant differences were also determined between groups with respect to the cost of treatment and the expectations of the animal owner (Figure 5). For companion animal practitioners, the cost of treatment was not important for 52% (52/100) of respondents compared to 36% (20/55) for farms and 32% (8/25) for mixed practice veterinarians (Figure 5). Similarly, 27% of companion animal veterinarians stated that the expectations of the owner were not important at all for their decision making with respect to AMU compared to 11% for farms and 12% for mixed practitioners (Figure 5).

AST was frequently used among almost half (47%) of the 180 veterinarians who responded to this survey, with 41% of all respondents stating that they regularly (i.e., in approximately 20%–50% of all cases requiring antibiotic treatment) and 6% always used AST confirmation of their choice of antibiotic. With the exception

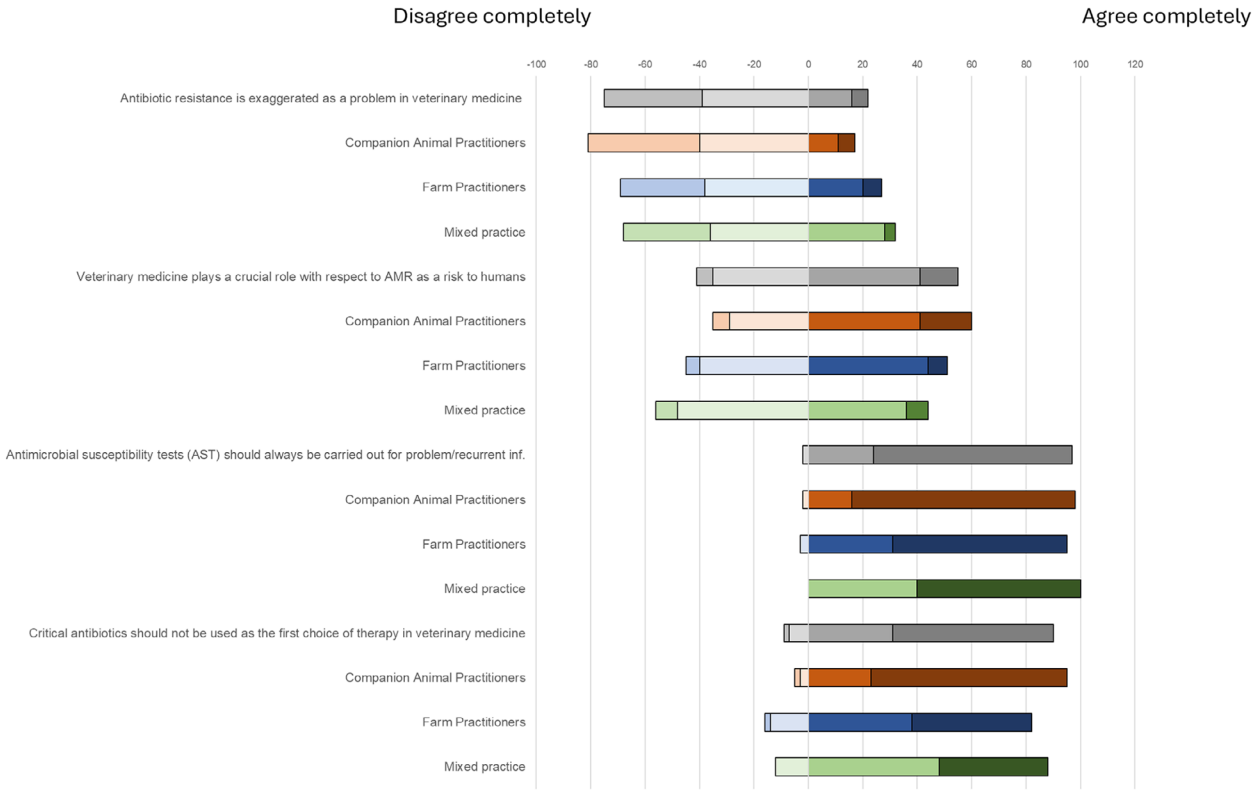


FIGURE 4 Attitudes of respondents to statements on antimicrobial use (AMU) and antibiotic resistance (AMR) in veterinary medicine: whole population in grey shades, companion animal practitioners in orange shades, farm practitioners in blue/violet shades and mixed practice in green shades. Negative percentage (light shades) denotes disagree; positive percentage (dark shades) denotes agree.

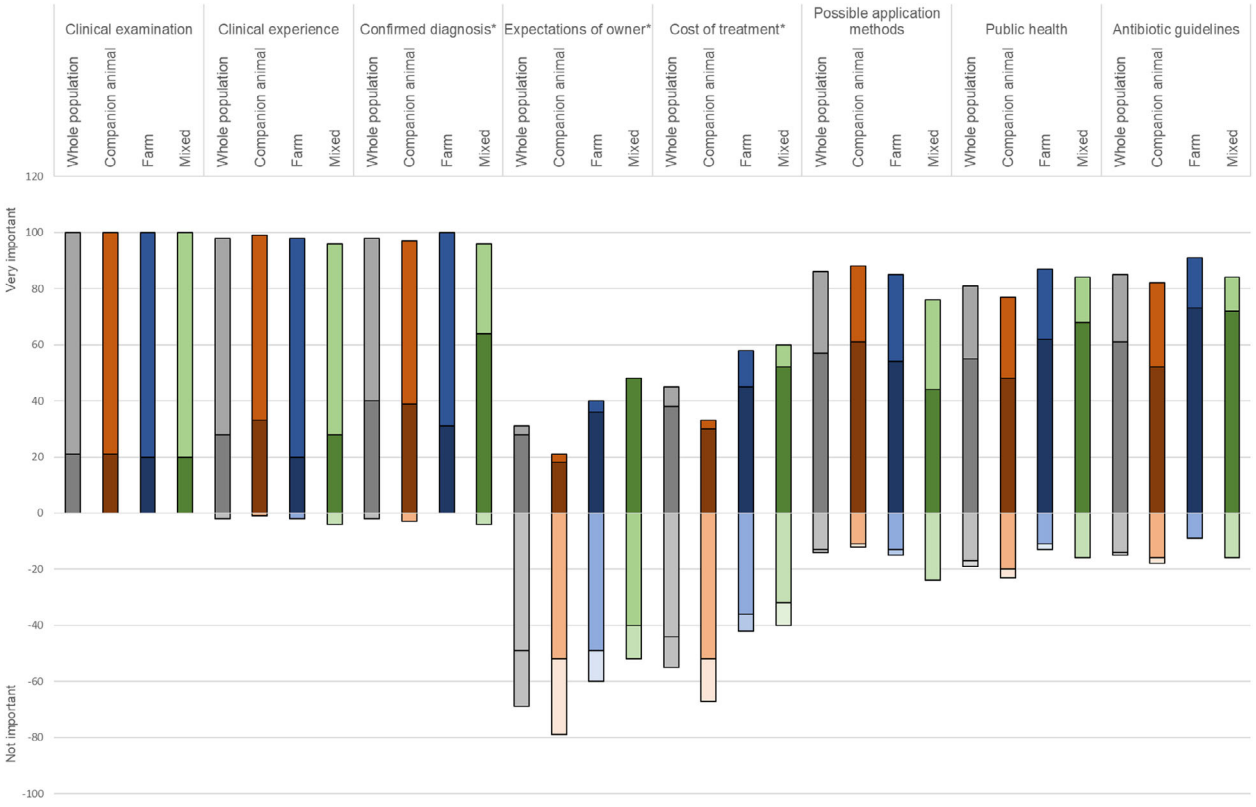


FIGURE 5 What veterinarians considered important when deciding to use antibiotics in clinical practice: whole population in grey shades, companion animal practitioners in orange shades, farm practitioners in blue/violet shades and mixed practice in green shades. *Statistically significant difference between animal species treated. Negative percentage denotes not important; positive percentage denotes important.

of one mixed practitioner, no respondents stated that they never used AST in clinical practice. When divided by animal species treated, the farm practitioners were more frequent users of AST, with 49% stating that they regularly and 11% that they always used an AST (combined total: 60% of farm practitioners) compared to companion animal practitioners, 40% of whom used AST confirmation regularly and 5% who always used AST (combined total: 45%). Companion animal practitioners were more likely to only use AST for problematic or relapsed cases (26%), compared to just 7% of farm veterinarians who only used AST in these cases.

DISCUSSION

This KAP survey was carried out in 2022, and it is important to note that, since then, an additional Austrian veterinary medicine law—in accordance with EU regulation 2019/6 (the Veterinary Medicines Regulation)—has been implemented.[7,8] As an example, the use of fluoroquinolones and third/fourth-generation cephalosporins now requires confirmation of the necessity of using these category B drugs by AST in most cases.

Knowledge

There was a large difference in CPD attendance between practice types, with around 50% of companion animal (pets and equine) veterinarians attending CPD on AMU/AMR in the past 5 years, compared to over 80% for those treating farm animals. Reasons for this are likely to include the fact that since 2015, AMU monitoring has been in place for farm veterinarians and it is mandatory to report antibiotics dispensed to farmers for use in food-producing animals to the relevant authorities.[6] Farm and mixed practitioners were therefore offered much more specific CPD in this area than companion animal practitioners in the years preceding this study (2015–2021).

From 2027, equine practitioners will be required to report all AMU to the Austrian authorities and from 2030 this requirement will be extended to cover veterinarians treating dogs and cats.[7] As such, we would expect companion animal practitioners to be the focus of much more species-specific CPD in future, with the Austrian Ministry of Health and Austrian Chamber of Veterinarians already offering webinars on AMU monitoring to companion animal practitioners. A study of veterinary practitioners from seven EU countries reported that veterinarians in all species' groups considered training and literature on AMU to be the most important information sources.[12] As companion animal practitioners are also (theoretically) permitted to use human antibiotics off-label, and as two recent German studies reported that 51% of the respondent equine practitioners and 47.9% of the small animal veterinarians have done so to treat animals in their care,[13,14] the importance of this training for these veterinarians becomes even clearer in a One Health context.

A recent review of factors influencing behaviour for AMU and awareness of AMR in agriculture reported that there were large differences between countries among veterinarians and their attitudes towards training and published literature for farmers,[15] with Dutch veterinarians believing that educational programmes should be compulsory for farmers. Through the Animal Health Service, this is already the case in Austria, although the scheme covers all training courses and not just a focus on AMU/AMR. A Swedish study of farm veterinarians also confirmed that their decision-making process was easier when farmers had a good understanding and knowledge of the importance of antimicrobial stewardship and that Swedish farmers generally accepted when antibiotics were not necessary for their particular animal.[16] Similarly, a survey of pig veterinarians found that practitioners in countries with long-standing and extensive/restrictive AMU monitoring schemes (such as Sweden and Denmark) reported less pressure from farmers to prescribe antibiotics than their colleagues from Germany, Belgium and Switzerland, where restrictive AMU programmes have more recently been introduced.[17] Unfortunately, a good level of basic knowledge on AMR is not present in the general public in Austria (as shown by a recent survey in 2023 which reported that 43% of respondents aged less than 25 years would take antibiotics to treat influenza and 32% for the common cold).[18]

The recognition of certain antibiotic classifications, as defined by the WHO, EMA and WOAH, was not as well-known as expected by the authors given the fact that these terms have been in place for many years and, in some cases, even decades. In fact, the vast majority of all veterinary practitioners participating in this survey had not heard of any of them, which is a concerning finding with respect to the general knowledge of antimicrobial stewardships programmes among Austrian veterinarians. Unexpectedly, older clinicians (i.e., those with >20 years of clinical experience) did not have a lower level of classification recognition, although none of these terms were in use when they obtained their veterinary degrees. Colloquial German terms ('reserve antibiotics' and 'critical antibiotics') attained a higher level of recognition; however, these terms do not correspond to any particular antibiotic classes but merely refer to the fact that these antibiotic drugs should be 'reserved for human use'. Again, companion animal practitioners had the lowest levels of recognition, with around a quarter of this group recognising the EMA category B 'restrict'.

Further investigation in this area, namely, how veterinarians would categorise specific antibiotics, demonstrated that the commonly used long-acting third-generation cephalosporin, cefovecin, was only correctly classified according to the EMA categorisation as a critically important antimicrobial by 31% of companion animal practitioners, while 16% of this

group classified it as a first-choice drug. Cefovecin is frequently used in small animal clinical practice as it is an injectable long-acting drug, which therefore ensures that owners do not have to attempt to give daily tablets to cats. A study of first opinion practices in the USA reported that 50% of more than 14,000 dental procedures on cats were accompanied by cefovecin treatment.[19] By comparison, 47% of farm veterinarians did correctly respond that ceftiofur was a critically important antimicrobial (according to the EMA classification), with only 6% stating it was a first-choice drug. It is important to note that examples of brand names, as well as active ingredients, were given in this survey question to ensure maximum recognition of drugs that the respondents were familiar with using in everyday practice and that respondents were also given the option 'I do not recognise this antibiotic' rather than being forced to choose one of the other options.

Attitudes

Most veterinarians in all practice areas did not agree that the problem of AMR in veterinary medicine was exaggerated and almost 60% agreed that veterinary medicine plays a crucial role in the risk of AMR to humans. This demonstrates that the Austrian veterinarians responding to this survey are aware of the problem and are taking their role in antimicrobial stewardship seriously.

The vast majority (>95%) of respondents (in all practice groups) in the current study agreed or completely agreed that AST should always be used for problematic or recurrent infections. When asked about their general use of AST in clinical practice, only one mixed practitioner stated that they never used susceptibility testing, and all companion animal and farm veterinarians used AST at some level of frequency in their clinical practice.

Given that this practice was banned throughout the EU in 2006,[20] the fact that almost 20% of the companion animal practitioners reported that they believed antibiotics were routinely used for growth promotion in Austria and 40% did not know, was unexpected. While initially considered a knowledge gap, this question began with the phrase 'in your opinion', which led to this area being considered more of an attitude than a knowledge question. Upon reflection and considering that fact that around 5% of farm/mixed practitioners also stated that they did not know whether antibiotics were used for growth promotion, the authors believe that this question was perhaps not clearly formulated, but nevertheless, we believe that this clearly demonstrates the need for further training in this area. It is important to note that respondents could only pick one answer to this question, which may have caused conflicted choices between those who may have observed illegal use of antibiotics in this manner, but did in fact know that such use was banned. Nevertheless, such use should never be considered to be 'routine'. While approximately 5% of farm veterinarians stated that they had not recently attended CPD on antibiotics, this regulation has been in place for 20 years and cannot be classed as new information. However, the fact that companion animal veterinarians were much less likely to have attended CPD on AMU or AMR than farm veterinarians in the last 5 years further demonstrates the importance of targeted training and education for these practitioners.

While the knowledge of which antibiotics belonged to critically important categories was somewhat limited, the vast majority (>80% in all practice groups) felt that they should not be used as a first-choice drug in veterinary medicine. An investigation into farm veterinarians' opinions of antimicrobial stewardship schemes in Wales reported mixed results on what should be done to reduce the use of critically important antibiotics, with some respondents stating that they believed that government-led increased taxation on such drugs was less feasible and would be less effective than other surveyed antimicrobial stewardship initiatives. A minimum requirement for CPD on antibiotics for veterinarians in the practice was considered to be an extremely effective initiative with respect to antimicrobial stewardship by almost half of respondents. Furthermore, the veterinarians surveyed stated that benchmarking schemes for farmers were highly acceptable to them as veterinarians, while the implementation of such schemes for veterinarians was considered less feasible.[21]

Practices

All respondents in the present study considered the clinical examination to be important or very important when deciding to use antibiotics. Almost all practitioners also stated that clinical experience and a confirmed diagnosis were important or very important. With respect to a confirmed diagnosis, this corresponds to a study of physicians and veterinarians in Hong Kong, where 97% of veterinarians considered that laboratory results were an important variable in their prescribing decisions with respect to antibiotics.[22] In a Portuguese study pet owners reported in 41.5% of cases that their pets were prescribed antibiotics after a test had been done to confirm the diagnosis.[23]

There was a difference between practice types with respect to how frequently AST was done or not. Farm practitioners were more likely to always or regularly use (bacteriological culture and) AST (combined total: 60% of farm respondents) compared to 45% of companion animal practitioners. This is likely in part due to the legal requirements in place in Austria with respect to food-producing animals, and the Austrian Animal Health Service and its local laboratories providing free or subsidised bacteriological culture and AST to members. As the Austrian Animal Health Service does not provide a subsidised laboratory service to companion animal practitioners, this difference was

expected. While direct comparisons with other countries are difficult due to a wide variety of antibiotic prescribing practices and veterinary medicines legislation at the time of the survey, this relatively high proportion of farm veterinarians regularly using culture and sensitivity testing is in stark contrast to a recent survey of UK farm veterinarians, where 38% stated that they never used AST to confirm their choice of prescribed antibiotic and 57% stated that they rarely used an AST prior to making a treatment decision.[24] Similarly, a small study of Cypriot farm veterinarians reported that only 30.8% of respondents routinely used AST for treatment decisions.[25] By contrast, in an older study from Italy, cattle veterinarians reported that they always/often requested AST in 67% of mastitis cases, 37% of calf scours cases but only in 17% of respiratory indications[26]; this may, of course, be due to the difficulty to obtain suitable samples from respiratory cases for bacteriological investigations compared to the ease of collecting milk or faeces. Sampling difficulties being a barrier to the use of AST were also reported in the pan-European study by De Briyne et al.[12]

An American study of companion animal veterinarians reported that financial constraints often led to pet owners rejecting AST or interfered with the veterinarians' ability to make optimum decisions with respect to antibiotic treatment.[27] AST represents an additional cost to animal owners and is only subsidised in farm animals in Austria, not pets or horses, and this would explain the lower proportion of companion animal practitioners regularly (compared to farm practitioners) using AST in the present study. In the current study, around a quarter of companion animal veterinarians (26%) stated that AST was only used for problematic/relapse cases, a scenario that was reported as much less likely in farm practices (only 7% reserved the use of AST for problematic cases). De Briyne et al. also reported that more than 68% of EU veterinarians surveyed stated that a cheaper cost for AST would promote susceptibility testing, with this proportion increasing to 73% among small animal practitioners.[12]

Over 65% of companion animal veterinarians claimed that the cost of treatment was not important or not important at all in their clinical decision-making process. This confirms a previous study of EU veterinarians, which reported that economic factors, such as the price of antibiotics, were a neutral to less important aspect in their prescribing decisions.[12] Nevertheless, 30% of companion animal practitioners in our study did feel that the cost of treatment was important in this decision-making process, which demonstrates the complexity of this issue.

With respect to clients' expectations, companion animal practitioners, in particular, were likely to report these as not important or not important at all with respect to their clinical decision making to use antibiotics. Similarly, a pan-European study gave a mean score of very low importance of 1.02 (on a scale of 0 = not important to 4 = most important) for 'owner demand' for all veterinarians questioned on their antibiotic prescribing behaviour and a slightly higher mean importance score of 1.31 among farm veterinarians compared to those treating small animals (1.02) and horses (1.0).[12] On the one hand, this is a positive finding, as it confirms that Austrian veterinarians are not being pressured to prescribe antibiotics unnecessarily. On the other hand, it is important to strike a balance between managing client expectations and adhering to evidence-based medicine with respect to antibiotic stewardship, to ensure client compliance with potentially challenging treatment protocols, such as administering tablets to cats.

The fact that our study population was made up of a large proportion of veterinarians with more than 20 years in clinical practice, who may be less likely to be swayed by clients' wishes and in whom clients may have more trust than in younger practitioners, may have also played a substantial role in the responses obtained to this question. In the farm environment, studies have shown that trust in their veterinarian is important for advisory services to be accepted and this is reportedly difficult for newly graduated practitioners to obtain.[28] A recent study of veterinary students in the USA reported that they underestimated dog and cat owners treatment compliance with respect to antibiotics and that they overestimated the same owners' knowledge of AMR, which demonstrates the particular importance of veterinarian–client communication.[29] Furthermore, a Delphi study reported an expert consensus that antibiotics are often prescribed unnecessarily (in 'just in case' scenarios) and also added that effective communication between veterinarians and animal owners is necessary to ensure prudent AMU.[30]

Limitations

An overall limitation of this study is that, despite the authors' best efforts to ensure maximum distribution via a wide variety of channels, only 180 veterinarians completed the online survey. For this reason, the results presented here cannot be considered to be representative for Austrian veterinarians as a whole. While the study population included a relatively large proportion of companion animal (pet and/or equine) practitioners, and farm practitioners were also quite well represented, the group of mixed practitioners was very small and may have led to more outlying views being recorded. Furthermore, voluntary surveys usually attract people with a particular interest in a subject, and so for that reason, the actual levels of knowledge may be considerably lower than those shown here. While the veterinarians responding here used AST to confirm diagnoses, even before this was legally mandated in the Austrian federal law on veterinary medicines in 2024, it is important to note that even frequent use of AST does not necessarily imply confidence in the results or the ability to correctly interpret and apply these results to clinical practice

and this aspect was not questioned in our survey. Furthermore, with hindsight, the authors would have tested the survey more thoroughly to ensure the clarity of the survey questions. The frequency of AST question did not permit respondents to choose multiple answers (such as 'infrequently' and 'for problematic/relapse cases'), and there was a gap between 'regularly' (20%–50% of all antibiotic treatments) and 'always' (implying 100% of treatments), which may have caused some frustration among practitioners. Some terms, such as 'confirmed diagnosis', which was included by the authors to mean laboratory confirmation, may have been too ambiguous and been misinterpreted by some respondents and other questions were apparently not sufficiently clear for all participants. For future research, the use of mixed methods, including in-person interviews, would be an extremely interesting and useful addition to the KAP survey to enable respondents to add nuance to their answers.

CONCLUSIONS

Some essential areas for improvement (such as the differences in knowledge and practices between companion animal and farm animal veterinarians) have been brought to light by this survey. In particular, the knowledge of antibiotic categories and the use of bacteriological culture and AST needs further investigation. While government policies over the past decade have prioritised AMU in farm animals, in future, the focus of antimicrobial stewardship programmes and CPD needs to be on small animal and equine practitioners. Furthermore, although clinical decision making should remain the responsibility of the individual veterinarian, effective antimicrobial stewardship requires a collaborative effort and shared responsibility between government organisations, the veterinary profession, clients, universities, regulatory bodies and other stakeholders. Overall, we believe that this study demonstrates the need for further training and educational materials to be made available to all veterinarians in clinical practice to allow them to improve their existing level of knowledge and ensure prudent antimicrobial use while promoting animal health and wellbeing.

AUTHOR CONTRIBUTIONS

Clair L. Firth, Annemarie Käsbohrer and Klemens Fuchs conceived and designed the study, developed the survey and supervised the project. Clair L. Firth and Patricia Mayer collected the data, analysed the data, and prepared figures and tables. Clair L. Firth wrote the initial manuscript draft. Tanja Tripolt and Klemens Fuchs performed the statistical analyses. All the authors were involved in data interpretation and manuscript writing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data are available upon request due to privacy/ethical restrictions.

ETHICS STATEMENT

All participants provided their informed consent prior to completing the survey and all the responses were anonymous. However, as the survey included some personal demographic information (location, age), it was sent to the ethics committee of the Medical University of Vienna for assessment. This ethics committee decided on 2 September 2022 that an official decision was not required, in accordance with local Austrian laws.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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