

Article

Antimicrobial Resistance Patterns of Cutaneous Samples in Companion Animals in North-Western Italy from 2013 to 2024

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Abstract

Skin diseases are among the most frequently diagnosed conditions in companion animals and have historically been treated empirically with antibiotics, contributing to the emergence and persistence of antimicrobial resistance (AMR). In recent years, greater awareness of AMR has led to a reduction in antibiotic use in veterinary medicine, particularly in dermatology. To assess AMR trends in skin infections and evaluate the use of diagnostic tools to guide antimicrobial prescriptions, we conducted a retrospective study of medical records from a veterinary hospital in northwestern Italy between 2013 and 2024. A total of 447 antimicrobial susceptibility tests from dogs and cats with clinical signs of skin disease were analyzed. Of these, 391 yielded positive bacterial cultures, and 56 were negative. Most positive samples came from dogs (83.4%), with cats accounting for 16.6%. The most frequently isolated bacterial families were Staphylococcaceae, Enterobacteriaceae, and Pseudomonadaceae. Amoxicillin-clavulanic acid was prescribed in 36.6% of patients, fluoroquinolones in 25.9%, while 17% received only detergent–disinfectant products. Among first-line drugs, ampicillin showed the lowest susceptibility, with resistance exceeding 60%, whereas imipenem (used as an indicator of carbapenemase production but avoided in veterinary medicine) retained high activity, with susceptibility rates of 77.2% in dogs and 90.3% in cats. These findings are clinically relevant, but continuous AMR surveillance remains essential within a One Health framework to limit the spread of resistant bacteria and resistance genes to cohabiting humans.

Keywords: one health; antimicrobial resistance; veterinary dermatology; companion animals; antimicrobial susceptibility testing; antimicrobial stewardship



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1. Introduction

Skin diseases are among the most frequently diagnosed conditions in dogs and cats and represent one of the leading reasons for presentation to veterinary clinics. These conditions encompass a broad spectrum of disorders, including hypersensitivity reactions, atopic dermatitis, adverse food reactions, fungal, yeast and dermatophyte infections, parasitic infestations, neoplasia, inflammatory disorders—particularly involving the ears and perianal glands—and bacterial infections [1,2]. Bacterial infections, whether primary or secondary,

are particularly common. Historically, veterinarians have frequently relied on empirical antimicrobial therapy, often without performing bacterial culture and antimicrobial susceptibility testing, for both topical and systemic treatment [3].

This practice may also be influenced by pet-owner-related factors, including financial constraints, expectations regarding treatment, and self-directed initiatives. In some cases, owners may begin administering antimicrobial drugs already available at home before a diagnosis or prescription has been provided, irrespective of a veterinary clinical examination and even when antimicrobial therapy is not indicated. As shown in a 2024 survey, many pet owners expect antibiotics to be prescribed even for procedures for which such treatment is not recommended, including elective surgeries such as castration [4].

Although this practice may previously have been considered justifiable in some circumstances, it is no longer acceptable. Increasing bacterial resistance to antibiotics has made the selection of effective treatments progressively more challenging, particularly in dermatological conditions [4]. Antimicrobial resistance (AMR) is widely recognized as a critical threat not only to animal health but also to human medicine. In 2019, the World Health Organization (WHO) identified AMR as one of the top ten global health threats, associating it with an estimated 4.95 million human deaths worldwide, including 1.27 million deaths directly attributable to bacterial resistance [5].

The authorization and commercial availability of novel antibiotics in veterinary medicine are limited, as research efforts are increasingly focused on identifying new compounds that are reserved exclusively for human use. Consequently, despite the growing number of companion animals in recent decades, veterinarians are required to adopt a more rational, prudent, and evidence-based approach to antimicrobial use [6,7].

Until recently, when considering the role of veterinary medicine in AMR management within a One Health framework, antimicrobial use in livestock was regarded as the principal driver of resistance development. Accordingly, surveillance systems largely focused on food-producing animals, while companion animals received comparatively little attention [8]. However, the role of dogs and cats in the transmission of resistant bacteria to humans is increasingly recognized [9]. As a result, Regulation (EU) 2019/6 [10] includes companion animals in antimicrobial surveillance programs, although targeted implementation across the European Union will not begin until 2029. Some countries, including Denmark and Sweden, have already initiated such surveillance activities [10–12]. In Italy, however, integrated data on antimicrobial use in companion animals remain scarce, although the introduction of electronic veterinary prescriptions in April 2019 has improved the ability of the competent authorities to monitor antimicrobial prescribing [8].

Since the entry into force of the new regulation, veterinarians have been encouraged to follow the classification proposed by the Antimicrobial Advice Ad Hoc Expert Group (AMEG) when prescribing antimicrobials. This framework classifies antibiotics into four categories—A, B, C, and D—based primarily on their importance in veterinary medicine and the associated public-health risk of resistance development when used in animals [10,11]. Category D antibiotics are considered to pose the lowest risk, as they exert lower selective pressure for resistance and are appropriate for first-line treatment. Categories C and B include antimicrobials associated with higher risk and greater selective pressure, with Category B reserved for restricted use. Category A includes antibiotics that are prohibited in veterinary medicine because of their critical importance in human healthcare.

Continuous data collection and surveillance of antimicrobial use are essential for identifying resistance trends and guiding appropriate interventions. The One Health approach, which emphasizes the interconnectedness of human, animal, and environmental health, is fundamental to addressing AMR effectively [13].

Given the limited availability of data on antimicrobial resistance in companion animals in Italy, particularly in dermatological settings, this retrospective study reviewed the medical records of dogs and cats presenting with skin and ear infections between 2013 and 2024. The aims of the study were to:

- identify the bacteria isolated and characterize their antimicrobial resistance patterns;
- assess which antibiotics were prescribed;
- evaluate clinical outcomes, including cure and relapse rates.

2. Materials and Methods

2.1. Ethical Approvals

All data collected in this study were part of routine diagnostic procedures in client-owned animals. No additional invasive procedures were performed for research purposes. Informed consent was obtained from all pet owners before inclusion.

2.2. Study Population

This retrospective study included canine and feline patients referred to a veterinary clinic in the Piedmont region of northwestern Italy between 1 January 2013 and 31 December 2024. All animals included in the study were referred with dermatological conditions, diagnosed through clinical evaluation. Sex, breed, and age were not considered inclusion or exclusion criteria, but they have been recorded for further considerations of the present study.

2.3. Samples

Samples were obtained during clinical examination using sterile swabs. Swabs were collected from the ears, skin, adnexa, and perianal area, including anal glands. Pathogen identification was carried out using the VITEK-MS mass spectrometry system (bioMérieux, Craponne, France), based on Matrix-Assisted Laser Desorption/Ionization–Time of Flight (MALDI-TOF) technology, following the manufacturer’s instructions.

All bacterial isolates were assessed for multidrug resistance. Specifically:

- Enterobacteriaceae isolates were tested for the production of extended-spectrum β -lactamases (ESBLs);
- Staphylococcaceae isolates were screened for methicillin resistance using oxacillin and ceftiofur, indicating methicillin-resistant bacteria (MR).

2.4. Laboratory Procedures and Susceptibility Testing

All specimens obtained from auricular, cutaneous, adnexal, and perianal swabs were immediately sent to the laboratory and deemed suitable for culture. The laboratory performed bacterial isolation and antibiotic susceptibility testing according to the Clinical & Laboratory Standards Institute (CLSI) guidelines; a threshold value of more than 1000 colony-forming units (CFU)/mL was considered clinically significant; furthermore, the laboratory determined the minimum inhibitory concentration (MIC).

2.5. Data Analysis

Excel software (Microsoft, Redmond, WA, USA) was used to create a database containing the following data: species, breed, sex, age of the patients, seasonality, anatomical sites, isolated pathogens, and their antimicrobial sensitivity profiles. The collected data were subdivided using pivot tables, and descriptive statistics were applied. Because antimicrobial panels differed according to the isolated organism, susceptibility percentages were calculated only among isolates tested for each molecule. Considering that some antimicrobials are not equally relevant across taxa and that intrinsic resistance mechanisms, particularly

in *Pseudomonas* spp. and Gram-negative bacteria, must be taken into consideration when interpreting the data, results were stratified by major bacterial groups to account for differences in intrinsic resistance and clinical relevance. Given the multitude of combinations and possibilities, we decided to conduct a literature search with the aim of compiling a list of the most used molecules in veterinary dermatology (considering representatives of each AMEG category) to analyze sensitivity patterns. Finally, the management software used in the veterinary hospital was used to access and analyze all the medical records of the subjects included in the study. This allowed to record both the pharmacological therapy prescribed for each subject and the number of relapses. Documented recurrence was defined as a new consultation for the same or closely related dermatological condition within six months after completion of the therapeutic protocol. Because repeat cultures were not consistently available, persistence of the same infection could not always be distinguished from reinfection.

3. Results

Between 1 January 2013 and 31 December 2024, a total of 447 dermatological swab samples were collected from dogs and cats presenting with skin-related conditions at the veterinary clinic. Among these, 391 samples (87.5%) yielded positive bacterial cultures, while the remaining 56 swabs (45 from dogs and 11 from cats) showed no microbial growth. The results are summarized in Figure 1.

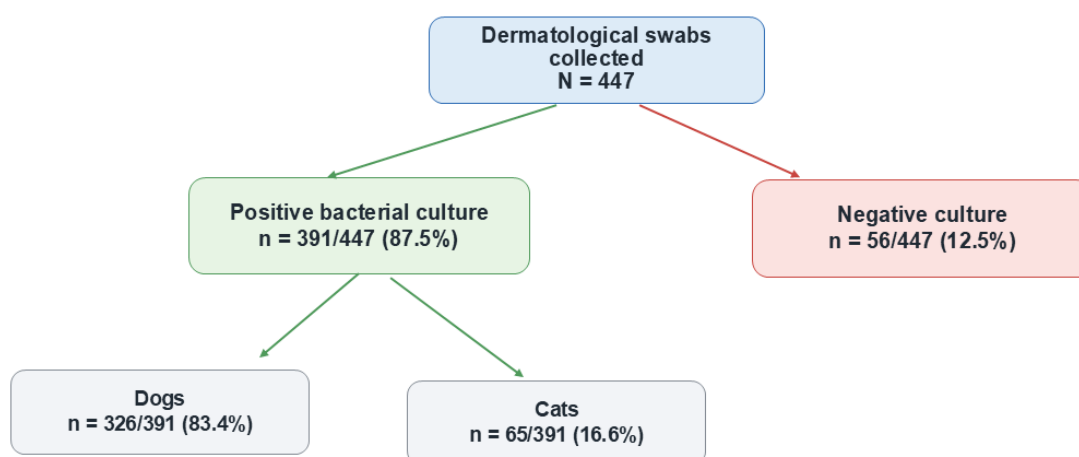


Figure 1. Flow diagram of sample selection and culture results.

3.1. Demographic Data of Enrolled Patients

Among the 391 subjects whose swab was positive, 83.4% belonged to dogs (326/391) while 16.6% to cats (65/391). Considering the canine population, 37.7% (123/326) were females and 62.3% (203/326) were males. Meanwhile, the feline population was divided as follows: 47.7% (31/65) females and 52.3% (34/65) males.

Indeed, in relation to the breed in the population analyzed, the most represented among dogs with 44.2% were mixed breeds, followed by German Shepherd (8.9%), Labrador Retriever (5.2%), Cocker Spaniel (4.9%), West Highland White Terrier (3.7%), Golden Retriever (3.4%). Among the breeds less frequently represented Boxer, French Bulldog, Poodle, Argentine Dogo, Jack Russell Terrier, Shar Pei were found. Breeds represented by less than 1% are not listed in the present manuscript.

In the cat population, almost the entire population (89.2%) was composed of domestic short-hair cats, 6.2% of Maine Coon, and then the same percentage of 1.5% Persian breed, Exotic shorthair, and Devon Rex was recorded.

3.2. Seasonality

Animals were referred to the clinic more frequently in the warm seasons (spring and summer) rather than in the colder ones (autumn and winter). In fact, 55.6% and 56.9% of dogs and cats, respectively, were visited when temperatures were higher ($>20^{\circ}\text{C}$).

3.3. Microorganisms

As shown in Tables 1 and 2, the bacterial families most commonly found in both dogs and cats were Staphylococcaceae, Enterobacteriaceae, and Pseudomonadaceae. In fact, the percentages were 38%, 29.8%, and 13.2% in dogs, while 43.1%, 27.7%, and 3.1% in cats.

Table 1. List of bacteria and yeast isolated from dermatological swabs in dogs.

Staphylococcaceae: 38.5%	<i>S. intermedius/pseudointermedius</i> : 86.3%
	<i>S. aureus</i> : 6.5%
	<i>Staphylococcus schleiferi</i> : 2.4%
	<i>Staphylococcus chromogenes</i> : 1.6%
	<i>Staphylococcus auricularis</i> : 0.8%
	<i>Staphylococcus epidermidis</i> : 0.8%
	<i>Staphylococcus haemolyticus</i> : 0.8%
Enterobacteriaceae: 29.8%	<i>Staphylococcus simulans</i> : 0.8%
	<i>E. coli</i> : 45.4%
	<i>P. mirabilis</i> : 29.9%
	<i>Enterobacter cloacae</i> : 7.3%
	<i>Klebsiella pneumoniae</i> : 5.2%
	<i>Klebsiella oxytoca</i> : 3.1%
	<i>Serratia marcescens</i> : 2.1%
	<i>Citrobacter freundii</i> : 1%
	<i>Enterobacter cloacae</i> complex: 1%
	<i>Enterobacter cloacae</i> spp. <i>cloacae</i> : 1%
	<i>Enterococcus faecalis</i> : 1%
	<i>Klebsiella aerogenes</i> : 1%
	<i>Proteus hauseri</i> : 1%
Pseudomonadaceae: 13.2%	<i>Salmonella enterica</i> spp. <i>enterica</i> : 1%
	<i>P. aeruginosa</i> : 95.3%
Other bacterial species + yeast: 18.5%	<i>P. luteola</i> : 4.7%
	<i>Enterococcus faecalis</i> : 3.7%
	<i>Streptococcus canis</i> : 2.8%
	<i>Bacteroides pyogenes</i> : 1.3%
	<i>Raoultella ornithinolytica</i> : 1.3%
	<i>Pantoea agglomerans</i> : 0.9%
	<i>Pasteurella canis</i> : 0.9%
	<i>Kokuria rosea</i> : 0.6%
	<i>Streptococcus</i> spp.: 0.6%
	<i>Acinetobacter baumannii</i> : 0.3%
	<i>Aerococcus viridans</i> : 0.3%
	<i>Aeromonas caviae</i> : 0.3%
	<i>Clostridium tertium</i> : 0.3%
	<i>Corynebacterium amycolatum</i> : 0.3%
	<i>Enterococcus gallinarum</i> : 0.3%
	<i>Enterococcus</i> spp.: 0.3%
	<i>Kokuria kristinae</i> : 0.3%
	<i>Lysinibacillus fusiformis</i> : 0.3%
	<i>Micrococcus luteus</i> /lylae: 0.3%
	<i>Pasteurella multocida</i> : 0.3%
	<i>Sphingomonas paucimobilis</i> : 0.3%
	<i>Streptococcus dysgalactiae</i> spp. <i>equisimilis</i> : 0.3%
	<i>Malassezia</i> spp.: 2.5%

Table 2. List of bacteria isolated from dermatological swabs in cats.

Staphylococcaceae: 43.1%	<i>S. intermedius/pseudointermedius</i> : 50% <i>S. aureus</i> : 32.1% <i>Staphylococcus felis</i> : 7.1% <i>Staphylococcus epidermidis</i> : 3.6% <i>Staphylococcus haemolyticus</i> : 3.6% <i>Staphylococcus simulans</i> : 3.6%
Enterobacteriaceae: 27.7%	<i>E. coli</i> : 50% <i>Klebsiella pneumoniae</i> : 16.7% <i>P. mirabilis</i> : 11.1% <i>Enterobacter cloacae</i> : 11.1% <i>Klebsiella oxytoca</i> : 5.6% <i>Enterococcus faecalis</i> : 5.5%
Pseudomonadaceae: 3.1%	<i>P. aeruginosa</i> : 100%
Other bacterial species: 26.1%	<i>Pasteurella multocida</i> : 13.8% <i>Streptococcus canis</i> : 4.6% <i>Burkholderia contaminans</i> : 1.5% <i>Fusobacterium russii</i> : 1.5% <i>Kokuria kristinae</i> : 1.5%

Specifically, among the Staphylococcaceae family, the two most frequently isolated pathogens were *Staphylococcus intermedius/pseudointermedius* (*S. intermedius/pseudointermedius*) in 86.3% of dogs and 50% of cats, and *Staphylococcus aureus* (*S. aureus*) in 6.5% of dogs and 32.1% of cats. Instead, among the Enterobacteriaceae were *Escherichia coli* (*E. coli*) in 45.4% of dogs and 50% of cats, and *Proteus mirabilis* (*P. mirabilis*) in 29.9% of dogs and 11.1% of cats. Among the Pseudomonadaceae were *Pseudomonas aeruginosa* (*P. aeruginosa*) in 95.3% of dogs and 100% of cats, and *Pseudomonas luteola* (*P. luteola*) in 4.7% of dogs and 0% in cats, respectively.

Finally, only among canine patients, *Malassezia* spp. was isolated from 8 auricular samples (2%).

3.4. Anatomical Sites

In Table 3, the percentage of positive swabs are divided according to the anatomical region where the samples were collected thus ears, perianal area, and skin. A total of 233 ear swabs have been collected, 90% of which came from dogs. In this anatomical region, the most common microorganism isolated was *S. intermedius/pseudointermedius* in 37.8% of cases, followed by *P. aeruginosa* in 17.2%. Twelve swabs were collected from the anal glands and *E. coli* was identified in 33.3%, *P. mirabilis*, and *Enterococcus faecalis* (*E. faecalis*) in 25%. Finally, there were 146 samples from the skin in which the most isolated microorganisms were *S. intermedius/pseudointermedius* and *E. coli* (17.8%) followed by *S. aureus* in 7.5%.

Table 3. Subdivision by anatomical sites of the most common bacteria isolated from dermatological swabs in dogs and cats. Dog (D) and Cat (C).

Auricular region: 59.6%	<i>S. intermedius/pseudointermedius</i> : 37.8%—(D) 90%, (C) 10% <i>P. aeruginosa</i> : 17.2%—(D) 97.5%, (C) 2.5%
Perianal area: 3.1%	<i>E. coli</i> : 33.3%—(D) 75%, (C) 25% <i>P. mirabilis</i> : 25%—(D) 100%, (C) 0% <i>E. faecalis</i> : 25%—(D) 66.7%, (C) 33.3%
Skin: 37.3%	<i>S. intermedius/pseudointermedius</i> : 17.8%—(D) 83.9%, (C) 33.3% <i>E. coli</i> : 17.8%—(D) 76.9%, (C) 23.1% <i>S.aureus</i> : 7.5%—(D) 45.5%, (C) 54.5%

3.5. Antimicrobial Susceptibility Testing and Resistance Profile

The molecules assayed in susceptibility testing are numerous and vary according to the pathogen isolated. For this reason, the results relating to the molecules still effective have been classified considering those of greatest use and interest in the field of veterinary dermatology. Following the AMEG classification, from category D to category A, the susceptibility to the different drugs is presented in Table 4.

Table 4. Sensitivity profile found in canine and feline samples related to the antibiotics most used in veterinary dermatology and relative category belonging to the AMEG classification.

Sensitivity Profile	Dogs	Cats	AMEG Classification
Fusidic acid	78%	66.7%	D
Oxacillin	65.5%	67.9%	D
Sulfamethoxazole–trimethoprim	60.5%	75.8%	D
Ampicillin	36.2%	37%	D
Amoxicillin + clavulanic acid	51.5%	52.8%	C
Gentamicin	85.3%	82.8%	C
Clindamycin	50%	45.7%	C
Enrofloxacin	51.3%	61.3%	B
Cefovecin	57%	60.4%	B
Imipenem	77.2%	90.3%	A

Ampicillin was not efficient against 63.8% in canine and 63% in feline isolates, respectively, while oxacillin (used as a marker to screen methicillin-resistant strains) was effective in 65.5% of canine and 67.9% of feline isolates, respectively. Moving on to category C molecules, amoxicillin associated with clavulanic acid was effective in 51.5% of canine and 52.8% of feline samples. Moving on to category B, enrofloxacin demonstrated reduced efficacy, considering that only 51.3% of canine and 61.3% of feline isolates were sensitive to this molecule. Finally, imipenem, which belongs to category A and was effective in 77.2% of canine and 90.3% of feline. Imipenem is not authorized for veterinary use and was considered only as a marker of multidrug resistance or reduced carbapenem susceptibility.

Using the data obtained in the first part of the Results section, it was also possible to organize the data in order to link the identified bacteria with the anatomical sites in which they have been collected (Figure 2), the overall trend of the numbers of positive samples collected during the entire period and the related resistance (Figure 3) and also trend of resistance for selected molecules (Figure 4).

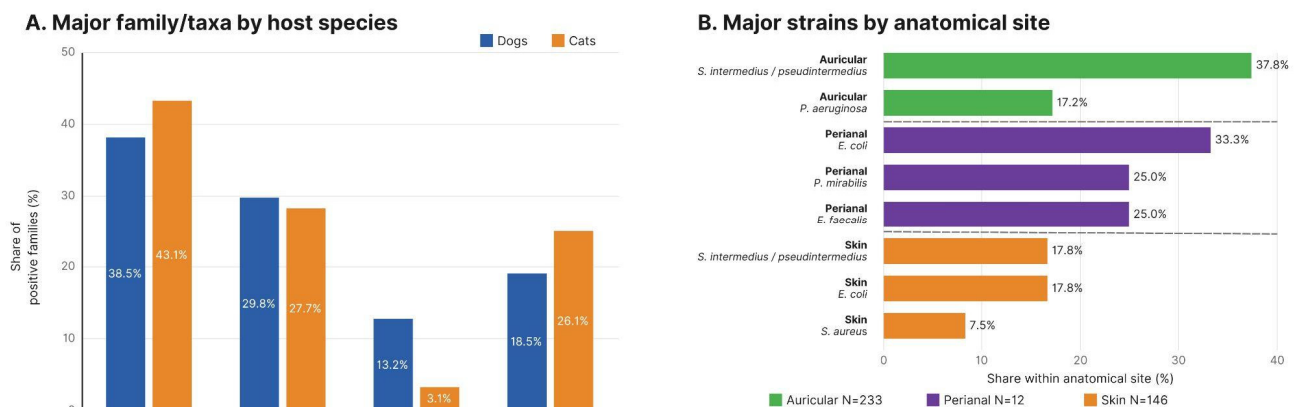


Figure 2. Major bacterial families by species and dominant taxa by anatomical site.

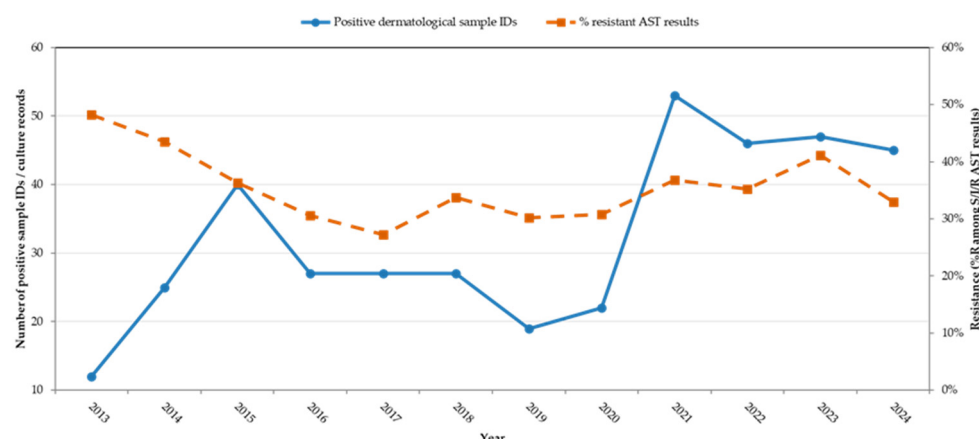


Figure 3. Temporal trend: positive dermatological cultures and resistance.

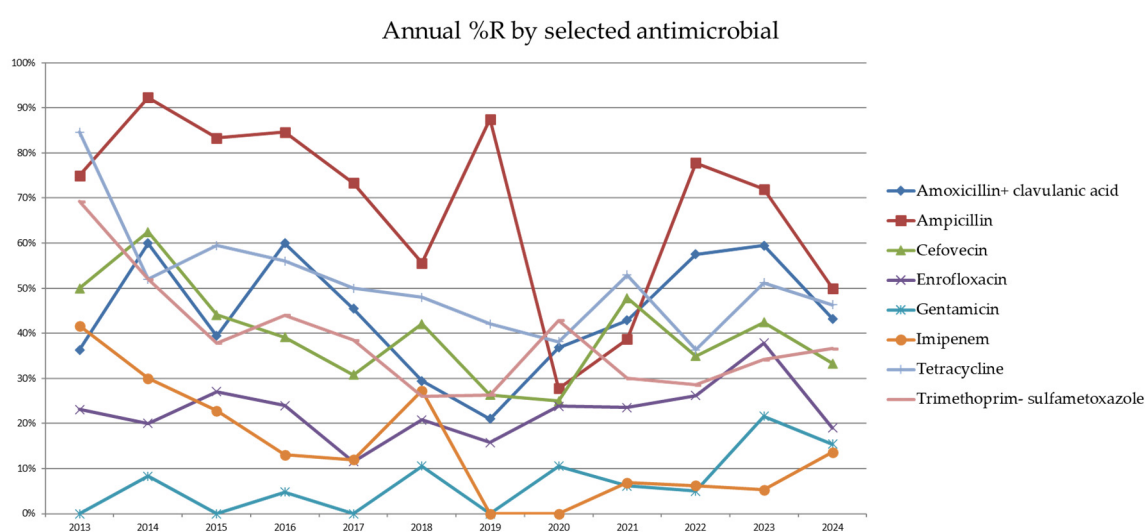


Figure 4. The figure show the temporal trend of positive dermatological samples and the trend of resistance during the 12 years of observation.

3.6. Therapeutic Prescription and Relapses

By consulting the medical records of the clinic management software it was possible to follow the clinical history of 112 patients divided as follows: 6 in 2013, 6 in 2014, 10 in 2015, 4 in 2016, 0 in 2017, 0 in 2018, 3 in 2019, 13 in 2020, 22 in 2021, 19 in 2022, 13 in 2023 and finally 16 in 2024. The most prescribed molecules were amoxicillin—clavulanic acid in 36.6% of patients as monotherapy or in combination with other molecules, and fluoroquinolones (enrofloxacin, marbofloxacin, pradofloxacin 25.9%). In 17.6% of cases, a cleaning and/or disinfectant product was prescribed in combination with the drug, and in 17% of patients, the prescribed therapy consisted solely of the application of disinfectant products. Other antibiotics, such as cefazolin, cefovecin, florfenicol, gentamicin, polymyxin B, tylosin, either alone or in combination, were prescribed in 13.4% of patients. Finally, the documented relapses among the 112 patients whose follow-up was reconstructed were 22.3%.

4. Discussion

Dermatological conditions are among the most common reasons for veterinary consultation in companion animals [3]. This is likely attributable to the fact that skin disorders are readily recognized by pet owners because of visible clinical signs, such as alopecia,

erythema, exudation, or malodor, whereas other diseases may present with more subtle or less easily detectable manifestations.

In 2014, a European survey identified dermatological disorders as the leading indication for antibiotic prescription in veterinary medicine [14]. Historically, these treatments have often been administered empirically, with limited support from antimicrobial susceptibility testing, which was generally reserved for recurrent or refractory cases [15]. However, this approach has increasingly been questioned because of its contribution to the development of antimicrobial resistance (AMR), particularly in the context of skin infections, where inappropriate antibiotic use has been common in the past.

The expanding population of domestic dogs and cats increases the potential for AMR dissemination in both veterinary and human contexts [16]. Within the One Health framework, prudent and rational antimicrobial use across all sectors—human, animal, and environmental—is essential to mitigate this global threat [13,17].

The present study was conducted to evaluate AMR in dermatological cases in a clinical population of dogs and cats over a 12-year period in northwestern Italy. The analysis revealed several important findings.

Among dogs, the most frequently represented breeds included German Shepherds, Labrador Retrievers, West Highland White Terriers, and Golden Retrievers. These breeds are known to be predisposed to canine atopic dermatitis, a condition that may lead to secondary bacterial infections requiring antimicrobial therapy [18]. Similarly, atopic dermatitis in cats has been associated with superficial pyoderma, with a reported prevalence of up to 49% [19].

Cocker Spaniels were also well represented, most likely because of their anatomical predisposition to otitis externa. Their pendulous pinnae and higher density of ceruminous glands create a favorable environment for bacterial and yeast overgrowth [20,21].

With regard to seasonality, 55.2% of canine cases and 56.9% of feline cases occurred during the warmer seasons, namely spring and summer. This finding may be explained by the fact that elevated temperature and humidity promote bacterial proliferation, thereby increasing the likelihood of skin infections. In addition, several environmental allergens, such as pollen, are more abundant during summer and may act as exacerbating factors in allergic and atopic patients [22].

The aggregate susceptibility percentages should be interpreted with caution, as they include isolates with different intrinsic resistance profiles. Therefore, clinically relevant interpretation was based primarily on taxon-stratified results. Members of the family Staphylococcaceae accounted for 39.9% of detected infections, a finding consistent with the literature, given the well-recognized predominance of coagulase-positive staphylococci in veterinary dermatology. In the past, many infections were attributed to *Staphylococcus aureus*; however, refinements in microbiological techniques have enabled the identification of additional species, including *Staphylococcus intermedius* and *Staphylococcus pseudintermedius* [23]. In the present study, *S. pseudintermedius* and *S. intermedius* were responsible for 30.9% of infections, whereas *S. aureus* was identified in 4.3% of patients. These data are consistent with previous studies that recognize *S. pseudintermedius* as a major pathogen, particularly in superficial pyoderma [24], and attribute approximately 10% of infections to other staphylococci, such as *S. aureus*, *Staphylococcus schleiferi*, and *Staphylococcus hyicus* [23]. Nevertheless, the descriptive statistics used in the present study are not without value. Although larger sample sizes provide greater statistical power, the current sample size is sufficient for a descriptive analysis of bacterial isolates and antimicrobial resistance trends. In the present paper, a retrospective study design was selected because it enables the systematic evaluation of existing clinical data, which is essential for generating insights into antimicrobial resistance. Although simple and primarily descriptive, this dataset may help

clinicians identify relevant bacterial patterns and emerging resistance trends. Moreover, the retrospective approach relies on real-world data obtained from clinical patient samples, thereby supporting the practical relevance of the findings despite the limited sample size. The results may also serve as baseline data for future studies involving larger cohorts and longer observation periods. This methodological approach is widely reported in both veterinary medicine [24,25] and human medicine [26,27].

It is also recognized that the microorganisms present on the skin are similar to those colonizing the ear canal. Accordingly, the data reported in the present study are consistent with a 2022 study in which swabs from canine and feline patients affected by otitis externa were analyzed. In that study, the same bacterial groups, namely *Staphylococcus* spp. and *Pseudomonas* spp., were identified, although with different frequencies: 39% and 11.3%, respectively, compared with 37.8% and 17.2%, respectively, in the present study [28]. In a Brazilian retrospective study of canine otitis externa involving 616 affected dogs, beta-hemolytic *Staphylococcus* spp. were the most frequently isolated microorganisms. Specifically, *Staphylococcus* β -hemolyticus was identified in 26.3% of cases, followed by *Malassezia pachydermatis* in 12.4% and *Pseudomonas aeruginosa* in 8.8%. In that study, mixed-breed dogs were the most frequently represented group (25.2%), followed by Poodles (17%) and Cocker Spaniels (11.4%) [29].

In cases of otitis externa, the role of *Malassezia* spp. should also be considered. This yeast is frequently isolated together with bacteria and may less commonly represent the primary pathogenic microorganism responsible for otitis. This finding underscores the importance of microbiological culture in establishing optimal therapy, which, in cases of yeast overgrowth, may require a multimodal therapeutic approach or the use of phytotherapeutic compounds [3,29,30].

Enterobacteriaceae were isolated in 29.4% of cases; among these, 46.1% were infections caused by *Escherichia coli*. The high prevalence of these bacteria may be related to the inclusion of swabs obtained from the anal region, as conditions affecting this anatomical area, such as infections of the perianal glands, fall within the scope of veterinary dermatology. Moreover, these disorders are commonly encountered in clinical practice [31].

The finding that nearly 12% of infections were caused by *Pseudomonas* spp. is clinically relevant, as these bacteria are capable of producing biofilms. Biofilm formation is important because it can inactivate detergents, reduce antimicrobial penetration, and provide protection for bacterial cells. Furthermore, biofilms may facilitate the development of antimicrobial resistance, particularly among Gram-negative bacteria [30,32].

One of the most concerning findings was the high prevalence of methicillin-resistant staphylococci, as assessed by oxacillin screening. The 34% resistance rate observed in this study is consistent with global reports of increasing methicillin resistance in *S. pseudintermedius*, which is now recognized as an emerging zoonotic pathogen [33,34]. Furthermore, dogs may remain carriers for up to 11 months after infection, thereby increasing the risk of transmission [23]. Although several aspects of the epidemiology, transmission dynamics, and risk factors remain unclear, *S. pseudintermedius* infections in humans have been reported worldwide. To date, reported infection sites include the endocardium, ear, and prosthetic joints. Transmission may occur horizontally or interspecifically, particularly among veterinary personnel and dog owners through close contact with colonized animals. As with many other infections, risk factors in humans include immunosuppression, postoperative infections, and advanced age. Notably, there is currently no evidence of human-to-human transmission of this pathogen [35].

Resistance to ampicillin, a Category D first-line antimicrobial, exceeded 60% in both species, highlighting the reduced clinical utility of this drug in dermatological settings. This finding emphasizes the importance of susceptibility testing, even when prescribing

antimicrobials traditionally considered low-risk. Penicillin and its derivatives are among the most widely used antibiotics in both human and veterinary medicine. Ampicillin, like amoxicillin, belongs to the aminopenicillin subgroup of β -lactam antibiotics and is a semisynthetic molecule with broad-spectrum activity against both Gram-positive and Gram-negative bacteria [18]. Therefore, the resistance detected against ampicillin is problematic because it may also imply resistance to commonly used molecules such as amoxicillin, with potential consequences for both animal and human health.

Fusidic acid showed favorable susceptibility results, particularly in dogs, with 78% susceptibility, and remains a valuable topical agent for the treatment of superficial pyoderma. This antimicrobial is approved for veterinary use in several European countries and in Canada [33]. Fusidic acid belongs to the fusidane class of antibiotics. It has a steroid-like structure, although it does not possess steroidal activity, and this structure is believed to contribute to its high tissue penetration. Its antimicrobial activity is primarily directed against Gram-positive pathogens, including *S. aureus*, against which it is considered one of the most potent topical antibiotics. Fusidic acid is used in dermatology for the treatment of mild to moderately severe skin and soft tissue infections [36]. Similarly, sulfamethoxazole–trimethoprim demonstrated moderate susceptibility in dogs (60.5%) and high susceptibility in cats (75.8%), suggesting that it may represent a viable systemic option for infections involving Enterobacteriaceae.

In contrast, amoxicillin–clavulanic acid, although still widely used empirically, showed resistance rates exceeding 45% in both dogs and cats. This finding highlights the need to reconsider its use as a first-line agent and supports AMEG recommendations to restrict the use of Category C antimicrobials [10].

Excessive use of amoxicillin–clavulanic acid may promote the emergence of bacterial strains resistant not only to this drug but also to cephalosporins. This may occur through the selection of non-inhibitable β -lactamases, mutations in penicillin-binding proteins or porins, mutagenesis mechanisms, and increased expression of efflux pumps [37]. Therefore, the indication, duration, and clinical context should be carefully evaluated before prescribing this antimicrobial in order to reduce the risk of selecting for cross-resistance.

For Gram-negative pathogens such as *P. aeruginosa*, gentamicin, a Category C antimicrobial, remains an effective option, with susceptibility rates exceeding 80% in both species. However, the use of fluoroquinolones, such as enrofloxacin, which belongs to Category B, should be restricted because of their importance in human medicine and the increasing rates of resistance. Fluoroquinolones are essential in human medicine because of their broad spectrum of activity and their efficacy against a range of bacterial infections, including potentially life-threatening infections. They are particularly useful for treating respiratory, urinary, gastrointestinal, and skin infections caused by both Gram-positive and Gram-negative bacteria. Their ability to penetrate tissues and achieve high concentrations at infection sites contributes to their effectiveness in several clinical settings [38].

According to European Union legislation, imipenem is prohibited for veterinary use and was included in this study only as a marker of multidrug resistance. The detection of imipenem-non-susceptible isolates—16.3% in dogs and 6.5% in cats—should be interpreted with caution. In the absence of confirmatory phenotypic or molecular testing, these findings do not demonstrate carbapenemase production. However, they may indicate resistance mechanisms potentially associated with reduced carbapenem susceptibility and therefore warrant continued surveillance [39–41].

Rational and informed antimicrobial use in veterinary dermatology also requires increased use of antiseptics, including as monotherapy, which should be prioritized over topical antibiotics when appropriate. In the present study, antiseptics were prescribed as monotherapy in 17% of patients. Chlorhexidine is a widely studied and well-established

antiseptic. In one study, chlorhexidine administered as both shampoo and 4% spray demonstrated efficacy comparable to systemic antimicrobial therapy in 31 dogs with superficial pyoderma [42]. However, a 2019 in vitro study suggested that low-concentration chlorhexidine products may have limited efficacy against ESBL-producing *E. coli* and no efficacy against *Pseudomonas* spp. [43]. This finding further emphasizes the importance of cytological examination in dermatology, as the predominance of cocci and/or rods may help guide the selection of the most appropriate therapeutic approach before susceptibility testing results become available. Antiseptics are particularly important when the primary cause of a condition cannot be fully resolved, such as in chronic skin folds or pressure sores, and/or when the risk of recurrence persists. In such cases, antiseptic treatment may be continued proactively on previously affected skin, potentially on a long-term basis [44].

Skin infections are generally secondary to an underlying primary cause, such as allergy, endocrine disease, or parasitic infestation. It is therefore the veterinarian's responsibility to identify and manage the primary etiology in order to prevent recurrence [45]. Consequently, even when an appropriate treatment protocol is applied, relapse may occur if the underlying cause has not been identified and addressed. In the present study, the recurrence rate was 22.3%.

This study has several limitations. First, the numbers of canine and feline samples were not homogeneous, as the study relied on the availability of samples from the selected veterinary clinic, where the number of referred canine patients was greater than that of feline patients. In addition, complete clinical histories could be reconstructed for only 28.6% of enrolled cases, and recurrence data were available only for a limited subset of patients; therefore, these findings should not be generalized to the entire study population. Detailed information regarding specific dermatological diagnoses, disease severity, previous antimicrobial exposure, comorbidities, hospitalization history, and control of underlying disease was not consistently available. These factors may have influenced both antimicrobial resistance patterns and recurrence risk.

Another important consideration is that the diagnostic sample population represents a limited subset of animals. Finally, because this surveillance was based on antimicrobial susceptibility testing results, it was not possible to reliably distinguish colonization from clinical infection. Nevertheless, all samples were obtained from animals presenting clinical signs consistent with dermatological disease. Despite these limitations, the present data provide useful information for monitoring antimicrobial resistance in veterinary dermatology in dogs and cats in northwestern Italy from 2013 to 2024.

5. Conclusions

Dermatological infections are a common reason for veterinary consultation in companion animals. This 12-year retrospective analysis provides valuable insights into the bacterial species involved and their antimicrobial susceptibility profiles in dogs and cats in northwest Italy. The most frequently isolated organisms *S. pseudintermedius*, *E. coli*, and *P. mirabilis* are consistent with global findings in veterinary dermatology. Importantly, this study confirms the emergence of AMR across several commonly used drugs, including first-line agents such as ampicillin and amoxicillin–clavulanic acid.

Although the retrospective design and uneven annual sample distribution prevent firm conclusions about changes in prescribing behavior over time, the findings support the clinical value of culture and susceptibility testing to guide antimicrobial therapy in veterinary dermatology. Notably, agents such as fusidic acid, sulfamethoxazole–trimethoprim, and gentamicin continue to show good efficacy and remain valuable options when guided by culture and sensitivity results.

With easy access to specimen collection and topical therapy, the skin offers unique opportunities for effective antibiotic management. Routine use of cytology, antibiotic susceptibility testing, topical antimicrobial therapy and antiseptics, and a focus on addressing the underlying causes are the tools we have to reduce AMR in this area of veterinary medicine. These findings underscore the importance of routine diagnostic testing, antimicrobial stewardship, and ongoing surveillance. Future research should aim to stratify antimicrobial resistance patterns by specific dermatopathies and further explore molecular resistance mechanisms. This would enable more targeted interventions and reinforce One Health principles to protect both animal and human health.

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Institutional Review Board Statement: Ethical review and approval were not required for this study. This work is a retrospective analysis of clinical records from client-owned animals that received routine veterinary care. No experimental procedures were performed on the animals. The study falls outside the scope of Italian Legislative Decree 26/2014 (implementing EU Directive 2010/63/EU), which regulates the use of animals for experimental purposes. Informed consent was obtained from all owners for the use of anonymized clinical data.

Informed Consent Statement: Informed consent was obtained from all owners before enrolment.

Data Availability Statement: Data are unavailable due to the privacy of the patients and owners involved.

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Abbreviations

The following abbreviations are used in this manuscript:

AMR	Antimicrobial Resistance
WHO	World Health Organization
AMEG	Antimicrobial Advice Ad Hoc Expert Group
ESBLs	Extended-Spectrum Beta-Lactamases
MR	Methicillin-Resistant

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