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Overview on antimicrobial prescription habits in cats at different clinical services of the Veterinary Teaching Hospital of Parma

Francesca Fidanzio[1], Martina Rega[1], Simone Bertini[1], Alicia Maria Carrillo Heredero[1], Andrea Corsini[1*], Francesca Corti[1], Serena Crosara[1] and Cecilia Quintavalla[1]

Abstract

Antimicrobials are frequently administered for therapeutic and prophylactic purposes in companion animals. Their use is closely monitored as related to antimicrobial resistance both in human and veterinary medicine. This retrospective study aimed to describe antimicrobial prescription by different clinical services in cats visited at the Veterinary Teaching Hospital of the University of Parma (VTH-UP) between January 2021 and December 2023. The antibiotic classes were divided according to the categorization of antibiotics adopted by the European Medicines Agency (EMA); EMA categories A and B were classified as Critically Important Antimicrobials (CIAs). Overall, 43.8%, 35.0%, and 35.0% of visited cats received an antimicrobial prescription in 2021, 2022, and 2023, respectively. Most of the prescriptions were Category C "Caution" antibiotics (49.0%, 54.0%, and 55.0% in 2021, 2022, and 2023, respectively). Category B "restrict" antibiotics represented 13.0%, 12.0%, and 11.0% of the total antimicrobials prescribed in 2021, 2022, and 2023, respectively. Penicillins associated with beta-lactam inhibitors were the most common antibiotics prescribed each year at the VTH-UP (32.0%, 31.3%, and 23.7% of total prescriptions in 2021, 2022, and 2023, respectively). Among CIAs, quinolones were the most common, with 12.1%, 11.2%, and 10.1% of the total prescriptions in 2021, 2022, and 2023, respectively. Culture and sensitivity tests (CSTs) were performed for 18.1% (85/470), 17.4% (73/420), and 23.0% (96/417) of the total prescriptions in 2021, 2022, and 2023, respectively. Considering only CIA prescriptions, CSTs were performed in 70.0% (49/70), 66.7% (38/57), and 70.9% (39/55) of CSTs in 2021, 2022, and 2023, respectively. Antimicrobial use varies considerably depending on the clinical service. The use of "restrict" antibiotics was very limited, and attention should be given to therapeutic and prophylactic use.

Keywords Antimicrobial stewardship, Multi-drug resistance, One-health, Quinolones, Antibiotics, Internal medicine, Surgery, Emergency and critical care

*Correspondence:
Andrea Corsini
andrea.corsini@unipr.it
[1]Department of Veterinary Sciences, University of Parma, strada del Taglio 10, 43126 Parma, Italy

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Background

Antimicrobials save countless lives, but soon after they were introduced to clinical practice, resistance to these medications was found in clinical specimens [1]. Antimicrobial resistance (AMR) has dramatically increased over the past ten years, and it is now thought to be a major public health issue and an emerging global phenomenon [2].

The Antimicrobial Advice ad hoc Expert Group considered the risk to public health from AMR due to the use of antimicrobials in veterinary medicine. In 2019, this group drafted a classification of antibiotics, adopted by the European Medicines Agency (EMA), that includes 4 classes, from A to D: Avoid, Restrict, Caution and Prudence [3]. This document took into account the first categorization of antibiotics published in 2014, in which the World Health Organization (WHO) proposed 3 categories for antibiotics classified as Critically Important Antimicrobials (CIAs) for human health [4].

Category A ("Avoid") includes antibiotics reserved for the treatment of certain infections in humans and currently not authorized in veterinary medicine in the European Union (Regulation EU 2022/1255); these drugs may be used exceptionally in non-food producing animals in compliance with the prescribing "cascade". This category includes 18 antibiotic classes [3].

Category B ("Restrict") refers to quinolones, third- and fourth-generation cephalosporins, and polymyxins. The use of these antibiotics in veterinary medicine should be limited because they are of fundamental importance in human medicine [3].

Category C ("Caution") includes individual antibiotic classes listed in different categories by the WHO, including macrolides, aminopenicillins in combination with beta-lactamase inhibitors, first- and second-generation cephalosporins, and lincosamides. These antibiotics should be used only when there are no antimicrobial substances in category D that are clinically effective [3].

Category D ("Prudence") includes antibiotics that should be used as first-line treatments whenever possible, for example, aminopenicillins without beta-lactamase inhibitors, nitroimidazoles, sulfonamides, and tetracyclines [3].

In both human and veterinary medicine, the idea and practice of antimicrobial stewardship are still developing, but it is an approach that emphasizes an active, dynamic process of continuous improvement contained in the concept of good stewardship practice [5].

The implementation and monitoring of antimicrobial stewardship programs require an understanding of antibiotic consumption patterns; in this context, one of the best strategies for lowering AMR in a hospital setting is antimicrobial stewardship, which has been proven to be successful [6–9].

Therefore, the aim of this study was to describe the antibiotic prescriptions to cats from different services at the Veterinary Teaching Hospital of the University of Parma over the three-year period between 2021 and 2023, with a focus on the prescription of different antibiotic classes and their use guided by culture and susceptibility testing.

Methods

Study design

The records of cats visited at the Veterinary Teaching Hospital of the University of Parma (VTH-UP) between January 2021 and December 2023 were reviewed using a digital patient management system (Fenice, Zaksoft Software Technology). The patients were allocated to different groups according to the clinical service of the VTH-UP that managed the case; patients visited several times for the same pathology were included once.

The following exclusion criteria were applied to ensure the integrity of the dataset: patients whose medical records were incomplete or whose animals died within 24 h of hospitalization. The assembled data were recorded in an Excel spreadsheet; the worksheet's content can be summarized into three sections: patient identification, antibiotic prescriptions, and sensitivity assessment.

Information regarding signalment (i.e., sex, breed, age and weight), date of the visit, service, and diagnosis were collected. Whether the selected patient underwent surgical procedures was registered. The clinical services responsible for the case included cardiology, soft tissue surgery, dermatology, internal medicine, neurology, ophthalmology, oncology, orthopedics, shelter medicine, emergency and critical care (ECC), and primary care.

Information regarding the antibiotic prescriptions, antibiotic associations, and antibiotic classes was collected in the second section of the worksheet. The "Antibiotic Class" cell included a dropdown menu containing 15 distinct classes of antimicrobials: aminoglycosides (AMN), cephalosporins (CEF), enhanced cephalosporins (CEF+), macrolides (MAC), nitroimidazoles (NITRO), penicillins (PEN), penicillins associated with beta-lactam inhibitors (PEN+), a combination of fixed antibiotics (FIXED), phenicolates (PHE), polymyxins (POLY), quinolones (QUI), sulfonamides (SULF), tetracyclines (TTR), lincosamides (LINC), and ureidopenicillins (PEN++).

The antibiotic classes were divided according to the categorization of antibiotics adopted by the EMA. The classes belonging to EMA categories A and B (PEN++, QUI, CEF+, POLY, and MAC) were classified as CIAs.

Finally, in the third section, information regarding the culture and sensitivity tests (CSTs) performed and the results and the matrix on which the bacteriological examination was carried out was also recorded.

Statistical analysis

A descriptive statistical analysis of the collected data was performed. The analysis considered general study data, including the total number of visits, the total number of antimicrobial prescriptions and the number of CSTs performed on total antimicrobial prescriptions and on CIAs. For each of these data points, the total count and the corresponding percentage were calculated for each service provided by the VTH-UP.

The type of antibiotic prescriptions recorded in the worksheet was examined. These were categorized into monotherapy, empirical associations, and fixed combinations. The CIAs prescribed were examined relative to the total number of antibiotics.

Results

Study population

A total of 1625, 1803, and 2025 cases were retrieved from the database search in 2021, 2022, and 2023, respectively. A total of 1072, 1200, and 1184 visited cats met the inclusion criteria in 2021, 2022, and 2023, respectively. Within the cat population enrolled in the study, the patients were split into several service groups; the data are shown in Table 1.

Antimicrobial prescription

As shown in Tables 1 and 43.8%, 35.0%, and 35.0% of visited cats received an antimicrobial prescription in 2021, 2022, and 2023, respectively. Antimicrobial prescriptions for the different services in the years 2021–2023 are shown in Table 1; Fig. 1.

Within the included cases, the antibiotic prescription type was considered antibiotic monotherapy, empirical association or fixed combinations. In 2021, 48.7% (229/470) of antibiotic prescriptions were in the form of monotherapy, 13.6% (64/470) were empirical combinations of drugs, and 37.7% (177/470) were fixed combinations. In 2022, 57.1% (240/420) of antibiotic prescriptions were prescribed as monotherapy, 7.6% (32/420) as empirical associations and 35.2% (148/420) as fixed combinations. In 2023, 42% (175/417) of antibiotic prescriptions were prescribed as monotherapy, 12.5% (52/417) as empirical associations and 45.6% (190/417) as fixed combinations.

A total of 552, 464, and 473 antimicrobial molecules were administered to cats in 2021, 2022, and 2023, respectively; the prescriptions were distributed within clinical services, as shown in Table 2.

Overall, penicillins associated with beta-lactam inhibitors were the most common antibiotics prescribed at the VTH-UP yearly (32.0%, 31.3%, and 23.7% of total prescriptions in 2021, 2022, and 2023, respectively). Among CIAs, quinolones were the most common, accounting for 12.1%, 11.2%, and 10.1% of the total prescriptions in 2021, 2022, and 2023, respectively.

An overview of the prescription rate in the years 2021–2023 within the VTH-UP based on the European Medicines Agency (EMA) classification of antimicrobials for use in animals is shown in Fig. 2.

Culture and susceptibility tests

In 2021, 18.1% (85/470) of CSTs were performed; considering only CIAs prescriptions, 70.0% (49/70) of CSTs were performed. In 2022, 17.4% (73/420) of CSTs were performed; within the CIAs prescriptions, 66.7% (38/57) of CSTs were performed. In 2023, 23.0% (96/417) of CSTs were performed; within the CIAs prescriptions, 70.9% (39/55) of CSTs were performed. These were analyzed in the context of the different VTH-UP services, as shown in Table 1.

Among the tested CTS tests, 35.3% (30/85), 50.7% (37/73), and 30.2% (29/96) were positive in 2021, 2022, and 2023, respectively.

Discussion

This study described the antibiotic prescription habits at the VTH-UP. Within the feline population, antibiotic treatment was prescribed for 43.8% of cats visited in 2021 and for 35% of cats visited both in 2022 and 2023.

Mateus et al. (2011) reported antimicrobial prescription for 33% of cats that presented for consultations over a one-year period [10], Radford et al. (2011) reported antimicrobial prescription for 49% [11], and Singleton et al. (2020) reported antimicrobial prescription for 32.9% [12]. Other studies reported lower rates: 18.6% for Hsieh et al. (2022) [13] and 17.5% for Singleton et al. (2017) [14]. The reduced antibiotic prescribing in the last two studies could be due to the study setting itself. The first considered only specialty services (internal medicine, emergency and critical care, and surgery). The second was a large survey conducted in the United Kingdom with 50% of patients presenting for preventive care (e.g., vaccination, health checks).

Antibiotic prescriptions were then evaluated in the context of clinical services, and differences in prescribing habits were found, both in terms of the percentage of antibiotics prescribed and the type of molecule prescribed. The reason for these differences is inherent in the different uses of antibiotics in different services. For example, some services prescribed antimicrobial molecules as prophylactic therapy during surgeries to minimize surgical site infections, while other services prescribed antibiotics with a therapeutic goal.

Based on the total prescriptions for each service, shelter medicine, soft tissue surgery, orthopedics, and ophthalmology had the highest frequency of antibiotic prescription. Excluding the ophthalmology service, almost all

Table 1 Cat population evaluated within the study, divided by clinical services, for each year considered

2021					
Clinical Service	**Visited cats**	**Antibiotic prescription**	**CIAs prescription**	**CST performed**	**CST performed (CIAs)**
Internal Medicine	300 (28%)	123/300 (41%)	43/123 (35%)	65/123 (52,8%)	39/43 (90,7%)
ECC	245 (22,9%)	88/245 (35,9%)	10/88 (11,4%)	8/88 (9,1%)	7/10 (70%)
Shelter Medicine	146 (13,6%)	143/146 (97,9%)	0/143 (0%)	0/143 (0%)	-
Neurology	73 (6,8%)	17/73 (23,3%)	6/17 (35,3%)	0/17 (0%)	0/6 (0%)
Primary Care	67 (6,2%)	0/67 (0%)	-	-	-
Cardiology	60 (5,6%)	1/60 (1,7%)	0/1 (0%)	1/1 (100%)	-
Soft tissue surgery	64 (6%)	38/64 (59,4%)	3/38 (7,9%)	7/38 (18,4%)	3/3 (100%)
Ophtalmology	47 (4,4%)	41/47 (87,2%)	4/41 (9,8%)	1/41 (2,4%)	0/4 (0%)
Oncology	39 (3,6%)	4/39 (10,3%)	3/4 (75%)	2/4 (50%)	0/3 (0%)
Dermatology	17 (1,6%)	4/17 (23,5%)	1/4 (25%)	1/4 (25%)	0/1 (0%)
Orthopedics	14 (1,3%)	11/14 (78,6%)	0/11 (0%)	0/11 (0%)	-
Total	1072 (100%)	470/1072 (43,8%)	70/470 (14,9%)	85/470 (18,1%)	49/70 (70%)
2022					
Clinical Service	**Visited cats**	**Antibiotic prescription**	**CIAs prescription**	**CST performed**	**CST performed (CIAs)**
Internal Medicine	308 (25,7%)	86/308 (26,9%)	32/86 (37,2%)	53/86 (61,6%)	29/32 (90,6%)
ECC	305 (25,4%)	79/305 (25,9%)	12/79 (15,2%)	9/79 (11,4%)	5/12 (41,7%)
Shelter Medicine	134 (11,2%)	130/134 (97%)	0/130 (0%)	0/130 (0%)	-
Neurology	90 (7,5%)	11/90 (12,2%)	7/11 (63,6%)	1/11 (9,1%)	1/7 (14,3%)
Primary Care	71 (5,9%)	0/71 (0%)	-	-	-
Cardiology	89 (7,4%)	1/89 (1,7%)	1/1 (100%)	1/1 (100%)	1/1 (100%)
Soft tissue surgery	59 (4,9%)	55/59 (93,2%)	4/55 (7,3%)	9/55 (16,4%)	2/4 (40%)
Ophtalmology	46 (3,8%)	36/46 (78,3%)	1/36 (2,8%)	0/36 (0%)	0/1 (0%)
Oncology	63 (5,3%)	2/63 (3,2%)	0/2 (0%)	0/2 (0%)	-
Dermatology	16 (1,3%)	1/16 (6,3%)	0/1 (0%)	0/1 (0%)	-
Orthopedics	19 (1,6%)	19/19 (100%)	0/19 (0%)	0/19 (0%)	-
Total	1020 (100%)	420/1020 (35%)	57/420 (13,6%)	73/420 (17,4%)	38/57 (66,7%)
2023					
Clinical Service	**Visited cats**	**Antibiotic prescription**	**CIAs prescription**	**CST performed**	**CST performed (CIAs)**
Internal Medicine	270 (22.8%)	61/270 (22.6%)	34/61 (55.7%)	34/61 (55.7%)	29/34 (85.3%)
ECC	322 (27.3%)	69/322 (21.4%)	10/69 (14.5%)	10/69 (17.5%)	5/10 (50%)
Shelter medicine	176 (14.9%)	174/176 (98.9%)	0/174 (0%)	0/174 (0%)	-
Neurology	92 (7.8%)	6/92 (6.5%)	1/6 (16.7%)	1/6 (16.7%)	-
Primary Care	47 (4.0%)	0/47 (0%)	-	-	-
Cardiology	81 (6.8%)	2/81 (2.5%)	0/2 (0%)	0/2 (0%)	-
Soft tissue surgery	84 (7.1%)	51/84 (60.7%)	7/51 (13.7%)	10/51 (19.6%)	4/7 (57.1%)
Ophthalmology	31 (2.6%)	24/31 (77.4%)	0/24 (0%)	1/24 (4.2%)	-
Oncology	33 (2.8%)	4/33 (12.1%)	1/4 (25%)	1/4 (25%)	-
Dermatology	17 (1.4%)	2/17 (11.8%)	2/2 (100%)	1/2 (50%)	1/2 (50%)
Orthopedics	31 (2.6%)	24/31 (77.4%)	0/24 (0%)	1/24 (4.2%)	-
Total	1184 (100%)	417/1184 (35.2%)	55/417 (13.2%)	96/417 (23.0%)	39/55 (70.9%)

patients managed by these services have undergone surgery, meaning that almost all patients underwent routine perioperative antibiotic prophylaxis, as per the guidelines directive [15, 16].

The overall results should then be interpreted in light of this bias, which could considerably increase the frequency of antibiotic prescription due to prophylactic use.

Considering the antibiotic prescriptions in cats managed by surgical services, the VTH-UP prophylactic prescription rates were 17.9%, 20%, and 21.3% in 2021, 2022, and 2023, respectively. The data obtained are in line with those obtained from other studies, where antimicrobial prescriptions for prophylactic use were 25.7% in dogs and cats [17], 25% [18], and 15.8% [13] in cats.

In the ophthalmology service, most antibiotics are administered for herpesvirus conjunctivitis and corneal ulcers. In general, the use of antibiotics in the ophthalmic field recorded in the VTH-UP seems greater than the use reported in other studies, such as that of [19], in which the use of antibiotics in ophthalmology was very low and amounted to 3.87% of the total antibiotics used in patients enrolled in the study. Most of the prescriptions

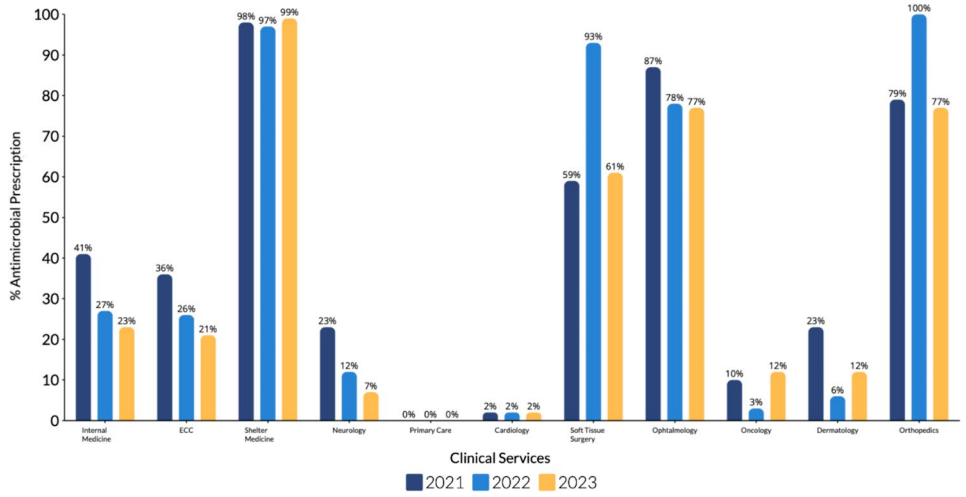

Fig. 1 Antimicrobial prescriptions within the different services of VTH-UP in 2021 and 2022. The y-axis represents the percentage of antimicrobial prescriptions (n of antimicrobial prescriptions/n of visited cats); the x-axis represents the different services

from the ophthalmology service are topical formulations. These data reflect the prescribing habits in this service, considering that in the literature, most therapies are administered topically [20, 21].

Lower rates of antibiotic prescriptions were noted in the three-year period at the cardiology service, the oncology service, the dermatology service and the primary care service. For the primary care service, 0% of antimicrobial prescriptions were positive, indicating that a general visit does not justify the use of antibiotic molecules in our facility. Instead, these are usually prescribed following a specialistic visit at one of the VTH-UP services, while Goggs et al. (2021) reported 10.3% of antimicrobial prescriptions in primary care services in Europe [22]. A service that also slightly differs from other research of a comparable nature is dermatology, where 36% [23], 30.6% [22], 24.6% [19], and 12.5% [13] of the antibiotics used are claimed to fall under this service. However, it must be considered that no cases of pyoderma, which comprise a significant portion of the cases considered by prior studies, were recorded during our investigation and that bite wounds and abscesses are referred to the ECC service rather than the dermatology service.

The services of internal medicine, ECC and neurology are the three services which visited most cats and with the highest prescription frequencies and greatest variety of antibiotic classes prescribed to their patients. The percentage of antimicrobial prescriptions within these services decreased during this three-year period, from 41 to 22.6% for the Internal Medicine service, from 35 to 21.4% for the ECC service, and from 23.3 to 6.5% for the Neurology service. The data for 2023 are comparable to those reported by Goggs et al. [22], who reported the prescription of systemic antimicrobials in 18.4% of the included cats in specialistic fields (e.g., internal medicine) and in 23.2% of the cats in emergency and critical care.

This tendency to prescribe fewer antibiotics in these services may be due to the turnover of staff and an increased focus on antibiotic resistance, even in the absence of a surveillance campaign promoted by the VTH-UP.

During this three-year period, the most commonly used antibiotic classes were fixed combinations and enhanced penicillins. Amoxicillin/clavulanic acid is generally the most prescribed antibiotic in veterinary medicine [10], but in general, enhanced penicillins are the most commonly prescribed antimicrobial agents [13, 24], and their use nearly doubled from 1995 to 2004 [25].

A fixed combination of antibiotics is commonly used in Shelter Medicine and Ophthalmology services. This is explained by the fact that the Shelter Medicine service of the VTH-UP uses a fixed association as a perioperative antibiotic, based on the active molecules benzylpenicillin benzatinic and dihydrostreptomycin, motivated by the existence of an agreement between the University of Parma and the municipal shelter of Parma for neutering interventions on colony cats. In this context, it allows a half-life of 48 h for a single intramuscular administration. The ophthalmology service, on the other hand, usually prescribes a topical antibiotic registered for human use based on chloramphenicol, colistimethate sodium and rolitetracycline.

The third class most represented among the antibiotics used is cephalosporins, particularly first-generation cephalosporins. This class is widely used in surgery, especially cefazolin, as the antibiotic of choice in the perioperative setting [15]. Cefazolin is the recommended antimicrobial for orthopedic surgery due to its rapid distribution between the bloodstream and surgical wound

Table 2 Overview of antimicrobial class prescription years 2021–2023

2021

	Tot Molecules	PEN++	CEF+	POLY	QUI	MAC	AMN	PEN+	CEF	PHE	LINC	PEN	TTR	NITRO	SULF	FIXED
Internal Medicine	153	0	0	0	43 (28,1%)	0	0	79 (51,6%)	0	0	4 (2,6%)	-	13 (8,5%)	13 (8,5%)	-	1 (0,7%)
ECC	118	0	1 (0,8%)	0	9 (7,6%)	0	2 (1,7%)	72 (61%)	10 (8,5%)	0	8 (6,8%)	-	5 (4,2%)	3 (2,5%)	-	8 (6,8%)
Reproduction	143	0	0	0	0	0	0	4 (2,8%)	0	0	-	-	-	-	-	139 (97,2%
Neurology	20	0	2 (10%)	0	4 (20%)	0	0	1 (5%)	2 (10%)	0	9 (45%)	-	-	1 (5%)	-	1 (5%)
Primary Care	0	0	0	0	0	0	0	0		0	-	-	-	-	-	-
Cardiology	1	0	0	0	0	0	0	1 (100%)		0	-	-	-	-	-	-
Soft tissue surgery	48	0	1 (2,1%)	0	3 (6,3%)	0	1 (2,1%)	11(22,9%)	31 (64,6%)	0	-	-	-	-	-	1 (2,1%)
Ophtalmology	48	0	0	0	4 (8,5%)	0	10 (21,3%)	4 (8,5%)	3 (6,4%)	0	-	-	-	-	-	27 (56,2%)
Oncology	6	0	0	0	3 (50%)	0	0	3 (50%)	0	0	-	-	-	-	-	-
Dermatology	4	0	0	1 (25%)	1 (25%)	0	0	1 (25%)	0	0	1 (25%)	-	-	-	-	-
Orthopedics	11	0	0	0	0	0	0	1 (9,1%)	10 (90,9%)	0	-	-	-	-	-	-
Total	552	0	4 (0,7%)	1 (0,2%)	67 (12,1%)	0	13 (2,4%)	177 (32%)	56 (10,2%)	0	22 (4%)	-	18 (3,3%)	17 (3,1%)	-	177(32%)

2022

	Tot Molecules	PEN++	CEF+	POLY	QUI	MAC	AMN	PEN+	CEF	PHE	LINC	PEN	TTR	NITRO	SULF	FIXED
Internal Medicine	94	1 (1,1%)	0	0	31 (32,9%)	0	0	50 (53,2%)	0	0	1 (1,1%)	0	11 (11,7%)	0	0	0
ECC	90	0	0	0	12 (13,3%)	0	5 (5,6%)	62 (68,9%)	0	7 (7,8%)	1 (1,1%)	0	2 (2,2%)	0	0	1 (1,1%)
Reproduction	130	0	0	0	0	0	0	1 (0,8%)	0	0	0	0	0	0	0	129 (99,2%)
Neurology	18	0	0	0	7 (38,9%)	0	0	2 (11,1%)	1 (5,6%)	0	8 (44,4%)	0	0	0	0	0
Primary Care		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cardiology	2	0	0	0	1 (50%)	0	0	0	0	0	0	0	1 (50%)	0	0	0
Soft tissue surgery	78	0	0	0	4 (5,1%)	0	0	25 (32%)	47 (60,3%)	1 (1,3%)	1 (1,3%)	0	0	0	0	0
Ophtalmology	36	0	0	0	1 (2,8%)	0	12 (33,3%)	0	3 (8,3%)	2 (5,6%)	0	0	0	0	0	18 (50%)
Oncology	2	0	0	0	0	0	0	2 (100%)	0	0	0	0	0	0	0	0
Dermatology	1	0	0	0	0	0	0	1 (100%)	0	0	0	0	0	0	0	0
Orthopedics	25	0	0	0	0	0	0	6 (24%)	19 (76%)	0	0	0	0	0	0	0
Total	476	1 (0,2%)	0	0	56 (11,8%)	0	17 (3,6%)	149 (31,3%)	70 (14,7%)	10 (2,1%)	11 (2,3%)		14 (2,9%)			148 (31,1%)

2023

	Tot Molecules	PEN++	CEF+	POLY	QUI	MAC	AMN	PEN+	CEF	PHE	LINC	PEN	TTR	NITRO	SULF	FIXED
Internal Medicine	72	0 (0%)	1 (1.4%)	0 (0%)	34 (47.2%)	0 (0%)	3 (4.2%)	21 (29.2%)	1 (1.4%)	1 (1.4%)	3 (4.2%)	0 (0%)	7 (9.8%)	1 (1.4%)	0 (0%)	0 (0%)
ECC	77	0 (0%)	0 (0%)	0 (0%)	6 (7.8%)	1 (1.3%)	1 (1.3%)	56 (72.7%)	5 (6.5%)	4 (5.2%)	1 (1.3%)	0 (0%)	2 (2.6%)	0 (0%)	0 (0%)	1 (1.3%)
Reproduction	175	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (0.6%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	174 (99.4%)
Neurology	7	0 (0%)	1 (14.3%)	0 (0%)	1 (14.3%)	0 (0%)	0 (0%)	1 (14.3%)	1 (14.3%)	0 (0%)	3 (42.9%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Primary Care	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cardiology	3	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (33.3%)	1 (33.3%)	0 (0%)	1 (33.3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Soft tissue surgery	75	0 (0%)	0 (0%)	1 (1.3%)	6 (8%)	0 (0%)	0 (0%)	24 (32%)	39 (52%)	2 (2.7%)	1 (1.3%)	0 (0%)	1 (1.3%)	0 (0%)	0 (0%)	1 (1.3%)
Ophtalmology	28	(0%)	(0%)	(0%)	(0%)	(0%)	5 (17.9%)	2 (7.1%)	1 (3.6%)	1 (3.6%)	(0%)	0 (0%)	(0%)	0 (0%)	0 (0%)	19 (67.9%)
Oncology	7	0 (0%)	0 (0%)	0 (0%)	1 (14.3%)	0 (0%)	1 (14. 3%)	3 (42.9%)	2 (28.6%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Dermatology	2	0 (0%)	0 (0%)	2 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Table 2 (continued)

Orthopedics	27	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	3 (11.1%)	23 (85.2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (3.7%)
Total	473	0 (0%)	2 (0.4%)	3 (0.6%)	48 (10.1%)	1 (0.2%)	10 (2.1%)	112 (23.7%)	73 (15.4%)	8 (1.7%)	9 (1.9%)	0 (0%)	10 (2.1%)	1 (0.2%)	0 (0%)	196 (41.4%)		

Abbreviations: AMN: Aminoglycosides; CEF: Cephalosporins, CEF+: Enhanced Cephalosporins; MAC: Macrolides; NITRO: Nitroimidazoles; PEN: Penicillins; PEN+: Penicillins Associated with Beta-Lactam Inhibitors; FIXED: Fixed combination; PHE: Phenicolate; POLY: Polymyxins; QUI: Quinolones; SULF: Sulfonamides; TTR: Tetracyclines; LINC: Lincosamides; PEN++: Ureidopenicillines

site, effective antimicrobial coverage, long-lasting presence in tissues, minimal toxicity, and cost-effectiveness [26]. It is therefore not surprising to observe that the services in which cephalosporins are most commonly used are those of soft tissue surgery and orthopedics. Outside of the surgical context, first-generation cephalosporins have minimal use in cats [13] or are still used as a topical treatment for skin diseases [19].

Finally, the class of quinolones assumes importance because it falls within the CIAs, and it is therefore an antibiotic that, following the guidelines of the EMA [3], should be limited in its use. Our study revealed that the use of quinolones is more common at the Internal Medicine service; however, the use of quinolones at the top of prescriptions was lower than that of antibiotics at the top of prescriptions in this study.

In our study, ureidopenicillins (EMA category A "Avoid"), quinolones, 3rd-4th-5th generation cephalosporins, and polymyxins (EMA category B "Restrict") were considered CIAs and accounted for 13%, 12%, and 11.1% of the total prescriptions in 2021, 2022, and 2023, respectively. Considering the values reported in Italy, prescriptions of CIAs were 38.3% in the period 2000–2007 [19] and 29.8% in the period 2017–2022 [27]; prescription rates for these molecules were lower in our feline patients.

The CIAs mainly used in the VTH-UP are quinolones; enhanced cephalosporins and ureidopenicillines represent less than 1% of prescriptions, while there were no prescriptions of macrolides or polymyxins. Considering CIAs prescriptions, 70%, 66.7%, and 70.9% of CSTs were performed in 2021, 2022, and 2023, respectively. The internal medicine service has the most prescriptions of quinolones; however, this is also the service that performed the greatest number of CSTs on CIA molecules. In our structure, the habit of prescribing CIAs is mid-low for quinolones and very few to none for other CIAs. Moreover, the prescription is usually guided by a CST.

In this study, 18.1%, 17.4%, and 18.1% of feline patients underwent CSTs in 2021, 2022, and 2023, respectively. In the literature, the use of CSTs was reported to be antimicrobial for 8.8% [24] and 22.9% [13] of dogs and cats, respectively.

The VTH-UP services that performed most CSTs related to the total number of prescriptions were the internal medicine service and the emergency and critical care service. In contrast, the neurology service performed fewer CSTs; this low percentage is due to the inherent difficulty in sampling cerebrospinal fluid and the need for general anesthesia [28].

Promoting rational antimicrobial use is a core principle of antimicrobial stewardship programs. In veterinary medicine, various strategies have been implemented across Europe, such as the introduction of regulations

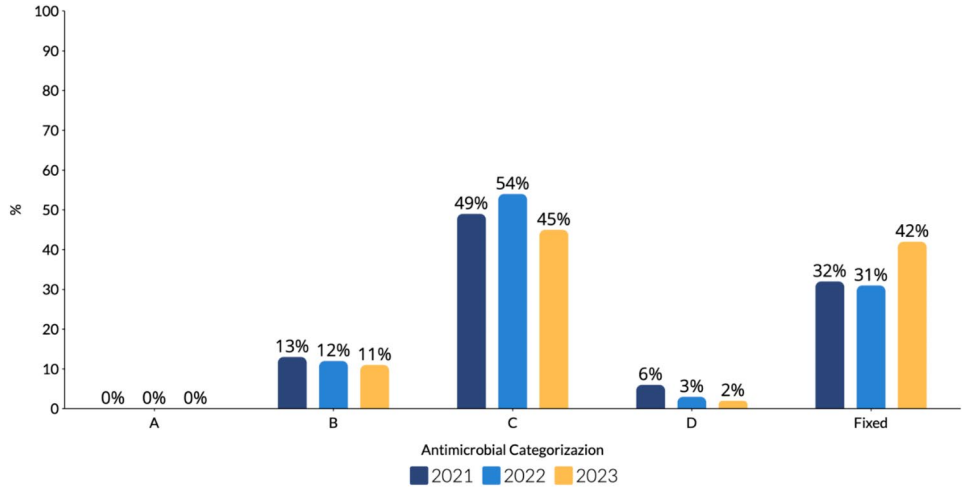

Fig. 2 Antimicrobial prescription rate based on EMA classification. The y-axis represents the percentage; the x-axis represents the EMA antimicrobial categorization. Abbreviations: EMA: European Medicines Agency; A: EMA Category A "Avoid"; B: EMA Category B "Restrict"; C: EMA Category C "Caution"; D: EMA Category D "Prudence"; Others: fixed combinations

limiting the use of certain antimicrobials and the encouragement of voluntary antimicrobial stewardship guidelines at both the national and clinical levels [29].

Understanding antibiotic usage at a VTH provides a critical foundation for developing an antimicrobial stewardship program, even if it is limited to a single institution. Although the practices at a specific VTH may not be directly transferable to other veterinary settings or broader regions, the data and insights gathered from monitoring antibiotic prescriptions within that facility offer invaluable information for creating tailored stewardship protocols. These localized programs can serve as pilot models, helping to identify patterns of antibiotic use, including overprescription or misuse, and provide evidence-based guidelines that can be adjusted to meet the specific needs of that particular hospital or clinic.

This study has several limitations. First, several services were involved within the same clinical case; it is possible that the prescribing service was misclassified in some cases. Additionally, in this study, neither the duration nor the dosage of the antimicrobial treatment was considered, placing a significant limit on the evaluation of correct management of antibiotic therapy and stewardship in the facility. Additionally, indications for prescriptions of antibiotics were not recorded, precluding us from reporting on the rates of antibiotic prescribing for specific conditions. Finally, the results of this study, related to a single teaching hospital, cannot be extrapolated to larger samples, different contexts or geographical regions.

Conclusions

The present study describes the antimicrobial prescribing habits of feline medicine and surgery at a Veterinary Teaching Hospital in Italy. The patterns of antimicrobial use varied considerably depending on the clinical service considered. The use of "restrict" antibiotics in our facility was limited to a small number of carefully selected feline patients; particular attention should be given to the use of non-critical categories of antimicrobial agents for therapeutic and prophylactic use. The collection of epidemiological data about antibiotic prescription habits is essential for the application of adequate antimicrobial stewardship, especially in the current climate, which is largely focused on resistance issues.

Abbreviations

AMN	Aminoglycosides
AMR	Antimicrobial Resistance
CEF	Cephalosporin
CEF+	Enhanced cephalosporin
CIAs	Critically Important Antimicrobials
CST(s)	Cultures and Sensitivity Test(s)
ECC	Emergency and Critical Care
EMA	European Medicines Agency
FIXED	Fixed Antibiotics Combination
LINC	Lincosamides
MAC	Macrolides
NITRO	Nitroimidazoles
PEN	Penicillins
PEN+	Penicillins associated with beta-lactam inhibitors
PEN++	Ureidopenicillins
PHE	Phenicolates
POLY	Polymyxins
QUI	Quinolones
SULF	Sulfonamides
TTR	Tetracycline
VTH	UP-Veterinary Teaching Hospital of the University of Parma
WHO	World Health Organization

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Author contributions

F.F., S.B., A.C., S.C, and C.Q. contributed to the conception and design of the work; F.F, M.R., A.M.C.H., and F.C. acquired and analyzed the data; A.C., and

F.F and made the interpretation of the data; F.F. and M.R. wrote the main manuscript text; F.F. and A.M.C.H. prepared the tables and figure; A.C., S.B., S.C, and C.Q. revised the manuscript. All authors reviewed the final draft of the manuscript.

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Data availability
The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request. Data are located in controlled access data storage at the Veterinary Teaching Hospital of the University of Parma.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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