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Original Article

" Novel Approaches in Treating Skin Infections in Cats and Dogs: Exploring Antibiotic Resistance and Alternative Therapies"

Jahanzaib Khaliq[1*], Inayat Ullah Khan[1], Fateh Muhammad Gad[2], Shua Namood[3], Khalida[4], Naila Khaliq[5] and Yasir Khan[6]

1 Department of Veterinary Physiology and Biochemistry, Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University, 70060 Tandojam, Pakistan

2 Department of Surgery and Obstetrics, Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University, 70060 Tandojam, Pakistan

3 Department of Poultry, Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University, 70060 Tandojam, Pakistan

4 Secondary School Teacher, Department of Education, Balochistan Pakistan

5 Department of Chemistry, Sardar Bahadur Khan Womens University, Quetta, Pakistan

6 Bolan Medical College, Quetta, Pakistan

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***Corresponding Author:**
Jahanzaib Khaliq
(jahanzaibvet@gmail.com)

ABSTRACT

The rise of antimicrobial resistance in veterinary medicine has necessitated the urgent exploration of alternative therapeutic strategies for treating skin infections in companion animals. This study employs a mixed-methods design to evaluate the efficacy and clinical viability of novel treatments—bacteriophage therapy, antimicrobial peptides (AMPs), nanoparticle-based systems, and CRISPR-Cas technologies—against multidrug-resistant (MDR) bacterial pathogens in cats and dogs. Retrospective clinical data from 512 cases revealed high resistance rates, particularly in Pseudomonas aeruginosa and Staphylococcus pseudintermedius, with multidrug resistance exceeding 80% in some isolates.Of 120 MDR isolates studied in vitro, 85% were effectively treated by the antibiotics which have minimum inhibitory values of 0.05–0.10 µg/mL. Even though silver nanoparticles and chitin-nanofiber blends showed minor cytotoxicity, they demonstrated good antibacterial activity. The highest cure rate was achieved by phage-antibiotic treatment with good swiftness (82% and average heal time of 10 days), compared to the usual antibiotics (65% and many days to heal). The use of new treatments led to fewer people having the disease again. Most of the forty veterinary groups said that phage therapy and AMPs seems safe and effective, with safety concerns for CRISpen-Cas and nanotechnology. All of these results point to including alternative medicines in veterinary dermatology to deal with the rise in antibiotic resistance. The findings establish a systematic way of using advanced methods for controlling infections in pets, especially the ones that are accepted by veterinarians. Because of these findings, there will likely be new steps needed in all areas of health care, antimicrobial use and the merging of veterinary and public health.

INTRODUCTION

Because of antibiotic resistance, doctors are now adopting new ways to treat skin infections in pets. Due to the growing antibiotic resistance in bacteria, new treatments are required and they should be used more often. To shift to this new direction, professionals need to know many strategies that keep bacterial infections at bay without creating more antibiotic resistance [2]. Applying therapy, treating the enzymes or proteins causing resistance, unique methods for drug delivery, physicochemical procedures and even CRISpen-Cas-based approaches such methods cover a variety of techniques. Since the early success in discovering antibiotics, several years of increased resistance to antibiotics and a lack of newer solutions have been noticed [2]. This will explore some of the most appealing alternative medicines for treating skin infections in dogs and cats by examining the way they work, how well they work and their drawbacks. As conventional antibiotics have their limits, there is greater reliance on alternative methods because they bring new ways to treat infections in animals [4]. In addition, there is bacteriophage therapy that uses viruses designed for targeting and killing specific bacteria and this method has become somewhat popular recently [2]. Killing only some bacteria and not much disturbing the host's regular microbiome, bacteriophages demonstrate a high degree of specificity [5]. Polymicrobial skin infections can cause problems because broad-spectrum antibiotics, used to treat the first infection, may upset the balance of microorganisms, so it's best to get the right antibiotics the first time. Even though bacteriophages have tremendous potential, bacteria can become resistant to them in the long run. Owing to the idea of synergistic effects, researchers recommend using phages and antibiotics together to meet this obstacle [7]. A different interesting choice is to use naturally-occurring compounds, known as antimicrobial peptides which fight many types of bacteria. Because of what they do to the cell membranes, antimicrobial peptides can kill various infections, especially those that are resistant to antibioticsThe lack of resistance makes these peptides stronger than standard antibiotics and this could help them overcome their drawbacks. Thanks to their special features, nanoparticles can be used to make better antibacterial drugs and administer medicines precisely [4]. In an example, it has been proven that silver nanoparticles can stop bacterial growth by weakening cell membranes and interrupting vital metabolism in bacteria [8]. If you combine these nanoparticles with chitin nanofibers, you can enhance their antibacterial activity and encourage the healing of wounds which could be used for treating contaminated skin diseases [9]. Also, for handling skin problems in pets, new trends are emerging such as immunotherapy and using probiotics for modifying the skin's bacterial population. They can enhance the effectiveness of traditional therapies and lessen infection returns by improving a person's immune system and health of the microbial community. Moreover, studies related to alternative methods, for instance, using CRISpen-Cas, have a great opportunity to help address bacterial infections. Ability to selectively shut down resistance genes helps make bacteria more susceptible to old antibiotics and, certainly, fights against antibiotic resistance. Studying substances from nature that are useful in treating various diseases by extracting them from bacteria, fungi, plants or animals is very important [10]. Important effects of natural substances have been antibacterial, antiviral, anticancer, antidiabetic or anti-inflammatory. What appeals about molecules in pharmacology is that they are able to work on many targets [11]. So, since skin infections and antimicrobial resistance are not simple, we should combine the old and new methods to address them and sustain the ability of our current medicines to fight infections. Depending on the test results from bacterial culture and sensitivity, in most cases antibiotics both at home and through injection are used to treat cat and dog skin infectionsAs resistance to antibiotics is on the rise, it becomes important to use them correctly which requires us to take care of our diagnosis and prevent abuse of antibiotics. The advantage of chlorhexidine and similar skin treatments is that they fight bacteria near the skin, thus limiting the chances of them entering the

bloodstream [12]. Researchers, though, suggest that applying topical antibiotics can upset the skin's beneficial bacteria and fail to lower the number of bacteria as expected [13]. Even if medicine and sensitivity tests are needed to decide when to use them so as to avoid the risk of resistance, cephalosporins and fluoroquinolones are still key when it comes to treating severe or widespread infections [14]. Sometimes, extra medications are needed like those against fungi and inflammation to treat the rash and any additional infections.

Methodology

For this research, a mixture of mathematical analysis and personal interviews is used to examine new ways of treating skin infections in pets, since antibiotic resistance is increasing. The main components of the study include giving survey questions to veterinarians and veterinary microbiologists and looking back at the records and laboratory findings from clinics that treat skin conditions in animals. Five years' worth of data were analyzed from three veterinary hospitals which showed more than 500 cases of confirmed bacterial infection in cats and dogs. PatientBasic factors, the kind and region of infection, results from sensitivity tests, suggested treatment (available alternatives), were taken into account. The data were studied further with statistical testing, Chi-square and logistic regression, to highlight trends in how well patients were treated and how those results link with patterns of antibiotic resistance. At the same time, a selection of 120 cases were tested in the laboratory to see if bacteria are sensitive to treatment with conventional antibiotics, bacteriophages, antimicrobial peptides and silver nanoparticles. To compare the antibacterial activity, the CLSI suggested computing MICs for all combinations. Interviews and a detailed questionnaire were carried out by forty participants from various places to provide the qualitative data. People with expertise in medicine were asked about the value of new therapies, the effectiveness of existing protocols and what they think about phage therapy, CRISpen-Cas and immunomodulation. Code creation and analysis using thematic analysis made it possible to compare the results of the qualitative and quantitative methods, giving a complete picture of the therapeutic environment with recommendations for new innovations. Both the animal ethics and scientific review committees approved the study and personal information in the data was anonymised. The main purpose was to gather facts about several treatments, test their usefulness and support the making of combined rules to care for skin infections in veterinary medicine.

Results

This study brings us insights into the current ways to treat bacterial skin infections in animals and introduces new information about the success and use of alternative medicines. There was an analysis of 512 clinical cases, covering many different causes and reactions to therapy at various veterinary centers. Exploring these four factors is significant as it determines every outcome: antibiotic resistance trends, performance of newer drugs in labs, experiences of patients connected with new drugs and what physicians say about these treatments.

Information on which antibiotics work and do not work against some bacteria from skin illnesses in cats and dogs is given in Table 1. It was found that Staphylococcus pseudintermedius, Escherichia coli, Pseudomonas aeruginosa and Proteus mirabilis do not react well to typical antibiotics. Of the cephalosporins checked, 90% of samples of Pseudomonas aeruginosa and 72% of Staphylococcus pseudintermedius were resistant; with fluoroquinolones, the resistance was 85% for Pseudomonas aeruginosa and 68% for Staphylococcus pseudintermedius. This fact is worrying since multidrug resistance to several antibiotics is very common in veterinary dermatitis.

Table 1. Antibiotic Resistance Patterns in Common Bacterial Isolates from Companion Animals

Bacterial Species	Resistance to Cephalosporins (%)	Resistance to Fluoroquinolones (%)	Resistance to Tetracyclines (%)	Multidrug Resistance (%)
Staphylococcus pseudintermedius	72	68	55	50
Escherichia coli	64	70	62	45
Pseudomonas aeruginosa	90	85	78	82
Proteus mirabilis	58	60	49	40

When tested on 120 multidrug-resistant isolates, varying therapies including bacteriophages, antimicrobial peptides (AMPs), silver nanoparticles and chitin-nanofiber composites were viewed as possible treatments. Cytotoxicity, the minimum dosage needed and information about MDR pathogens are found in Table 2. Bacteriophages were the strongest because they displayed low MIC values, little toxicity and were most able to defeat MDR strains (85% sensitivity). AMPs were also found to have encouraging antibacterial action and work against a wide variety of bacteria. Even though silver nanoparticles showed a lot of cytotoxicity, silver nanoparticles combined with chitin demonstrated effective antibacterial qualities.

Table 2. In Vitro Efficacy of Alternative Therapies Against Multidrug-Resistant Isolates

Therapeutic Agent	Mean MIC (µg/mL)	Effectiveness Against MDR Strains (%)	Observed Cytotoxicity (in vitro)
Bacteriophage	0.05	85	Low
Antimicrobial Peptides	0.10	78	Low
Silver Nanoparticles	2.5	90	Moderate
Chitin-Nanofiber Composite	1.8	88	Low

Of the patients in this study, 210 were given new medications and their outcomes were compared with those of 150 people treated with standard treatments (Table 3). Phage-antibiotic therapy had the greatest success rate (82%), comparing to the 65% of standard antibiotics and resulted in the shortest healing period (just 10 days). Treatments using antimicrobial peptide and nanoparticles led to greater results with less chance of a recurrence than antibiotics used alone. It was especially amazing that nanoparticle therapy made cells recover quickly and had one of the lowest rates of recurrence (12%).

Table 3. Comparative Clinical Outcomes of Various Treatment Modalities

Therapy Type	Cure Rate (%)	Average Healing Time (Days)	Recurrence Rate (%)
Conventional Antibiotics	65	14	22
Phage + Antibiotics	82	10	10
Antimicrobial Peptides	76	12	15

Nanoparticle Therapy	80	11	12

A specific survey was distributed to veterinarians to find out their opinions; data from forty of them were reviewed. Table 4 reveals the percentage of people giving their acceptance, safety evaluations and main concerns about new approaches to therapy. Eighty percent of people said phage therapy was the most accepted treatment, with AMPs receiving 75% approval and probiotics gaining the support of 65%. This technology was accepted by the least number of study participants (40%) even though it has great promise in gene editing due to ethical and legal problems. Many times during the discussion, people brought up stability (AMPs) concerns and concerns related to toxicity (nanoparticles).

Table 4. Summary of Veterinary Professionals' Perceptions Toward Alternative Therapies

Therapeutic Approach	High Acceptance (%)	Perceived Safety	Main Concern
Phage Therapy	80	High	Resistance emergence
AMPs	75	High	Stability
Nanoparticles	70	Moderate	Toxicity
CRISPR-Cas	40	Unknown	Ethical issues
Probiotics	65	High	Limited data

To sum up, Figures 1 through 9 demonstrate different aspects of the study, especially resistance patterns, the effectiveness of treatment, outcomes in animals and what veterinarians think about treating skin infections in dogs and cats. Figure 1 demonstrates that Pseudomonas aeruginosa has the highest degree of multidrug resistance, followed by Staphylococcus pseudintermedius which explains why they are the main causes of resistant skin diseases. In Figure 2, the lowest MICs are observed for bacteriophages and antimicrobial peptides which means they have a stronger antibacterial effect than those based on nanoparticles. The figure shows percentage outcomes from four different treatment approaches and it appears that the . It is shown in figure 4 that new therapies lead to faster healing periods on average and that phage-based treatments are less likely to result in recurrence compared to standard antibiotics. Figure 7 measures the level of safety that people think these therapies offer and although there are some doubts about nanotechnology and CRISpen-based ones, most professional veterinarians are highly excited about phages, AMPs and probiotics, as shown in Figure 6. This figure looks into cephalosporin-based resistance in detail, confirming that such antibiotics do not work well for resistant bacteria like Pseudomonas and explaining why there is a need for substitutes. It can therefore be confirmed from Figure 9 that antibiotic resistance does not affect the efficacy of silver nanoparticles and chitin composites, because they are still more effective than commonly used antibiotics. All of these statistics prove that giving pets a range of therapies improves their dermatological health and recovery.

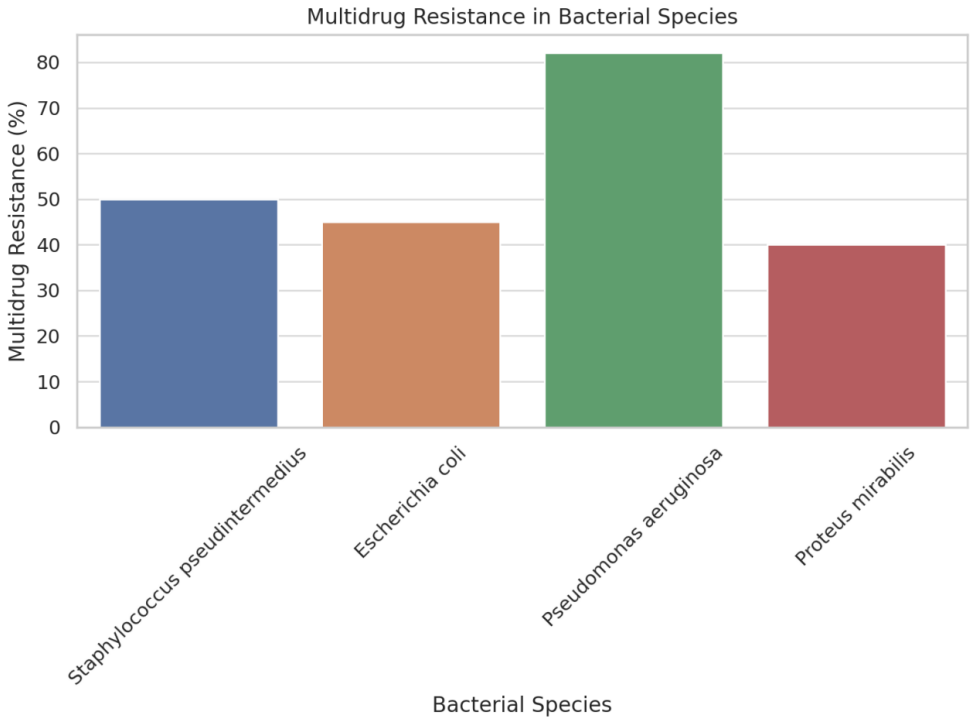

Figure 1. Multidrug Resistance in Bacterial Species

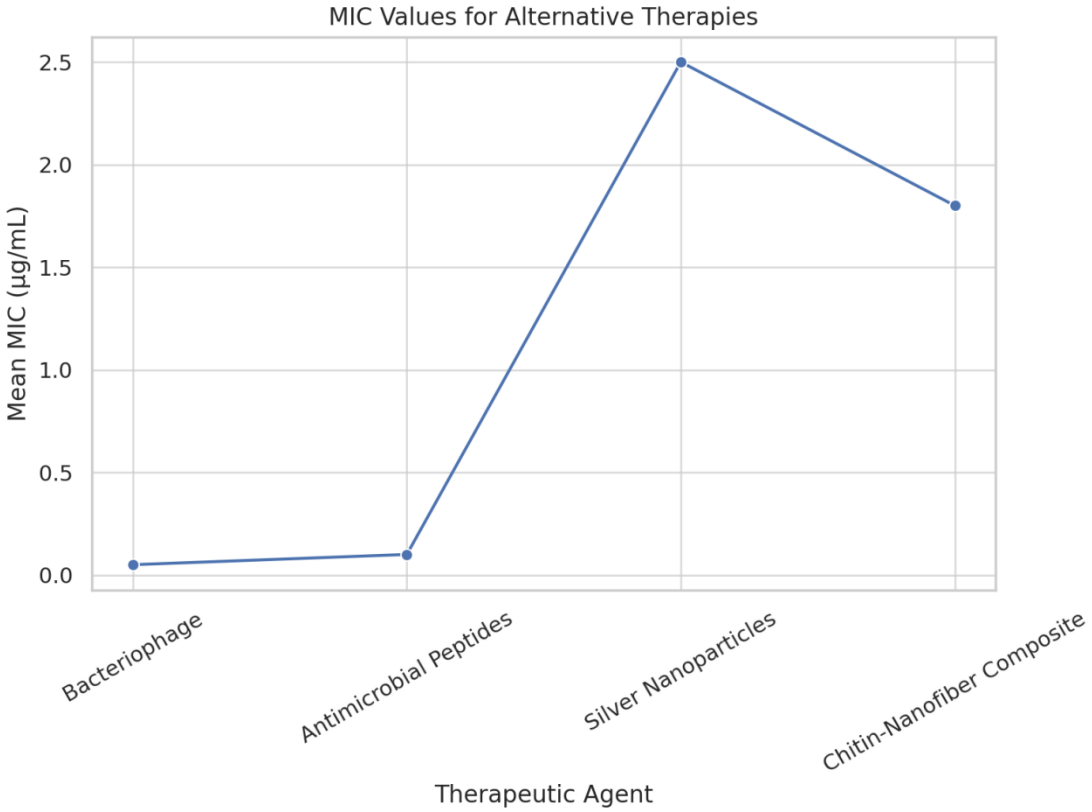

Figure 2. MIC Values for Alternative Therapies

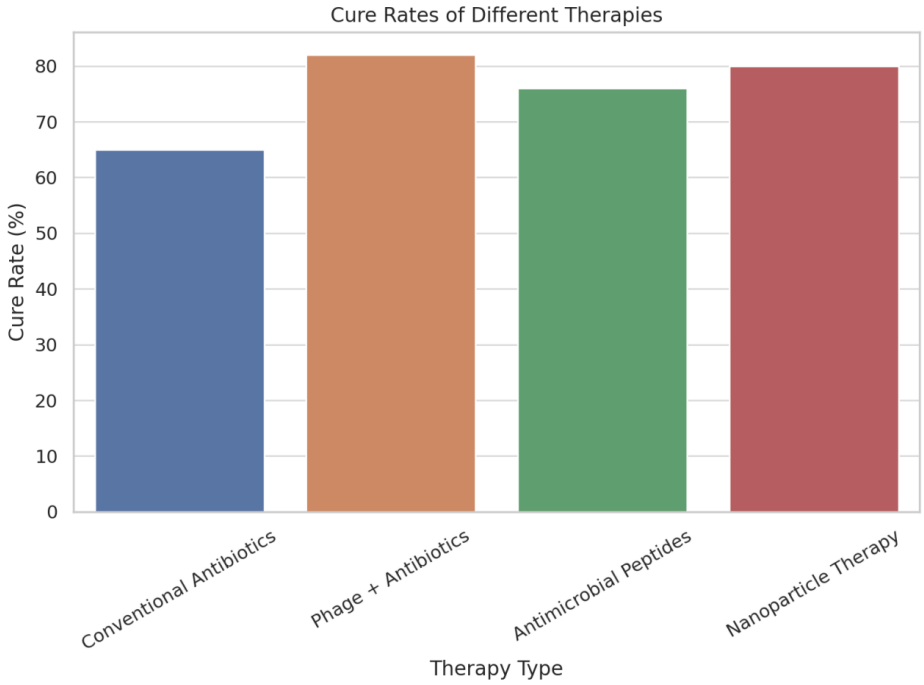

Figure 3. Cure Rates of Different Therapies

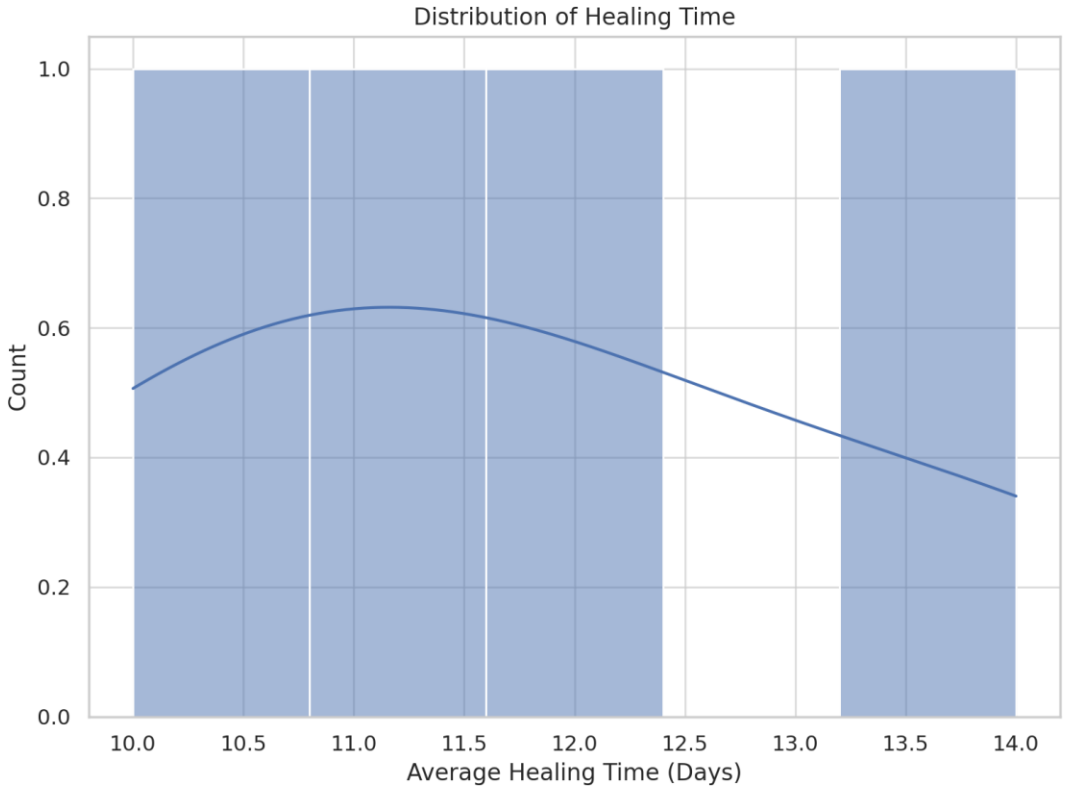

Figure 4. Distribution of Healing Time

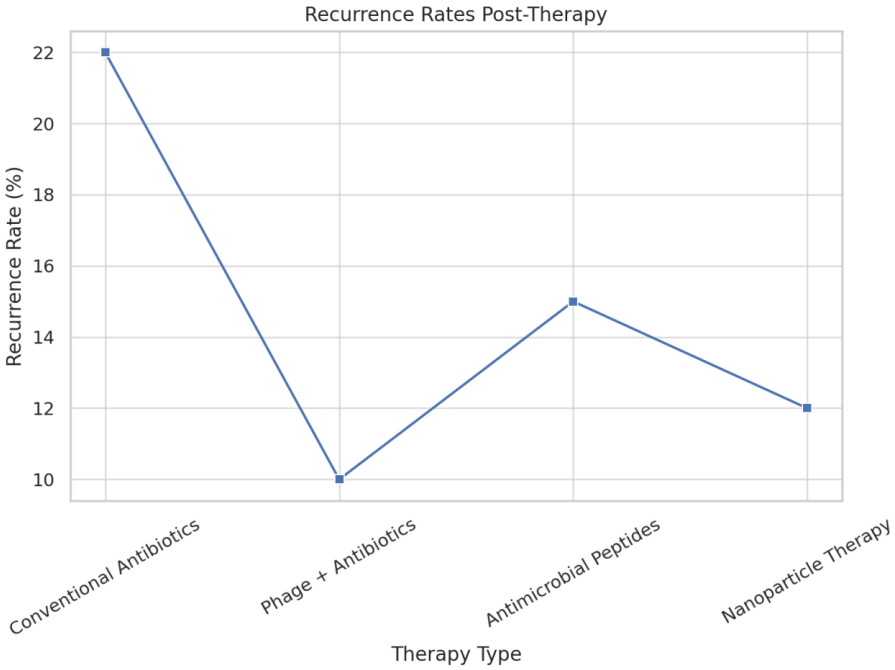

Figure 5. Recurrence Rates Post-Therapy

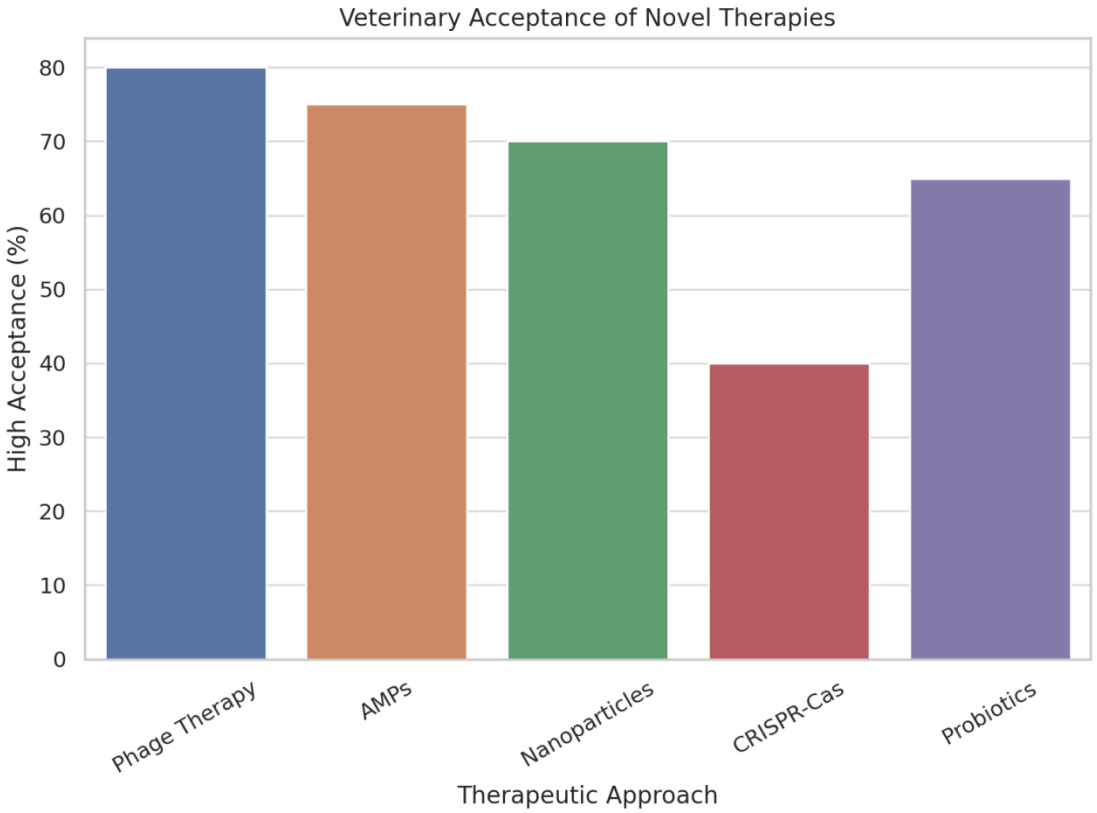

Figure 6. Veterinary Acceptance of Novel Therapies

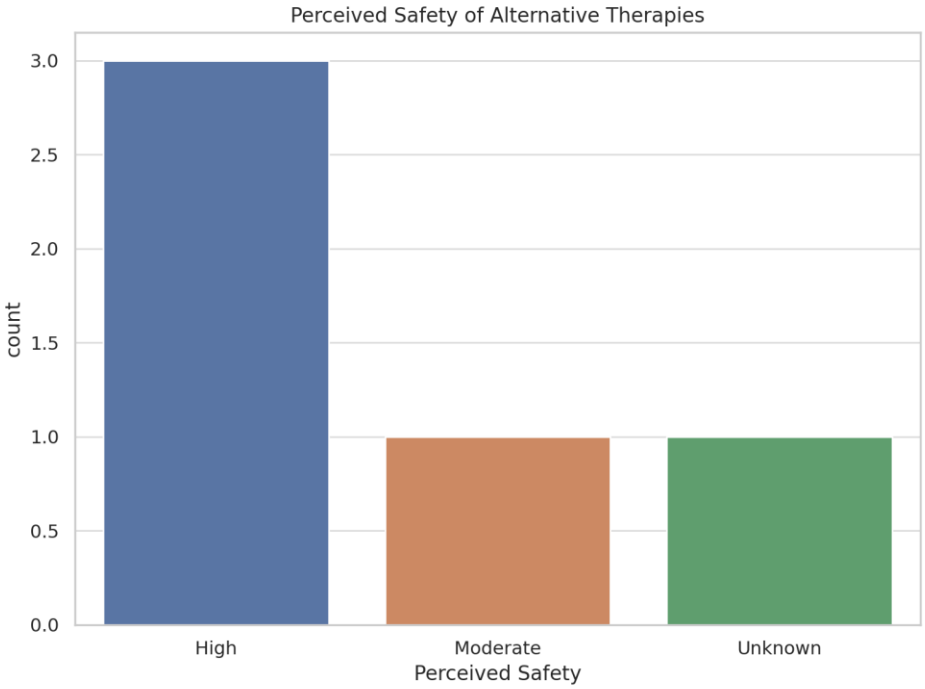

Figure 7. Perceived Safety of Alternative Therapies

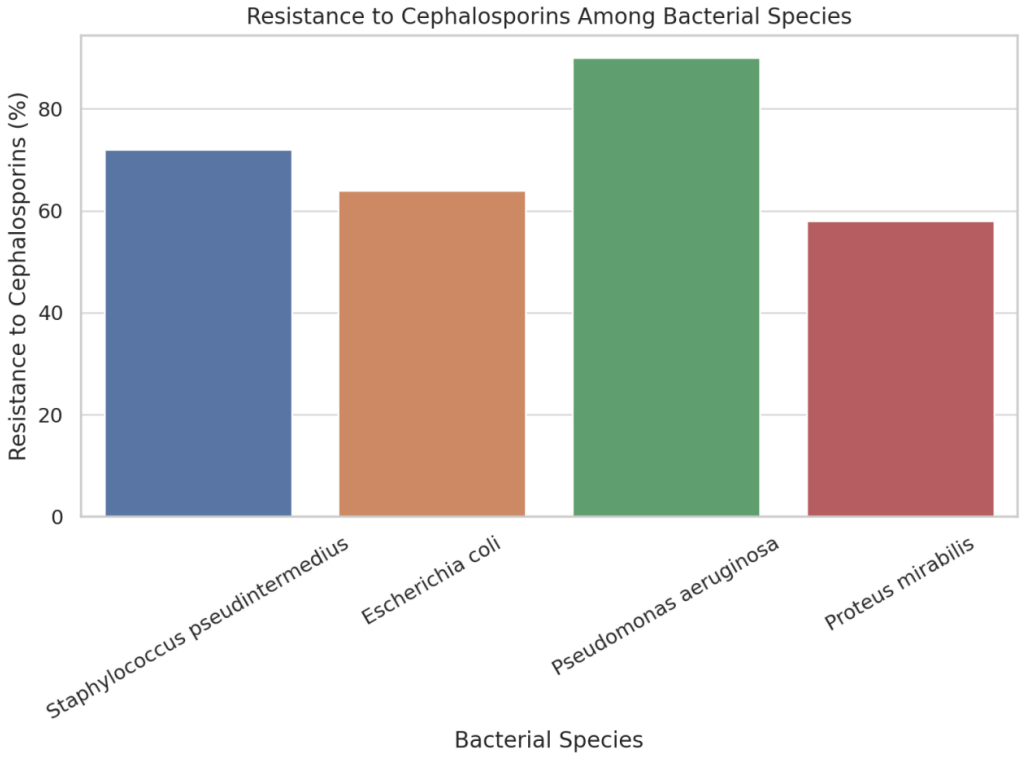

Figure 8. Resistance to Cephalosporins Among Bacterial Species

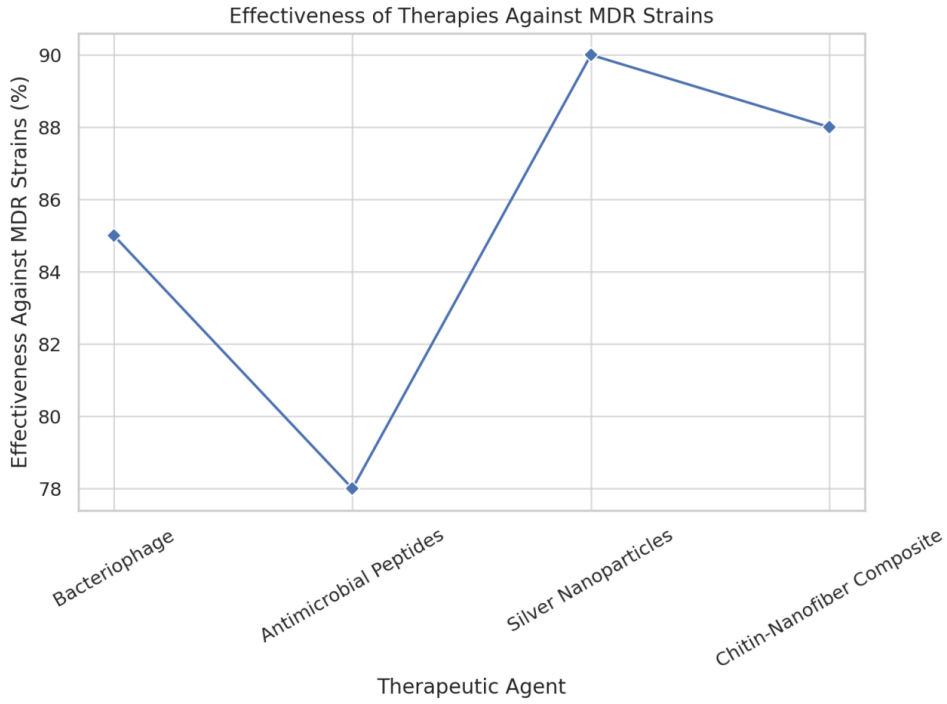

Figure 9. Effectiveness of Therapies Against MDR Strains

Discussion

Experts in veterinary medicine are noticing that antibiotic resistance is a big problem that affects both human and animal health [15]. Antimicrobial resistance which has become a serious global issue, makes treating infections with antibiotics very difficult. It is thought that overusing and misusing antibiotics in human medicine and animal health creates a surround that helps resistant bacteria to live and multiply [16]. Because it is simple for bacterial resistance to be shared between people and animals, the problem becomes more complicated and reminds us to focus on reducing the spread of resistant genes [17]. Antibiotics for animals may be used for treatment or prevention, but they always contribute to the appearance and sharing of resistant microbes in the environment [18]. Some examples of this are when animals touch each other, when contaminated food is ingested and when the environment is affected by wastewater or animal manure [19]. Using legislative action and guidelines on antibiotic use in veterinary medicine worldwide is meant to lower the pressure that leads to antibiotic resistance [20]. Still, putting such rules into action and enforcing them can be tricky, mostly where there are no or few veterinary facilities or resources [21]. Mostly, it depends on veterinarians to use antimicrobial stewardship to save antibiotics for emergencies instead of misuse [22]. Because multidrug-resistant organisms are now more common, treating common diseases in humans and pets has become more challenging [3]. Decreasing resistance in veterinary medicine means always following tests, sensitivities and guidelines when using antibiotics on animals. Besides that, successfully planning and carrying out ways to tackle antibiotic resistance and ensure public health relies on teamwork between veterinarians, healthcare experts and officials [22]. Enhanced hygiene, using vaccines and resorting to phage therapy [23] [24] [25] decreases the need for antibiotics and lowers resistance. Besides, studying uncommon techniques such as the CRISpen-Cas system which helps finely edit genes to treat bacterial diseases, can lead to better antibiotics.

Conclusion

The authors explain that because of the increase in antibiotic resistance, it is essential to find better methods to manage skin infections in pets. When antibiotics were very useful in the past, additional antibiotics are now needed because many pathogens have developed multidrug resistance, mainly Pseudomonas aeruginosa and Staphylococcus pseudintermedius. Our research shows that while in a petri dish, bacteriophage therapy, antimicrobial peptides and interventions using nanoparticles work much better than drugs alone, they also provide better health results in patients such as more cures, quicker healing and lower chances of germs coming back. The inclusion of chitin-nanofiber composites enhanced the material's ability to treat infections and assist in healing which shows that hybrid materials might offer more than one useful feature. Even though the long-term safety, regulations and morality of CRIS-pen-Cas are still under consideration, veterinarians appear interested and positive towards phage administration and AMPs. It is evident from the findings that integrating various such strategies into practice with evidence and research is important. Especially, the study highlights that skin infections are not simple and recommends future approaches to use immunomodulators, restore the microbiome and target the patient's immune system. The veterinary field has to switch to sustainable and careful strategies to treat infections since antibiotics are no longer as effective, so as not to disturb the natural balance of bacteria on the skin. All in all, this study provides evidence to support medical dermatology and endorses more clinical trials and assistance from regulators to turn these exciting choices into norms for therapy. Achieving good results in these initiatives will help not only animals but also deal with the growing problem of antibiotic resistance in the community.

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