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Antimicrobial prescription practices and opinions regarding antimicrobial resistance among veterinarians in Palestine 2024

Ibrahim M. Alzuheir[1*], Adnan Fayyad[1] and Ahmed Thabet[2,3]

Abstract

Background Antimicrobial use (AMU) by veterinarians is crucial for animal health management worldwide. Its extensive and improper use with insufficient monitoring has raised concerns about antimicrobial resistance (AMR). Veterinarians' opinions on antimicrobial agents and AMR are crucial in shaping their prescription practices. Understanding these opinions and practices is essential for mitigating the impact of AMR. Therefore, a questionnaire-based cross-sectional study was conducted to investigate the antimicrobial prescription practices and antimicrobial knowledge of veterinarians in Palestine. Descriptive and statistical analyses were performed at a confidence interval of 95%.

Results A survey targeting 358 veterinarians in Palestine received 104 responses (29.1%). The majority of respondents were male (92.3%) and aged 31–40 (47.1%) or under 30 (42.3%). Most practiced in Hebron (31.7%), while others practiced in Jenin (14.4%), Tulkarm (11.5%), and Nablus (11.5%). The practices mainly included mixed practices (48.1%), farm animals (26.0%), and small animals (13.5%). Training on antimicrobial agents was primarily in English (93.3%), lasting five years (91.3%), with 40.4% having multiple course emphases in nonclinical years and 46.2% in clinical years. Only 57.7% had no additional degrees, but 54.8% attended training courses or conferences. Most veterinarians (64.4%) felt that they did not overprescribe antimicrobial agents, although 41.3% used them in 41–60% of cases. Clinical signs were relied upon for prescriptions by 85.6%, but only 39.4% had access to laboratory facilities for antimicrobial susceptibility testing. Most respondents (76.0%) acknowledged antimicrobial misuse, and 71.2% felt there was inadequate supervision of AMU. AMR was seen as a serious issue by 99.0%, with improper prescription habits cited as a major cause (81.7%). Recommendations to combat resistance included conducting sensitivity tests, enhancing veterinary oversight, promoting biosecurity, and enforcing stricter regulations on antimicrobial sales and use.

Conclusion This study provides valuable insights into the knowledge, attitudes, and practices of veterinarians in Palestine regarding AMU and AMR. The study underscored gaps in oversight, with many respondents feeling that there was inadequate supervision of AMU in veterinary practice. The findings highlight the need for enhanced training, stricter regulations, and improved monitoring to mitigate the risks of AMR effectively. By implementing these

*Correspondence:
Ibrahim M. Alzuheir
ibrahimzuhair@najah.edu

Full list of author information is available at the end of the article

recommendations, it is possible to promote responsible AMU, safeguard public health, and ensure the continued effectiveness of antimicrobial agents for future generations. Addressing these challenges will require a concerted effort from all stakeholders to create a robust framework for antimicrobial stewardship in veterinary practice.

Keywords Antimicrobial stewardship, antimicrobial resistance, Survey, Veterinarians

Background

Livestock play a vital role in Palestinian agriculture, with veterinarians ensuring animal health and productivity through antimicrobial use (AMU) [1]. While AMU is an essential tool for disease management, its use raises concerns about antimicrobial resistance (AMR), a global public health threat [2]. In the United States, around 80% of antimicrobial are sold for use in animal agriculture, and of these, approximately 70% are classified as "medically important" due to their significance in human medicine [3]. Similarly, high-density farming, driven by population growth, increases reliance on AMU for disease prevention and treatment [4, 5]. The integration of diagnostic skills, pharmacology, and ethical considerations in veterinary medicine, especially in the treatment of food animals, highlights the importance of adhering to regulations like the Animal Medicinal Drug Use Clarification Act (AMDUCA) to ensure both drug safety and efficacy while maintaining human food safety [6]. Veterinarians face challenges such as pharmaceutical sourcing, mitigating unethical practices, and balancing economic pressures with professional responsibilities. Although AMU for growth promotion has been banned in developed countries,, it remains prevalent in some regions [7]. While this practice can offer immediate benefits, it carries the long-term risk of AMR, leading to chronic health burdens and economic losses [2].

AMU in both pets and food animals creates selection pressure, promoting the emergence and spread of resistant bacteria across animals, humans, and the environment [8]. The interconnectedness of animal, human, and environmental health underscores the importance of a global One Health approach. Over the past two decades, the Tripartite collaboration between the Food and Agriculture Organization of the United Nations (FAO), the World Health Organization (WHO), and the World Organisation for Animal Health (WOAH) has worked to combat AMR. In 2021, the United Nations Environment Program (UNEP) joined this initiative, forming the Quadripartite. This expanded partnership integrates environmental factors into One Health coordination, strengthening health security through evaluation frameworks and capacity-building initiatives [9]. This One Health framework recognizes that many human and veterinary antimicrobial agents overlap, emphasizing the need to prioritize critically important human antimicrobials for medical use [10, 11]. Awareness of AMU and AMR in human medicine is increasing; in contrast, the role of veterinary practices in AMR mitigation remains underexplored, particularly in developing countries such as Palestine [12, 13]. The absence of comprehensive regulations and enforcement mechanisms for AMU and AMR in these countries hinders data collection on veterinary AMU, creating a knowledge gap [14].

Understanding veterinarians' knowledge, attitudes, and practices (KAPs) regarding AMU and AMR is crucial for developing targeted interventions to address improper practices, knowledge gaps, and negative attitudes. Given the scarcity of systematic KAP studies assessing AMU and AMR in Palestine's animal husbandry sector, this study aimed to evaluate veterinarians' KAPs regarding these issues. A cross-sectional survey will be conducted to identify risk factors contributing to AMU and the development of AMR, providing a foundation for effective intervention strategies.

Results

Sociodemographic characteristics and education

The survey was distributed to all practicing veterinarians in Palestine ($n = 358$). There were 104 responses from various regions in Palestine, corresponding to a response rate of 29.1% who consented to and completed the survey (Table 1). While this response rate is comparable to similar studies in the region, it poses limitations in terms of generalizability [15, 16]. Key variables such as gender, geographical location and practice type (private vs. public) were found to be relatively balanced between respondents and the broader population of veterinarians. The study surveyed veterinarians, predominantly male (92.3%). Most participants were aged between 31 and 40 years (47.1%) or under 30 years (42.3%). The majority practiced in Hebron (31.7%), with other notable representations from Jenin (14.4%), Tulkarm (11.5%), and Nablus (11.5%). The primary areas of practice included mixed practices (48.1%), farm animals (26.0%), and small animals (13.5%). Many veterinarians were affiliated with primary veterinary clinics (35.6%) and veterinary pharmacies (analogous to human drug stores) (28.8%). Most facilities had between 2 and 5 veterinarians (48.1%), and over half of the veterinarians had less than 10 years of experience (57.7%) (Table 1).

Knowledge and attitudes toward AMU

The survey responses provide insights into veterinary education and antimicrobial training among veterinarians in Palestine (Table 2). The survey results revealed

Table 1 Demographic and professional characteristics of surveyed veterinarians in Palestine, 2024

Variable	Number of Veterinarians, *n* (%)	Confidence interval (95%)
Gender		
Male	96(92.3)	86.5, 97.1
Female	8(7.7)	9.2,13.5
Age (years)		
< 30	44(42.3)	32.7,51.9
31–40	49(47.1)	37.5,56.7
41–50	6(5.8)	1.9,10.6
51–60	4(3.8)	1.0,7.7
> 60	1(1.0)	0.0,2.9
City		
Gaza Strip	2(1.9)	0.0,4.8
Jerusalem	6(5.8)	1.9,10.6
Hebron	33(31.7)	23.1,41.3
Jericho & Al Aghwar	3(2.9)	0.0,6.7
Bethlehem	2(1.9)	0.0,4.8
Jenin	15(14.4)	7.7,22.1
Tulkarm	12(11.5)	5.8,17.3
Ramallah & Al-Bireh	11(10.6)	4.8,16.3
Salfit	3(2.9)	0.0,6.7
Nablus	12(11.5)	6.7,17.3
Tubas	2(1.9)	0.0,4.8
Qalqiliya	3(2.9)	0.0,6.7
Veterinary Practice		
Farm animals	27(26.0)	18.3,34.6
Small animals	14(13.5)	6.7,20.2
Equine	4(3.8)	1.0,7.7
Poultry	9(8.7)	3.8,14.4
Mix	50(48.1)	38.5,57.7
Veterinary Facility		
University	9(8.7)	3.8,14.4
Vet Hospital	6(5.8)	1.9,10.6
Primary Vet Clinic	37(35.6)	26.9,45.2
Public Vet Service	9(8.7)	3.8,14.4
Veterinary Pharmacy	30(28.8)	20.2,37.5
Field setting	11(10.6)	4.8,16.3
Slaughterhouse	2(1.9)	0.0,5.8
Number of Veterinarians per Facility		
One	40(38.5)	28.8,49.0
2—5	50(48.1)	38.5,57.7
> 5	14(13.5)	7.7,20.2
Experience (years)		
< 10	60(57.7)	48.1,67.3
10—20	38(36.5)	27.9,46.2
21–30	5(4.8)	1.0,9.6
> 31	1(1.0)	0.0,2.9

that most of the veterinary training occurred in the Middle East (93.3%), primarily in English (93.3%), over a typical duration of five years (91.3%). During their education, antimicrobial agents were emphasized to varying extents, with 40.4% receiving multiple course emphases in nonclinical years and 46.2% in clinical years. General veterinarians were the main educators of antimicrobial agents (86.5%), and postgraduate qualifications showed that 57.7% had no additional degrees. Over half of the respondents (54.8%) attended training courses or conferences to update their knowledge of antimicrobials. The analysis shows that there were no significant differences in the factors influencing antimicrobial prescription between veterinarians who had attended training courses and those who had not ($P = 0.264$) (Table 3). While professionals without training appeared to consider factors such as the cost of antimicrobial, withdrawal period, drug interactions, and AMR more frequently, the overall differences between the two groups were not statistically significant, suggesting that training does not substantially alter the weight given to these factors in prescribing decisions.

The main sources of current antimicrobial information were textbooks/drug handbooks (36.7%) and practice policies (26.6%). Knowledge of WHO-prohibited antimicrobial agents was adequate for 46.2% of respondents. Regarding AMU, 39.4% believed in combining classes of antimicrobial agents for better infection control, and a similar percentage (39.4%) favored broad-spectrum antimicrobial agents over highly selective ones. A majority (73.1%) felt that it was not possible to completely avoid using "priority antimicrobials" in animals. Alternatives to antimicrobials, such as vaccines (33.9%) and immune stimulants (32.3%), were commonly considered (Table 2).

Antimicrobial prescription practices, education, and perspectives

Antimicrobial prescription practices, education, and perspectives of surveyed Veterinarians in Palestine are shown in Table 4. The respondents indicated that most veterinarians do not feel that they overprescribe antimicrobial agents, with 64.4% responding "No," 15.4% answering "Yes," and 20.2% saying "Sometimes." Regarding the frequency of antimicrobial use (AMU), 41.3% of veterinarians reported prescribing antimicrobials in 41–60% of cases, while 36.5% did so in 61–80% of cases. Further analysis revealed that veterinarians with less than 10 years of experience, those working in mixed-animal practice, and those located in the southern regions exhibited higher AMU frequencies. This suggests that professional experience, practice type, and geographic location may influence prescribing behaviors, potentially due to differences in case load, client expectations, or disease prevalence.

Notably, only 26.9% of respondents had full autonomy in prescribing antimicrobials, whereas 44.2% could prescribe under certain conditions, and 28.8% lacked prescribing authority. For preventive purposes, 53.8% did not use antimicrobial agents, 14.4% did, and 31.7%

Table 2 Veterinary education, training, and perspectives on antimicrobials of surveyed veterinarians in Palestine, 2024

Variable	Number of Veterinarians, *n* (%)	Confidence interval (95%)
University of training		
Middle East	97(93.3)	88.5,98.1
Europe	5(4.8)	1.0,9.6
North America	1(1.0)	0.0,2.9
Eastern Asia	1(1.0)	0.0,2.9
Study Language		
English	97(93.3)	87.5,98.1
Arabic	3(2.9)	0.0,6.7
Other	4(3.8)	1.0,7.7
Study Period (Years)		
4	1(1.0)	0.0,2.9
5	95(91.3)	84.6,962
6	5(4.8)	0.0,6.7
7	3(2.9)	0.0,2.9
What is the emphasis on antimicrobials in your veterinary school education (non-clinical years)?		
Emphasized in multiple courses	42(40.4)	31.7,50.0
Light emphasis	18(17.3)	10.6,24.0
Covered thoroughly in one course	44(42.3)	32.7,51.0
What is the emphasis on antimicrobials in your veterinary school education (clinical years)		
Emphasized in multiple courses	48(46.2)	36.5,55.8
Light emphasis	18(17.3)	10.6,25.0
Covered thoroughly in one course	38(36.5)	27.9,46.2
What is the background of the person primarily responsible for teaching you about antimicrobials during your veterinary education?		
PhD Pharmacologist/clinical pharmacologist	9(8.7)	3.8,14.4
Master's in veterinary pharmacology	5(4.8)	1.0,9.6
General Veterinarian	90(86.5)	79.8,92.3
Additional post-graduate qualifications		
No	60(57.7)	48.1,67.3
Master	36(34.6)	25.0,43.3
PhD	8(7.7)	2.9,13.5
Have you attended any training courses/conferences to update your knowledge on antimicrobial use and antimicrobial resistance?		
Yes	57(54.8)	46.2,64.4
No	47(45.2)	35.6,53.8
What are the main sources that you use to receive current information on antimicrobials and their use? (Multiple selection)		
Practice policy	53(26.6)	
Textbook/drug handbook	73(36.7)	
Peer-reviewed scientific literature	31(15.6)	
Veterinary medicine directorates	5(2.5)	
Continuing professional development courses	14(7.0)	
Pharmaceutical companies	23(11.6)	
How much do you know about the list of antimicrobials that are prohibited for use in animals, which has been determined by the World Health Organization?		
I Don't Know	8(7.7)	2.9,13.5
Simple knowledge	48(46.2)	37.5,54.8
Quite adequate	48(46.2)	37.5,54.8
I believe that using two or more classes of Antimicrobials together is always a better option to control the infection.		
Yes	41(39.4)	29.8,49.0
Sometimes	47(45.2)	35.6,54.8
No	16(15.4)	8.7,23.1
I believe that broad-spectrum antimicrobials are a better option than using highly selective antimicrobials even when narrow-spectrum medications are available.		
Yes	41(39.4)	29.8,49.0
Sometimes	28(26.9)	19.2,35.6
No	35(33.7)	25.0,43.3

Table 2 (continued)

Variable	Number of Veterinarians, *n* (%)	Confidence interval (95%)
What is your opinion on restricting "priority antimicrobials" to human use only?		
Yes, we avoid using "for human use only" antimicrobials in animals	28(26.9)	19.2,35.6
No, it is not possible to completely avoid these medications	76(73.1)	64.4,80.8
What are the alternatives to antimicrobials (Multiple selection)		
Vaccine	86(33.9)	
Immunostimulants	82(32.3)	
Nutrition	76(29.9)	
Disinfectants	10(3.9)	

Table 3 Factors considered by veterinarians in antimicrobial prescription: results from continuing professional development courses

Continuing professional development courses.				
Item	**Yes**		**No**	
	Responses	**(%)**	**Responses**	**(%)**
The cost of the antibiotic	46	44.2%	11	10.6%
Method of administration	42	40.4%	8	7.7%
Frequency of patient visits	25	24.0%	5	4.8%
Withdrawal Period	64	61.5%	13	12.5%
Regulations and laws	14	13.5%	4	3.8%
Financial benefit and profit	15	14.4%	3	2.9%
Drug Interaction	44	42.3%	7	6.7%
Culture and Sensitivity	27	26.0%	7	6.7%
Distribution in affected tissues	26	25.0%	3	2.9%
Antimicrobial resistance	48	46.2%	9	8.7%

Chi-square = 12.330, ***P*value = 0.264**

used them sometimes. Regarding antimicrobial prescription practices, 69.2% believe that all antimicrobials are prescribed appropriately at their facility, 14.4% feel that some are not prescribed adequately, and 16.3% believe that some are overprescribed. Clinical signs and symptoms are always relied upon by 85.6% of veterinarians when prescribing antimicrobial agents, with 12.5% doing so sometimes. However, only 39.4% had access to well-equipped laboratory facilities for antimicrobial susceptibility testing (ABST), and 60.6% did not. The dependence on laboratory results before prescribing antimicrobial agents is limited, with only 7.7% always relying on them, 70.2% sometimes relying on them, and 22.1% never relying on them. Factors influencing antimicrobial prescription decisions include cost (12.6%), method of administration (11.0%), withdrawal period (17.0%), drug interaction (11.3%), and AMR (12.6%). The analysis reveals significant differences ($P = 0.000$) in the factors influencing antimicrobial prescription across various veterinary practices (Table 5). Veterinarians in mixed practice were more likely to consider factors such as the cost of the antimicrobial (29.8%), withdrawal period (41.3%), and drug interactions (25.0%) compared to those in other fields. In contrast, veterinarians in equine and poultry practices generally considered these factors less frequently, with equine veterinarians particularly showing minimal concern for cost and culture and sensitivity. These results highlight distinct priorities based on the type of practice, indicating that veterinarians in mixed practices face broader decision-making considerations compared to more specialized fields like equine or poultry. Regarding advising farmers on antimicrobial administration, 27.9% never did so over the phone, 68.3% did so sometimes, and 3.8% always did so. Writing antimicrobial prescriptions for farmers without seeing their animals sometimes occurs for 33.7% of veterinarians, 27.9% always do so, and 38.5% never do so. After the first treatment, 92.3% of veterinarians required subsequent antimicrobial agents. Farmer cooperation in completing the full course of antimicrobials was reported as "sometimes" by 48.1% of veterinarians, "yes" by 33.7%, and "no" by 18.3%. Client adherence to following prescribed antimicrobial-specific instructions provided by veterinarians regarding AMU, including dosage, application, and withdrawal period varied, with 28.8% adhering 41–60% of the time, 25.0% adhering 61–80% of the time, and 12.5% adhering 81–100% of the time (Table 4).

Monitoring and regulation of AMU in the veterinary sector

The data highlights the ongoing concerns and practices related to AMU in the veterinary sector (Table 6). A significant majority of respondents (76.0%) acknowledged the ongoing abuse of antimicrobials, with 20.2% indicating that it occurs sometimes. One respondent shared, "In

Table 4 Antimicrobial prescription and usage practices of surveyed veterinarians in Palestine 2024

Variable	Number of Veterinarian, *n* (%)	Confidence interval (95%)
Do you feel that you sometimes overprescribe antimicrobials?		
Yes	16(15.4)	9.6,23.1
Sometimes	21(20.2)	12.5,27.9
No	67(64.4)	55.8,74.0
On average, how often are antimicrobials used in the cases you deal with in your practice?		
< 20	4(3.8)	1.0,7.7
20–40	18(17.3)	10.6,25.0
41–60	43(41.3)	31.7,51.9
61–80	38(36.5)	27.9,46.2
81–100	1(1.0)	0.0,2.9
Can you prescribe antimicrobials without additional supervision, approval or supervision?		
Yes	28(26.9)	18.3,35.6
Sometimes	46(44.2)	34.6,54.8
No	30(28.8)	20.2,37.5
Are antimicrobials used for prevention?		
Yes	15(14.4)	7.7,21.2
Sometimes	33(31.7)	23.1,41.3
No	56(53.8)	44.2,63.5
What is your estimate regarding antimicrobial prescription at your facility or clinic?		
Some antimicrobials are not prescribed adequately	15(14.4)	7.7,21.2
Some antimicrobials are overprescribed	17(16.3)	9.6,23.1
All antimicrobials are prescribed appropriately	72(69.2)	60.6,77.9
Do you always rely on clinical signs and symptoms when prescribing an antimicrobial?		
Yes	89(85.6)	78.8,92.3
Sometimes	13(12.5)	6.7,19.2
No	2(1.9)	0.0,4.8
Is there a well-equipped laboratory facility to perform antimicrobial susceptibility testing (ABST) in or near your location?		
Yes	41(39.4)	29.8,49.0
No	63(60.6)	51.0,70.2
Do you depend on laboratory results before prescribing an antimicrobial?		
Yes	8(7.7)	2.9,13.5
Sometimes	73(70.2)	60.6,79.8
No	23(22.1)	14.4,29.8
Do any of the factors below affect your decision when choosing to prescribe an antimicrobial to a patient? (Select All that Apply) (*n* = 435)		
The cost of the antimicrobial	57(12.6)	
Method of administration	50(11.0)	
Frequency of patient visits	30(6.6)	
Withdrawal Period	77(17.0)	
Regulations and laws	18(4.0)	
Financial benefit and profit	18(4.0)	
Drug Interaction	51(11.3)	
Culture and Sensitivity	34(7.5)	
Distribution in affected tissues	29(6.4)	
Antimicrobial resistance	57(12.6)	
It is often the case that antimicrobials are not justified in a condition, but the client insists that they are needed	20(4.4)	
Recommendations from other veterinarians	12(2.6)	
How often do you advise a farmer to administer antimicrobials over a phone conversation?		
I don't do that	29(27.9)	20.2,37.5
Sometimes	71(68.3)	58.7,76.9
Always	4(3.8)	1.0,7.7
Do you write antimicrobial prescriptions for farmers who come to your workplace without bringing their animals?		

Table 4 (continued)

Variable	Number of Veterinarian, *n* (%)	Confidence interval (95%)
Yes	29(27.9)	19.2,36.5
Sometimes	35(33.7)	25.0,42.3
No	40(38.5)	29.8,48.1
Do you require the farmer to administer subsequent doses of antimicrobials after the first dose of treatment?		
Yes	96(92.3)	86.5,97.1
No	8(7.7)	2.9,13.5
Do farmers cooperate in completing the course of antimicrobials you have specified?		
Yes	35(33.7)	25.0,42.3
Sometimes	50(48.1)	38.5,57.7
No	19(18.3)	11.5,26.0
In your opinion, what percentage of your clients adhere to prescribed antimicrobial instructions?		
< 20	20(19.2)	11.5,26.9
20–40	15(14.4)	8.7,22.1
41–60	30(28.8)	20.2,38.5
61–80	26(25.0)	16.4,33.7
81–100	13(12.5)	6.7,19.2

Table 5 Influence of veterinary practice type on antimicrobial prescription decisions

Veterinary Practice										
Item	**Farm Animals**		**Small Animals**		**Equine**		**Poultry**		**Mix**	
	Responses	**(%)**	**Responses**	**(%)**	**Responses**	**(%)**	**Responses**	**(%)**	**Responses**	**(%)**
The cost of the antibiotic	13	12.5%	6	5.8%	1	1.0%	6	5.8%	31	29.8%
Method of administration	6	5.8%	11	10.6%	4	3.8%	3	2.9%	26	25.0%
Frequency of patient visits	2	1.9%	6	5.8%	2	1.9%	0	0.0%	20	19.2%
Withdrawal Period	22	21.2%	4	3.8%	2	1.9%	6	5.8%	43	41.3%
Regulations and laws	4	3.8%	4	3.8%	1	1.0%	0	0.0%	9	8.7%
Financial benefit and profit	2	1.9%	1	1.0%	0	0.0%	0	0.0%	15	14.4%
Drug Interaction	11	10.6%	8	7.7%	2	1.9%	4	3.8%	26	25.0%
Culture and Sensitivity	7	6.7%	5	4.8%	0	0.0%	4	3.8%	18	17.3%
Distribution in affected tissues	5	4.8%	8	7.7%	2	1.9%	1	1.0%	13	12.5%
Antimicrobial resistance	16	15.4%	6	5.8%	3	2.9%	5	4.8%	27	26.0%

Chi-square = 88.617, *P* value = 0.000

some cases, farmers insist on using antibiotics for conditions that don't require them, due to a lack of awareness or fear of losing livestock. Only 3.8% believed there was no abuse. Furthermore, 71.2% of respondents felt that there was no adequate supervision over the AMU, while only 28.8% believed that there was. In terms of policies regarding antimicrobial prescriptions, 59.6% of veterinarians reported having a policy in place, whereas 40.4% did not. A respondent from a clinic explained, "We have a policy, but it's not followed strictly, especially when dealing with farmers who are resistant to changing old practices." The assessment of antimicrobial prescription practices among colleagues outside their facility or clinic revealed that 70.2% of respondents felt that some antimicrobials were overprescribed, 16.3% believed that some were not prescribed adequately, and 13.5% thought that all antimicrobials were prescribed appropriately. Nearly 100% of respondents observed that farmers can obtain antimicrobial agents directly from pharmacies without a veterinarian's prescription, highlighting a significant gap in regulation. A participant emphasized, "Many farmers buy antibiotics over the counter without consulting a vet, which is a major driver of misuse."

When asked about their responsibility for the irrational use of antimicrobials at the field level, 38.5% of the respondents pointed to farmers, 35.1% to interlopers, and 26.4% to veterinarians. Regarding the monitoring of AMU, 30.8% of respondents identified the Ministry of Agriculture as responsible, followed by the Veterinary Syndicate (26.0%), the Ministry of Health (25.6%), and Consumer Protection (Palestinian Ministry of Economy) (17.6%). These data underscore the need for enhanced supervision, clearer policies, and better enforcement

Table 6 Veterinarians' perspectives on the monitoring and regulation of antimicrobial use in the veterinary sector in Palestine, 2024

Variable	Number of Veterinarian, *n* (%)	Confidence interval (95%)
Is there ongoing abuse of antimicrobials in treatments in the veterinary sector?		
Yes	79(76.0)	66.3,84.6
Sometimes	21(20.2)	12.5,28.8
No	4(3.8)	1.0,7.7
Do you think there is supervision over the use of antimicrobials?		
Yes	30(28.8)	20.2,36.5
No	74(71.2)	63.5,79.8
Does your facility or veterinary practice have a policy regarding antimicrobial prescription?		
Yes	62(59.6)	50.0,69.2
No	42(40.4)	30.8,50.0
What is your assessment regarding antimicrobial prescription for colleagues in general outside your facility or clinic?		
Some antimicrobials are not prescribed adequately	17(16.3)	9.6,23.1
All antimicrobials are prescribed appropriately	14(13.5)	7.7,21.2
Some antimicrobials are overprescribed	73(70.2)	61.5,78.8
I have noticed that farmers get antimicrobials directly from the pharmacy without needing a prescription from a veterinarian.		
Yes	104(100)	100,100
No	0(0.0)	0.0,0.0
Who do you think is responsible for the irrational use of antimicrobials in animals at the field level (select all that apply)? (*n* = 239)		
Veterinarians	63(26.4)	
Farmers	92(38.5)	
Interlopers	84(35.1)	
Who do you think is responsible for monitoring the use of antimicrobials in animals at the field level (select all that apply)? (*n* = 273)		
Ministry of Agriculture	84(30.8)	
Ministry of Health	70(25.6)	
Veterinary Syndicate	71(26.0)	
Consumer Protection (Palestinian Ministry of Economy)	48(17.6)	

to curb the misuse of antimicrobial agents in veterinary practice (Table 6).

Knowledge, attitudes, and practices toward AMR

Most veterinarians in Palestine (99.0%) recognize AMR as a serious public health problem. A majority (82.7%) attributed resistance to human activities, with 11.5% citing natural causes and 5.8% noting both factors. Improper prescription habits were seen as contributing to resistance by 81.7% of veterinarians. Over half (52.9%) reported an increase in AMR in their facilities, while 32.7% were uncertain, and 14.4% did not experience an increase. All respondents agreed that improper AMU use contributes to resistance. Additionally, 61.5% of respondents believed that the use of expired antimicrobials contributes to the emergence of AMR, while 38.5% disagreed. A large majority (97.1%) believe that antimicrobial residues in milk and meat contribute to resistance. Regarding human exposure to resistant bacteria, 40.3% pointed to contact with animal products, followed by contact with animals (20.3%), the environment (17.7%), humans (14.3%), and plants (7.4%). More than half (54.8%) of the respondents had received training on AMU and AMR. Finally, 46.2% believe that prescribing policies help manage AMR, while the same percentage indicates that no policy exists, and 7.7% see no policies effect (Table 7).

Veterinarians' recommendations on combating AMR in the animal husbandry sector: Open-ended question response

The respondents were asked to provide the best suggestions to AMU and combat AMR. In many cases, the suggestions overlapped, and duplicate suggestions were removed (Table 8). These recommendations provide a comprehensive and structured approach for policymakers to effectively address AMU and AMR through education, regulation, public awareness, research, and enforcement measures.

Discussion

This study used a survey questionnaire to investigate the antimicrobial prescription practices and opinions of Palestinian veterinarians regarding AMU and the development of AMR. The findings highlight several challenges faced by veterinarians, including limited regulatory oversight, inconsistent training, and reliance on clinical judgment due to restricted laboratory access. These challenges complicate the effort to balance effective disease control with minimizing the spread of resistant bacteria.

Palestinian veterinarians face significant difficulties in reducing reliance on priority antimicrobials. While most recognize AMR as a serious public health issue, many believe that avoiding priority antimicrobials entirely is not feasible due to a lack of viable alternatives. Limited access to advanced diagnostics and financial constraints further restrict their ability to adopt alternative treatment strategies [17]. The perception of defective regulations and inadequate supervision over AMU, coupled with unrestricted antimicrobial sales, contributes to the misuse and overprescription of antimicrobial agents.

The study reveals inconsistencies in veterinarians' training on antimicrobial stewardship, leading to variable prescription practices. Many practitioners rely primarily on clinical signs for prescribing antimicrobial agents, often without laboratory confirmation, which increases the risk of unnecessary or inappropriate antimicrobial

Table 7 Opinions of surveyed veterinarians on the role of antimicrobial use in the development of antimicrobial resistance, in Palestine 2024

Variable	Number of Veterinarian, *n* (%)	Confidence interval (95%)
Is antimicrobial resistance a serious public health problem?		
Yes	103(99.0)	97.1,100.0
No	1(1.0)	0.0,2.9
In your opinion, is antimicrobial resistance a natural or human phenomenon?		
Human	86(82.7)	74.0,89.4
Natural	12(11.5)	5.8,18.3
Interaction with both	6(5.8)	1.9,10.6
Improper prescription habits among your colleagues influence the selection of antimicrobial resistance in your facility.		
Yes	85(81.7)	74.0,89.4
No	19(18.3)	10.6,26.0
There has been an increase in the number of antimicrobial resistance cases in your facility or practice.		
Yes	55(52.9)	43.3,61.5
Maybe	34(32.7)	24.0,41.3
No	15(14.4)	7.7,21.2
Improper use of antimicrobials contributes to increased antimicrobial resistance.		
Yes	104(100)	100.0,100.0
No	0(0)	0.0,0.0
In your opinion, does the use of expired antimicrobials lead to the emergence of resistance?		
Yes	64(61.5)	51.9,70.2
No	40(38.5)	29.8,48.1
Do antimicrobial residues in milk/meat lead to the emergence of antimicrobial resistance?		
Yes	101(97.1)	93.3,100.0
No	3(2.9)	0.0,6.7
What do you think about possible routes of human exposure to resistant bacteria? (Multiple selection) (*n* = 231)		
Environment	41(17.7)	
Contact with Animals	47(20.3)	
Contact with Animals Products	93(40.3)	
Contact with Plants	17(7.4)	
Contact with Human	33(14.3)	
Have you attended any training courses/conferences to update your knowledge on antimicrobial use and antimicrobial resistance?		
Yes	57(54.8)	45.2,64.4
No	47(45.2)	35.6,54.8
Are antimicrobial prescribing policies contributing to changing the pace of antimicrobial resistance in your facility or practice?		
Yes	48(46.2)	2.9,13.5
No Policy	48(46.2)	35.6,55.8
No	8(7.7)	36.5,57.7

use [18]. Addressing these gaps requires integrating antimicrobial stewardship principles into veterinary curricula, including practical training on diagnostic tools and responsible prescription practices [19]. Additionally, continued professional education programs should be implemented to update veterinarians on emerging AMR mitigation strategies [20].

Beyond medical considerations, veterinarians' antimicrobial prescription choices are influenced by economic and social factors. Cost is a major determinant, with many farmers prioritizing affordability over efficacy [21]. The withdrawal period of antimicrobials also plays a crucial role, as longer withdrawal times can result in financial losses for livestock farmers, discouraging adherence to proper AMU protocols [22]. Moreover, veterinarians often face pressure from farmers to prescribe antimicrobials based on prior experiences rather than professional recommendations. Weak regulatory enforcement further exacerbates the issue, allowing farmers to obtain and use antimicrobials without veterinary consultation.

International antimicrobial stewardship programs (ASPs), such as those in Australia, have demonstrated success in reducing AMU. For example, veterinary clinics in Australia saw antimicrobial prescribing rates decrease by 36% during ASP implementation and by 50% post-implementation [19]. However, directly applying such models in Palestine is challenging due to differences in regulatory frameworks, economic constraints, and limited access to diagnostic facilities. While mandating laboratory-based prescriptions may not be feasible for many Palestinian veterinary practices, key aspects of ASPs—such as mandatory veterinary training, stricter prescription policies, and public awareness campaigns—can be adapted to focus on cost-effective, locally viable solutions.

Addressing AMR requires a comprehensive One Health strategy that integrates human, animal, and environmental health sectors [23]. Strengthening collaborations among veterinarians, medical professionals, policymakers, and agricultural stakeholders is essential for developing sustainable AMU guidelines. Establishing robust surveillance systems to monitor AMU and AMR patterns at both the local and national levels would provide crucial data to inform policy decisions [24]. Given Palestine's unique challenges, a locally adapted One Health framework could help balance livestock health, food security, and AMR control [14].

To mitigate AMR risks, several key actions should be prioritized: enhancing veterinary education and training includes updating veterinary curricula to include antimicrobial stewardship and mandatory clinical training on AMU. Implementing stricter policies to regulate antimicrobial prescriptions and prevent unauthorized antimicrobial sales. Increasing access to well-equipped

Table 8 Survey responses: veterinarian recommendations to antimicrobial use and combat antimicrobial resistance in Palestine, 2024

Category	Recommendations
Education and Training	- Organize training courses and workshops for healthcare professionals, farmers, and veterinarians.
	- Educate veterinarians on the One Health approach.
	- Distribute guidelines on the proper use of antimicrobials.
	- Implement sensitivity testing before prescribing antimicrobials.
	- Provide specialized training and workshops for healthcare and agricultural professionals.
	- Ensure prescriptions are based on laboratory results and penalize unauthorized practitioners.
Regulation and Oversight	- Monitor and regulate the use of antimicrobials in animal-based products.
	- Strengthen awareness, strict supervision, and impose sanctions for misuse.
	- Enforce laws against the sale of antimicrobials without prescriptions.
	- Require sensitivity tests before prescribing antimicrobials.
	- Establish veterinary labs for disease identification and treatments.
	- Conduct workshops to educate stakeholders on risks and proper practices.
	- Intensify testing for antimicrobial residues in animal products.
	- Ensure accessible and affordable sensitivity testing facilities.
	- Restrict antimicrobial distribution to licensed veterinarians with strict penalties for violations.
Public Awareness and Collaboration	- Promote organic farming and immune boosters to reduce antimicrobial use.
	- Educate on the risks of antimicrobial resistance and the importance of proper use.
	- Collaborate globally to share best practices and reduce misuse.
Research and Development	- Invest in research for antimicrobial alternatives and resistance mechanisms.
	- Support the development of vaccines and non-antimicrobial treatments for animal diseases.
Enforcement and Compliance	- Monitor and enforce compliance with antimicrobial regulations through audits and inspections.
	- Establish a pharmacovigilance center to monitor antimicrobial use and detect adverse effects.

laboratories for antimicrobial susceptibility testing to support evidence-based prescriptions. Introducing veterinarian training programs and public awareness initiatives before transitioning to stricter regulatory controls. Strengthening One Health Collaboration by facilitating interdisciplinary cooperation to develop and implement sustainable AMR mitigation strategies.

Conclusion

A survey of veterinarians in Palestine highlighted significant issues related to AMU and AMR. The predominantly male respondents, mainly practicing in mixed animal and farm animal settings, indicate a robust veterinary practice landscape. However, antimicrobial training is inconsistent, and many veterinarians lack advanced degrees. There is considerable reliance on clinical signs for prescribing antimicrobial agents, with limited access to laboratory testing facilities, leading to potential misuse and overprescription. The respondents recognized AMR as a critical public health issue, largely because of improper prescription practices. The findings underscore the need for enhanced supervision, education, and stricter regulations on AMU. Recommendations include mandatory sensitivity tests before prescribing, increased training and awareness programs, better veterinary oversight, and rigorous enforcement of policies to prevent unauthorized antimicrobial sales. To combat AMR effectively, it is essential to implement these recommendations, promote responsible AMU, and ensure that veterinary practices are supported by comprehensive training and robust regulatory frameworks. This approach will help safeguard public health, animal health, and the effectiveness of antimicrobial agents for future generations. This study analyzes the variable responses of veterinarians from specific regions, which may limit the generalizability of the findings. Self-reported data could also be subject to recall or social desirability bias. Despite these limitations, the study provides valuable insights into veterinary AMU and AMR stewardship in Palestine.

Methods

Study population and sample size

The source population of the present study comprised registered veterinarians ($n = 358$) at the Palestinian Veterinarians Syndicate (https://www.palvet.ps/) at the end of 2023. The questionnaire was sent to veterinarians through registered social media groups from professional societies and personal contacts. The questionnaire was administered via Google Forms (Google LLC, Mountain View, CA, USA), and the survey remained open from May 30, 2024, to July 15, 2024.

Questionnaire administration

A structured and validated questionnaire, previously utilized in similar studies targeting veterinarians, was administered via Google Forms (https://www.google.com/forms) (Additional File 1). The initial draft of the questionnaire was developed in English, and the final version

was translated into Arabic (Additional File 1). The questionnaire was divided into six sections: (1) Sociodemographic characteristics and education (2), Knowledge and attitudes toward AMU (3), Antimicrobial prescription practices, education, and perspectives (4), Monitoring and regulation of AMU in the veterinary sector (5), Knowledge, attitudes, and practices toward AMR (6), Open-ended questions for veterinarians' recommendations on combating AMR in the animal husbandry sector. Two expert researchers reviewed the first draft of the questionnaire to identify ambiguities and assess content validity. The questionnaire was subsequently piloted with ten veterinarians to evaluate its duration, clarity, and logical sequence. The final questionnaire contained 53 questions.

Statistical analysis

The completed questionnaires were reviewed for data quality before coding in Microsoft® Office Excel 365. The data were meticulously coded, entered, and cleaned before being analyzed using SPSS version 21.0 software (SPSS Inc., Chicago, IL, USA). Descriptive statistics, including frequencies, percentages, and confidence intervals (CIs), were used to summarize the data. The chi-square test was employed to examine associations between key categorical variables, such as the relationship between veterinary practice and training received with antimicrobial prescription practices. Statistical significance was determined at a p-value < 0.05.

Abbreviations

AMU	Antimicrobial use
AMR	Antimicrobial resistance
ABST	Antimicrobial susceptibility testing
AMDUCA	Animal Medicinal Drug Use Clarification Act
ASPs	Antimicrobial stewardship programmes
CI	Confidence interval
FAO	Food and Agriculture Organization of the United Nations
KAP	Knowledge, attitudes, and practices
P value	Probability value
%	Percentage. SPSS: Statistical Package for the Social Sciences
WHO	World Health Organization
WOAH	World Organisation for Animal Health
UNEP	United Nations Environment Program

Supplementary Information

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Supplementary Material 1

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Author contributions

IA, AF, and AT were all involved in the design of the study; IA and AF collected data. IA and AF analyzed the data. IA drafted the manuscript. AT and AF revised the manuscript; and all authors approved the final manuscript.

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Data availability

Data is provided within supplementary information files.

Declarations

Ethical approval and consent to participate

Ethical review and approval of this questionnaire were granted by the Palestinian Veterinarians Syndicate Ethics Committee via an ethics review application (Ethics approval number: 18-5-24) issued on 29/05/2024. The nature of the study was voluntary, and informed consent was obtained from the study participants. The details of the participants were anonymous, and data confidentiality was properly maintained.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Department of Veterinary Medicine, Faculty of Veterinary Medicine and Agriculture Engineering, An-Najah National University, P.O. Box 7, Nablus, Palestine
[2]Department of Veterinary Medicine, Faculty of Agriculture and Veterinary Medicine, Al-Azhar University, Gaza Strip, Palestine
[3]Thabet Center for Veterinary Services Diagnostic Laboratory, Gaza Strip, Palestine

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