

The role of veterinarians in the One Health approach to antimicrobial resistance perspectives in Jordan



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Abstract

This study aims to evaluate the role of Jordanian veterinarians in terms of their knowledge, attitudes and common practices in combating antimicrobial resistance (AMR) and summarize the registered veterinary drugs between 2017–2020. Descriptive study data were collected using a standardized questionnaire that focused on the knowledge, attitudes, and practices of Jordanian veterinarians. The findings were analyzed descriptively; 84% of the participants agreed with the statement on the definition of AMR. The majority (95.65%) of participants agreed that AMR is a challenge for the veterinary sector in Jordan and that it should be prioritized over other zoonotic diseases. Approximately 69% of the participants believed that the misuse and overuse of antimicrobials by unqualified, fraudulent, or unauthorized practitioners is the primary reason for the rise of cases associated with AMR and the challenges that accompany these. The most common practice among the respondents in this study was to recommend clients (e.g., farmers and owners) to practice good animal husbandry (80.00%). The study also revealed that there was a significant difference ($p = 0.015$) between attendance at AMR training sessions and the professional sector (private, public, and academic) of the veterinarians. This study underscores the importance of implementing a continuous education program on AMR so as to enhance the all-round knowledge of veterinarians and improve their advisory skills. In addition, laws should be enacted to ensure that veterinarians prescribe the correct antimicrobials and to improve surveillance systems for monitoring the use of antimicrobials in veterinary medicine.

Keywords: Antimicrobial resistance, Veterinarian, Knowledge, Practices, Attitudes, Jordan

Introduction

Antimicrobials, including antibiotics, antivirals, antifungals, and antiparasitics, are used to prevent and treat infections in humans, animals, and plants.¹ Microbes can become resistant to antimicrobials as a result of ineffective or prolonged antimicrobial treatment. This resistance may be “innate” owing to the slow and long evolutionary

process that microorganisms undergo to adapt to changing environmental conditions; this adaptation is based on the permeability of the bacterial cell to antibiotic molecules. Resistance can also be acquired through “rapid” adaptation to a sudden selection pressure such as resulting from antimicrobial treatment (Palma et al., 2020). When bacteria become resistant to most antimicrobials, they are often referred to as “superbugs.”²

¹An update on the fight against antimicrobial resistance. World Health Organization. <https://www.who.int/news-room/feature-stories/detail/an-update-on-the-fight-against-antimicrobial-resistance>. Accessed 6 March 2021

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²Antimicrobial resistance. World Health Organization. https://www.who.int/topics/antimicrobial_resistance/en/. Accessed 6 March 2021



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Antimicrobials are extensively used for the control and prevention of diseases in both human and veterinary medicine worldwide.³ Since 1950, antimicrobials have been used as growth promoters in livestock, using subtherapeutic doses to increase the growth and feed efficiency of animals while simultaneously reducing mortality (Starr and Reynolds, 1951). In 1951, the addition of streptomycin as a growth promoter resulted in three strains of streptomycin-resistant coliform bacteria (Starr and Reynolds, 1951). This evolution was caused by the bacteria's evolutionary machinery, which used its genomic flexibility to better adapt to the environment, including the ability to protect itself from toxic substances (Palma et al., 2020).

This study was conducted to assess the role of Jordanian veterinarians in combating antimicrobial resistance (AMR) in terms of their knowledge, attitudes, and common practices. A list of veterinary antimicrobials that are currently available in the market was also obtained to identify potential risk factors that may lead to the development and spread of AMR in food-producing animals.

Results

Knowledge, attitudes, and practices survey results

Demographic information

From the demographic information of the participants (Table 1), most veterinarians were found to be residing in Jordan during the survey period ($n = 101/115$, 87.83%). Approximately 72% ($n = 83/115$) of participants had an academic degree in veterinary medicine and surgery, whereas the remaining participants had a PhD. Most participating veterinarians were employed in the private sector ($n = 65/115$, 56.52%), with only 6.09% ($n = 7/115$) being unemployed. In terms of experience, half of the participants had 1–5 years of experience in the field ($n = 58/115$, 50.43%), whereas 4.348% ($n = 5/115$) had more than 30 years of experience.

Approximately 29% of the participants reported treating more than one type of animal, namely birds, horses, cats and dogs, food, and wildlife ($n = 33/115$, 28.69%), with 20.87% ($n = 24/115$) and 19.13% ($n = 22/115$) involved particularly in the treatment of food animals and companion animals (cats and dogs), respectively.

Knowledge

The knowledge of participants regarding AMR was assessed using six statements associated with the definition of antimicrobials and AMR and the role of veterinarians with respect to their use. All six statements were correct (Table 2). Most participants agreed that

Table 1 The demographic information of the participants

Variable	Response	Freq. (n=115)	Pct. (%)
Resident in Jordan	Yes	101	87.83%
	No	14	12.17%
Education level	Bachelor	83	72.17%
	Masters	24	20.87%
	PhD	8	6.96%
Vocational sector	Private sector	65	56.52%
	Public Sector	21	18.26%
	Academic	12	10.43%
	Other	1	0.87%
	Unemployed	7	6.09%
	Multiple sectors	7	6.09%
	Prefer Not to answer	2	1.74%
Years of experience	1-5	58	50.43%
	6-10	0	0.00%
	11-15	28	24.35%
	16-20	14	12.17%
	21-25	9	7.83%
	>30	5	4.348%
	Prefer not to answer	1	0.870%
Specialty	Avian	16	13.91%
	Equine	4	3.48%
	Feline and Canine	22	19.13%
	Food animal practice	24	20.87%
	Mix practices (wild Animal included)	33	28.69%
	Other	13	11.00%
	Prefer not to answer	3	2.609%

Note. ^aFreq. frequency, ^b Pct percentage

AMR occurs when a microbe evolves to become increasingly resistant to an antibiotic drug that it could have previously been treated with (98.26%). Most veterinarians (96.52%) agreed that the overuse of antibiotics in livestock poses a danger to humans. Moreover, 79.13% of participants agreed that antimicrobials contribute to food safety and public health, and 75.65% of participants agreed that human–animal contact leads to the cross-transmission of AMR. In terms of the position of AMR in the ecosystem, 17.39% disagreed that microorganisms are a pool for AMR (Table 2); overall, 84% agreed with this statement, 7.03% provided a neutral response, and 9.04% disagreed.

Attitudes

Before assessing the attitudes of the participants, they were asked if they considered AMR to be a challenge to

³Joint Opinion on antimicrobial resistance (AMR) focused on zoonotic infections. Brussels: European Medicine Agency. Accessed 6 March 2021

Table 2 Knowledge of veterinarians regarding antibiotic use and resistance

Question	Agree Freq. ^a (n=115)	Pct% ^b	Neutral Freq. ^a (n=115)	Pct % ^b	Disagree Freq. ^a (n=115)	Pct % ^b
Antimicrobial resistance (AMR) is when a microbe evolves to become more resistant to antimicrobial which previously could treat it. Antimicrobials include antibiotics, which kill or inhibit the growth of bacteria.	113	98.26%	1	0.87%	1	0.87%
Use of veterinary medicinal products, including antimicrobial agents, is essential for protecting animal health and welfare, and contributes to food safety and public health.	91	79.13%	16	13.91%	8	6.96%
Microorganisms represent a pool of antimicrobial resistance (AMR) traits in all ecological niches.	79	68.70%	16	13.61%	20	17.39%
The excessive use of antimicrobial in livestock (and aquaculture) will pose a threat to people's livelihoods.	111	96.52%	3	2.61%	1	0.87%
The increased contact between animals and human beings lead to a higher risk of infections and the cross-transmission of AMR traits.	87	75.65%	6	5.22%	22	19.31%

Note. The citations of the mentioned statements can be requested from the author. ^aFreq. frequency, ^b Pct percentage

the veterinary industry. The survey revealed that 95.65% of the participants considered AMR to be a challenge and believed that health authorities should prioritize AMR over other zoonotic diseases such as brucellosis and rabies. In addition, 53% of the participants indicated that vaccination is essential for the control of microbial infections in Jordan, followed by implementing biosecurity measures, controlling feed and water contamination, and the administration of probiotics (at 42%, 13%, and 4%, respectively). To assess the attitudes of participants, they were asked about the challenges they faced in controlling AMR (Fig. 1). Overall, 68.70% of participants believed that the misuse and overuse of antimicrobials by unqualified, fraudulent, or unauthorized practitioners, such as agricultural engineers, is a major challenge to controlling the AMR problem in Jordan, followed by the socioeconomic status of clients (39.13%). Moreover, the attitude of the Jordanian society toward veterinarians in addressing the AMR problem, as well as a lack of satisfactory knowledge, skills, and practices among local veterinarians in terms of using alternatives to antimicrobials were the factors that contributed the least, i.e., were minor challenges to the control of AMR, at 34.78 and 33.04%, respectively.

Practices

To assess the common practices in relation to AMR, participants were presented with nine statements regarding their prescription of antimicrobials and recommendations to clients (e.g., farmers and livestock owners; Tables 3 and 4). The most common practice was to recommend the practice of good animal husbandry to clients (80.00%), followed by the administration of the correct dose of antimicrobials by taking the waiting time into consideration (66.09%), and the prescription of

antimicrobials for therapeutic purposes (63.48%). More than half (60%) of the participants reported that they always recommended clients to wash their hands frequently after handling animals (60%); whereas 56.52% encouraged clients to reduce their dependence on such drugs, other than prescribing them in accordance with the World Organisation for Animal Health (OIE) list of antimicrobials; and 50.43% educated clients about the benefits of using alternatives to veterinary antimicrobials (e.g., phytogenics) and that antimicrobials should not be their first choice for treatment.

Some participants (36.52%) did not commit to continuing their education with respect to antibiotic resistance to increase their knowledge and implement good antibiotic use practices, whereas 32.17% were committed to these principles. A small percentage of participants indicated that they were satisfied with the veterinary and animal health services provided by the private and public sectors, as well as other related organizations, to combat the problem of AMR in Jordan (3.48%), whereas 38.26% of participants were not at all satisfied with the services provided. Overall, 11.88% of participants had never dealt with antibiotic use or resistance issues, whereas 4.45% rarely, 14.01% sometimes, 17.58% frequently, and 51.98% always experienced these issues.

The relationship between participation in AMR continuing education and the participants' professional sector

The chi-squared test results about relationship between participation in AMR continuing education (categorized as "rarely to sometimes" or "frequently to always") and professional sector (i.e., private, public, or academic) revealed a significant difference: participation differed

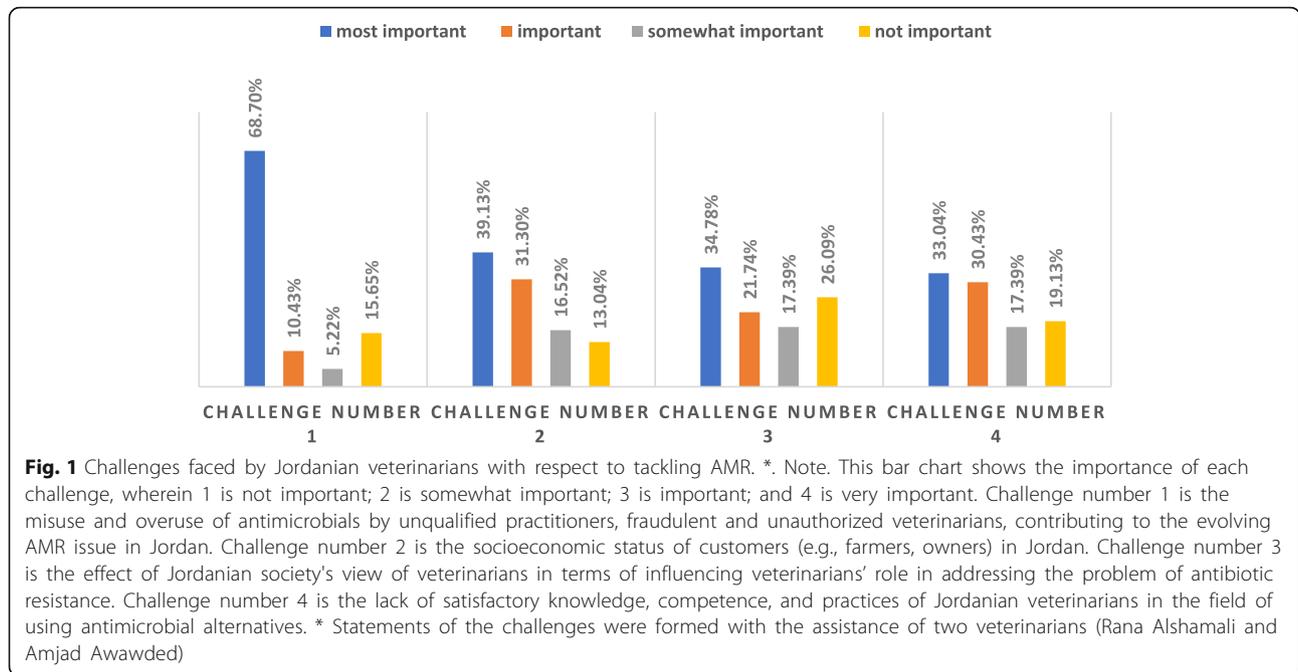


Table 3 Practices of veterinarians regarding antibiotic use and resistance

Question	Never	Rarely	S.t ^a	Freq. ^b	Always
You prescribe antimicrobial drugs only when they are needed to treat an animal medical condition after a clinical examination, i.e., for therapeutic purposes.	2.61%	0.87%	8.70%	24.35%	63.48%
You recommend the customers (farmers, owner.) to practice good animal husbandries such as biosecurity and hygiene.	4.35%	0.87%	5.22%	9.57%	80.00%
You make sure that the specific antimicrobial product you use is the most appropriate one for that purpose, with taking into consideration the World Organization for Animal Health OIE list of antimicrobials	6.09 %	5.22%	10.43%	21.74%	56.52%
You administer to the patient the correct dose with the correct frequency and duration, by an appropriate route and treatment protocol considering the withdrawal period.	4.35%	0.00%	7.83%	21.74%	66.09%
You explain to the customer's (farmers, owners...) that antimicrobial are not our first choice, and the alternatives to veterinary antimicrobial are also effective.	4.35%	1.74%	22.61%	20.87%	50.43%
You recommend the customer (farmers, owners...) to wash their hands frequently after dealing with animals.	6.96%	3.48%	15.65%	14.78%	59.13%
You committed to empowering the customers (farmers, owners...) to reduce reliance on antimicrobial with at least equal, or improved, animal health, welfare, and profitability.	3.48%	2.61%	16.52%	20.87%	56.52%
You train yourself with continual education material in antimicrobial resistance (AMR) to expand your knowledge, to implement good practices of antimicrobial use	36.52%	6.96%	10.43%	13.91%	32.17%
Your level of satisfaction from the veterinary and animal health services, which are provided by private and public sectors and associations, in tackling the antimicrobial resistance (AMR) issue in Jordan.	38.26%	19.13%	28.70%	10.43%	3.48%

Note. The citations of the mentioned statements can be requested from the author. ^aS.t. sometimes, ^bFreq. frequently

Table 4 The percentage of the registered veterinary pharmaceutical products between 2017 and 2020

Pharmaceutical drug's active substance class	Produced (per year)				Imported (per year)			
	2017	2018	2019	2020	2017	2018	2019	2020
Antibiotic (Per Oral)	19.09%	32.67%	23.35%	15.38%	16.36%	10.66%	16.16%	16.48%
Antibiotic (Parenteral)	4.55%	2.67%	15.57%	2.20%	26.36%	8.66%	17.96%	25.27%
Antibiotic (Intramammary)	0.00%	0.67%	1.20%	0.00%	2.73%	0.66%	0.00%	0.00%
Antiparasitic	16.36%	27.33%	15.57%	26.37%	13.64%	15.33%	9.58%	14.28%
Alternatives to antibiotics	0.00%	1.33%	0.60%	0.00%	0.91%	0.00%	0.00%	0.00%

Note. The original data were adapted from the registered veterinary products reports for each year, with the permission of JVA

depending on the professional sector of the participants ($df = 2$, $N = 98$; $X^2 = 8.34$, $p = 0.015$).

The percentage of registered and newly registered veterinary pharmaceutical drugs between 2017 and 2020

The analyzed data obtained from reports is categorized in Table 5 according to the class of each drug/year. During this period, the percentage of registered oral antibiotics was higher for produced drugs, with a peak in 2018 (32.67%); similarly, the percentage of both registered imported and produced oral antibiotics was also noted to be the highest in 2018 (43.3%; Fig. 3). In contrast, the percentage of registered parenteral antibiotics was higher for registered imported drugs, ranging from 8.66% to 25.27%, whereas that of produced drugs ranged from 2.20% to 15.57%. The percentage of produced intramammary antibiotics ranged from 0.00% to 1.33%, and the percentage of imported intramammary antibiotics ranged from 0.00% to 0.91%.

As for antiparasitic drugs, the highest level of imported veterinary drugs was registered in 2018, accounting for an average of 27.4% between 2017 and 2020 (Fig. 2), whereas the highest percentage of both registered imported and produced drugs (42.7%) was noted in 2018 (Fig. 3). Moreover, the average percentage of registered produced medicines between 2017 and 2020 was 32.3% (Fig. 2).

Phytobiotics, which are alternatives to antibiotics, accounted for the lowest average percentage of registered veterinary pharmaceutical products for both produced and imported products, at 1.1% and 0.4%, respectively (Fig. 2).

Discussion

The present study focused on the knowledge, attitudes, and practices (KAP) of Jordanian veterinarians in combating AMR. In doing so, the data of registered veterinary drugs available between 2017 and 2020 were analyzed. In terms of knowledge about AMR, the participants showed an advanced level of knowledge (84%), similar to that of Jordanian pharmacists (Darwish et al., 2021), but higher than that of veterinarians in India (69%; Vijay et al., 2021). Most

participants agreed with the correct definition of AMR and that antimicrobials mainly include antibiotics. More than 75% of participants agreed that the overuse of antimicrobials in livestock is a threat to human livelihood, that antimicrobials contribute to food safety and public health, and that they are essential to protecting animal health and welfare. This finding is consistent with that of a Dutch study (Speksnijder et al., 2014), in which respondents felt that it was their duty as veterinarians to treat sick animals for animal welfare and health reasons, regardless of issues concerned with AMR. Moreover, in a previous study from India, 98.7% of veterinarians agreed that antibiotic resistance is a serious public health problem (Vijay et al., 2021). Nonetheless, in this study, 19.36% of participants disagreed that increasing contact between animals and humans could lead to higher risk of infections and cross-transmission of AMR traits, and 17.39% disagreed that microorganisms in all ecological niches constitute a pool for the development of AMR traits. These findings demonstrated that the basic knowledge of Jordanian veterinarians was satisfactory in terms of defining AMR and its associated risks. However, there is room for improvement in terms of ecological aspects, which is one of the key elements of the One Health approach (McEwen and Collignon, 2018). This is evident from the fact that there is high prevalence of resistant *Escherichia coli* in drinking water from Jordan (Swedan and Abu Alrub, 2019). The environmental reservoir is now widely recognized as a complex and diversified reservoir of AMR genes that can be transferred in and between environmental and clinically relevant bacteria (EMA and CVMP, 2018); as such, the environmental aspect is crucial for the prevention of AMR. Moreover, water bodies contaminated with resistant genes, bacteria, and antimicrobial compounds from human and animal feces are an ideal environment for the emergence and spread of superbugs (WHO, 2020).

This study revealed that most participants considered AMR to be a challenge that should be

Table 5 The total number of registered and reregistered veterinary pharmaceutical in Jordan between 2017-2020

Antimicrobial	Produced				Imported			
	2017	2018	2019	2020	2017	2018	2019	2020
Antibiotic (Per Oral)								
Aminoglycoside	3	4	2	0	1	2	2	0
Cephalosporin (cefalexin)	0	0	0	0	0	1	0	0
Fosfomycin	0	1	1	0	0	0	1	0
Ionophores	0	0	0	0	0	1	0	2
Lincosamid	0	0	0	0	0	0	2	0
Macrolides	1	6	2	2	4	4	3	5
Penicillin's	1	3	3	1	3	0	1	3
Phenicol's	3	5	3	0	1	0	0	0
Pleuromutilin's	0	0	0	0	0	0	0	2
Polypeptide	2	3	1	1	2	1	1	1
Quinolones	2	7	5	1	2	2	3	1
Sulfonamides	3	4	6	4	0	0	1	0
Fluoroquinolones	0	0	0	0	0	0	0	0
Tetracycline	4	6	2	1	2	0	7	1
More than one active material	2	10	14	4	3	5	6	0
Percentage per Year	19.09%	32.67%	23.35%	15.38%	16.36%	10.66%	16.16%	16.48%
Antibiotic (Parental)								
Aminoglycoside	1	0	1	0	2	0	1	2
Cephalosporin	0	0	1	1	2	1	2	5
Macrolides	0	0	2	1	5	0	5	2
Penicillin's	1	1	0	0	4	0	2	0
Phenicol's	0	0	4	0	2	2	2	2
Quinolones	0	0	3	0	1	2	1	3
Sulfonamides	1	0	1	0	0	0	2	1
Tetracycline	1	2	11	0	9	5	9	4
More than one active material	1	1	3	0	4	3	6	4
Percentage per year	4.55%	2.67%	15.57%	2.20%	26.36%	8.66%	17.96%	25.27%
Antibiotic Intramammary ^a								
Total	1	0	0	0	0	0	0	0
Percentage per year	0.00%	0.67%	1.20%	0.00%	2.73%	0.66%	0.00%	0.00%
Antiparasitic								
Ectoparasite ^b	10	15	7	12	1	7	3	3
Anticoccidial ^c	0	3	3	3	7	1	2	2
Antiprotozoal ^d	0	1	1	0	0	0	0	0
Anthelmintics ^e	8	22	15	9	7	15	11	8
Percentage per year	16.36%	27.33%	15.57%	26.37%	13.64%	15.33%	9.58%	14.28%
Alternative to antibiotics ^f								
Percentage per year	0.00%	1.33%	0.60%	0.00%	0.91%	0.00%	0.00%	0.00%

Note. The following are the main active material of the mentioned pharmaceutical product:

^aCefalonium, Lincomycin hydrochloride and Neomycin sulfate, Benzathine and Ampicillin trihydrate, Cefalexin monohydrate and Gentamycin sulfate, Oxytetracycline and Neomycin

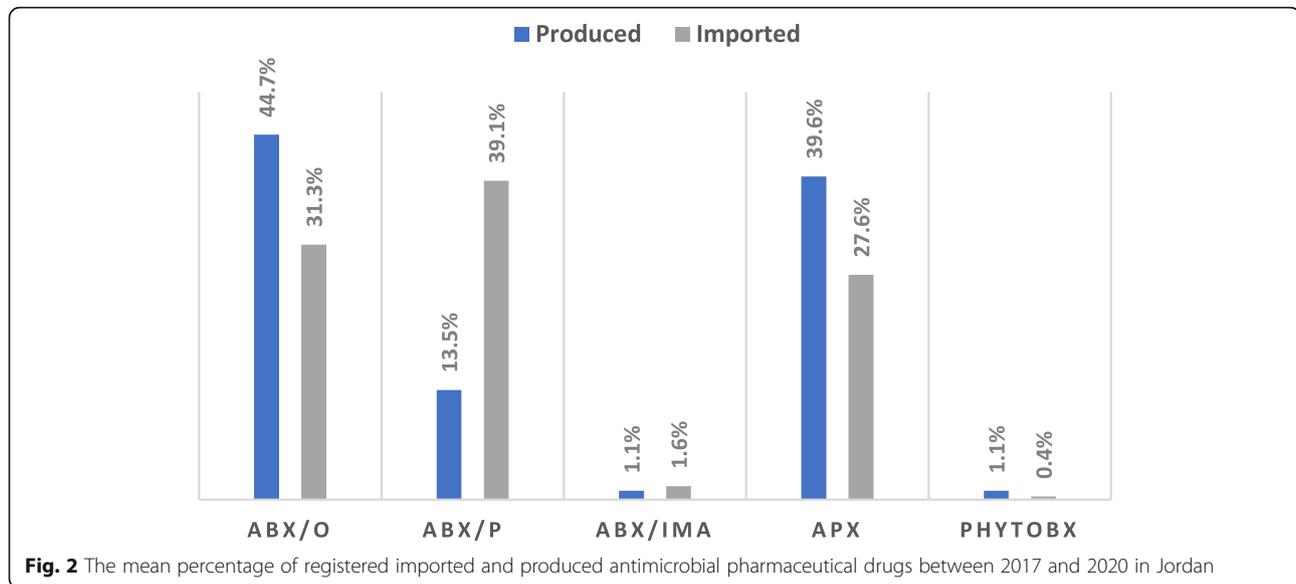
^bAfoxolaner, Milbemyacin oxime, Clopidol, Fenvalerate, Permethrin, Fipronil, Lambda cyhalothrin Flumethrin, Cyromazin, Alphacypermethrin, Imidacloprid, Organophosphates, and Amitraz

^c Clopidol, Narasin, Narasin-Nicarbazin, Diclazuril, Toltrazuril, and Sulphaquinoxaline

^d Diminazen

^e Ivermectin, Eprinomectin, Rafoxanide, Oxytoclozanide, Tinidazole, Netobimin, Oxfendazole, Flubendazole, Amprolium, Albendazole, Levamisole, Tetramisole, and Fenbendazole

^f Thymol, Menthol, Eucalyptus oil and Artichoke Extract



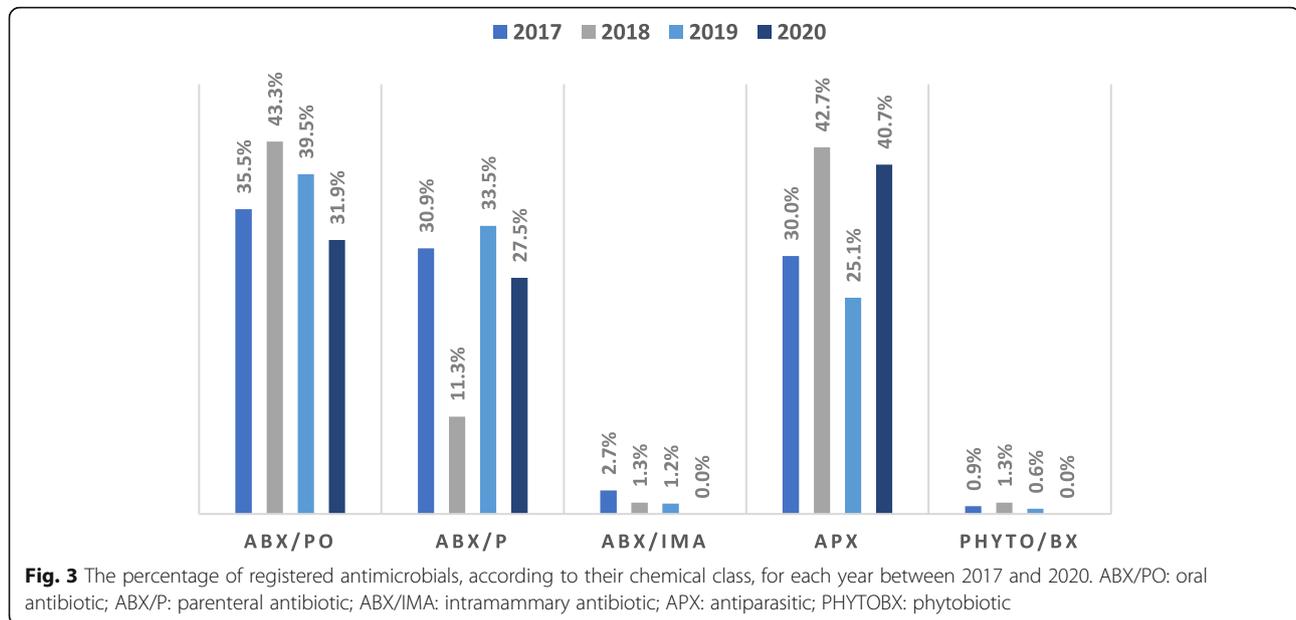
prioritized. Most veterinarians also believed that the misuse and overuse of antimicrobials by unqualified professionals, in terms of prescribing veterinary medicines, is a major challenge (68.70%). A recent study in India revealed that such practices could jeopardize ongoing efforts to combat AMR (Mutua et al., 2020). For instance, Indian dairy farmers are opting to use the services of unqualified practitioners rather than veterinarians owing to the high expenses involved in treating their animals (Vijay et al., 2021). In Jordan, legislation grants permission to non-veterinarians (agricultural engineers) to dispense antimicrobials without veterinary supervision, despite the fact that they lack sufficient training or background to do so⁴. The high cost of treating animals is correlated with the socioeconomic status of the clients, as revealed by this study. This result is in line with that of a similar study conducted by Jordanian pharmacists, which showed that the socioeconomic status of the clients reflects their health literacy (Darwish et al., 2021). Therefore, socioeconomic factors have an impact on both human and animal health. Consequently, legislation should be amended to include the role of the veterinarian, along with other health professionals, in AMR stewardship, apart from other proven zoonotic diseases in the country (brucellosis and rabies; Sorrell et al., 2015).

Veterinarians have a huge responsibility in hygiene practices and thus in reducing AMR. In the current study, 42% of respondents indicated that the implementation of biosecurity measures is crucial for the control of microbial infections. Similarly, 80% of participants consistently recommended good hygiene practices to their clients (e.g., customers, owners, and farmers) and 59.13% of participants recommended that their clients wash their hands after handling animals.

In terms of their practices in determining the need for antimicrobials, 63.48% of respondents always prescribed antimicrobials for therapeutic practice, with 66.06% considering the proper dose and frequency upon administering the pharmaceutical drug. Moreover, 56.52% of participants referred to the OIE list while selecting antimicrobials and encouraged clients to reduce their dependence on antimicrobials in the treatment of their animals. Half of the participants (50.43%) recommended that their clients use alternatives to antimicrobials. These findings suggest that approximately half of the respondents should further improve their counseling skills and participate in regular training on updated treatment guidelines with respect to the correct selection and administration of antimicrobials, which is important to structure future AMR reduction interventions (Speksnijder et al., 2014).

This study shows that there is a relationship between participants' willingness to enroll in AMR continuing education and their professional field. Approximately one-third of the participants (36.52%) had never engaged with AMR educational materials. This finding suggests a need to implement an AMR continuing education program that incorporates best AMR practices during undergraduate education, as has been developed in

⁴ Jordan: National action plan for combating antimicrobial resistance in the Hashemite Kingdom of Jordan. World Health organization. <https://www.who.int/publications/m/item/jordan-national-action-plan-for-combating-antimicrobial-resistance-in-the-hashemite-kingdom-of-jordan>. Accessed 5 February 2021



Nigeria (Sorrell et al., 2015). This program will enable all veterinarians to improve and update their knowledge on AMR and antimicrobial use prior to graduation and employment in different sectors (Adekanye et al., 2020).

In Jordan, the animal health sector is well served by Agriculture Law No. 13 of 2015, which includes instructions for the registration of antimicrobial medicines; responsibility lies with the Department of Registration of Veterinary Pharmaceutical Products at MOA (i.e., the committee of Veterinary Services)⁴.

In the reports of pharmaceutical products registered between 2017 and 2020, 3rd and 4th generation cephalosporins were only registered for the parenteral route of administration; this is similar to some French reports, as these drugs are poorly absorbed after oral administration. The spread of AMR in fecal flora has environmental implications (Hornish and Katarski, 2002)^{5,6}. Although colistin is approved for oral administration and is used as a growth promoter for livestock, it may contribute to the emergence of the *mcr-1* gene in colistin-resistant bacterial isolates (Vidovic and Vidovic, 2020). Ionophores, such as monensin, maduramycin, and salinomycin, have been approved as growth promoters in livestock, although

recent regulations prohibit the prescription of antibiotics as growth promoters.⁴

For registered veterinary antiparasitic drugs, the route of administration varies between parenteral (e.g., ivermectin IM/SC injections), oral (e.g., albendazole tablets), and topical administration (e.g., cypermethrin dust powder). From the analyzed reports, registered ectoparasite drugs were produced at about four times higher frequency than that of imported ones (total 14 imported and 44 produced ectoparasite drugs), indicating that the sector is dependent on the local market.

Plant extracts or phytobiotics are widely used in veterinary medicine. Most of the medicines registered and produced from 2017 to 2020 were extracted from menthol and thymol. However, phytobiotics accounted for approximately 1% of the total registered medicines between 2017 and 2020, compared with 0.002% ($n = 1/470$) in some African countries⁷. Nonetheless, although small, this is still a step toward reducing AMR in animals.

Conclusion

The introduction of AMR continuing education programs is crucial to improving veterinarians' knowledge in all aspects of AMR. These programs will also improve veterinarians' advisory skills, and if they involve the public, will facilitate communication and the flow of information between veterinarians and their clients. In addition, binding legislation that only authorizes veterinarians to prescribe antimicrobials, considering the withdrawal period and the appropriate dosing regimen, to be used under

⁵Reflection paper on antimicrobial resistance in the 5 environments: considerations for current and future risk assessment of veterinary medicinal products. European Medicine Agency (EMA) and Committee for Medicinal Products for Veterinary Use (CVMP) https://www.ema.europa.eu/en/documents/scientific-guideline/draft-reflection-paper-antimicrobial-resistance-environment-considerations-current-future-risk_en.pdf. Accessed 6 March 2021

⁶Sales Survey of Veterinary Medicinal Products Containing Antimicrobials in France in 2019. French Agency for Food, Environmental and Occupational Health & Safety (ANSES).

⁷IGAD MRH dashboard. <https://mrh.igad.int/production/index>. Accessed 6 March 2021

their supervision, is crucial to counter prescription by unqualified practitioners, who are considered a main contributor to the excessive and abusive use of antimicrobials. In addition, surveillance systems should be developed to monitor antimicrobial consumption and incorporate zoonotic antimicrobial susceptibility testing data in order to strengthen veterinary stewardship in the national action plan. Lastly, last choice drugs in human medicine should be avoided in veterinary medicine to reduce the spread of microbial resistance.

Methods

Study design and sample size

The aim of this study was to evaluate the role of veterinarians in Jordan in combating AMR, as well as to illustrate the distribution of approved veterinary drugs in Jordan. A cross-sectional web-based questionnaire survey was designed to assess the participants' KAP. Questions were based on related research into the role of veterinarians in tackling AMR. The survey included 25 questions, was conducted in Arabic and English, and was previously reviewed by two academics and one veterinarian. Ethical approval was not required as neither animals nor patients were included. The questionnaire consisted of closed-ended questions, Likert scale statements, and one open-ended question; it was conducted using a Google[®] form. Because of the pandemic, a link to the form was sent electronically (online) to randomly selected veterinarians; the link was sent *via* e-mail to 26 veterinarians, whereas 67 veterinarians received it as a message *via* LinkedIn[®], and 196 veterinarians received it *via* Facebook Messenger[®].

The total recruited sample size was 215; this was calculated using the Rasoft[®] application by submitting the total number of registered veterinarians (1649 after excluding those who had died), with a 95% confidence level and 5% acceptable margin of error.

A total of 119 individuals responded, 4 of whom did not complete the survey and were excluded from the study; as such, responses from 115 respondents were included. The response rate was 41.2%. This low response rate is because of either low internet access or the participants' inactive status on social media. The survey was available between October 23, 2020 and November 13, 2020.

There was a lack of reliable data on the percentage of registered antimicrobial veterinary drugs, but these data were important to supporting the results of this study. As such, annual reports of registered and newly registered veterinary drugs between 2017 and 2020 were obtained directly from the Jordanian Veterinary Association (JVA), categorized as imported or produced veterinary drugs, and then subdivided according to their chemical classification. The exception was antibiotics, which were categorized by route of administration as parenteral (injection), oral (powder, liquid, suspension, tablet, solution, or drainage), or

intramammary drugs. Although vaccines play an important role in biosafety, they were not included.

Data analysis

The collected results were coded and analyzed using XLSTAT[®] software 2021. The data were divided into four sub-sections: demographics, knowledge, practices, and attitudes; these data were analyzed descriptively. To evaluate veterinarians' knowledge, the following scoring system was used: agree, neutral, or disagree. When rating their practices, participants were asked to select the indicator that best reflected their practices on a scale from one (never) to five (always). For attitudes, participants were asked to rank, in ascending order, the most important challenges with respect to addressing AMR, ranging from one (least important) to four (most important).

A bivariate analysis using Pearson's chi-squared test was performed to assess the relationship between "Participation in continuous AMR training" and the statement "You train yourself with continuous AMR training materials to increase your knowledge with respect to implementing good antimicrobial use practices" with the following selected variable "Veterinary professional sector: private, public and academic." More specifically, using the 98 responses, the outcome variable was categorized as "rarely to sometimes" or "frequently to always." The threshold for statistical significance was set at $p \leq 0.05$, and Eq. 1 was used to calculate the results. In addition, Minitab[®] Software 2021 was used for further analysis.

Pearson's chi-squared test

$$\chi^2 = \sum (O_i - E_i)^2 / E_i \quad (1)$$

The registered veterinary drugs from 2017 to 2020 were requested directly from the JVA and then manually counted based on the registration numbers. They were then categorized as antibiotics (*via* oral, parenteral, or intramammary routes of administration; topical administration was not included), antiparasitics, or antibiotic alternatives. Data were analyzed using Microsoft[®] Office Excel 2010. These reports are not available online; they were requested by e-mail from AWU.^{8,9,10,11,12}

⁸Drugs 2017. Jordanian Veterinary Committee. Accessed 5 February 2021

⁹Drugs 2018. Jordanian Veterinary Committee. Accessed 5 February 2021

¹⁰Registered drugs 2019. Jordanian Veterinary Committee. Accessed 5 February 2021

¹¹Re-Registered drugs 2019. Jordanian Veterinary Committee. Accessed 5 February 2021

¹²Report 2020. Jordanian Veterinary Committee. Accessed 5 February 2021

Abbreviations

ABX/IMA: Intramammary antibiotic; ABX/O: Oral antibiotic; ABX/P: Parenteral antibiotic; AMR NAP: Antimicrobial resistance National Action Plan; AMR: Antimicrobial Resistance; APX: Antiparasitic; JUST: Jordan University of Science and Technology; JVA: Jordanian Veterinarian Associations; KAP: Knowledge, attitudes, and practices; MOA: Ministry of Agriculture; MOH: Ministry of Health; PHYTOBX: Phytobiotics; USA: United States of America; WHO: World Health Organization

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Authors' contributions

AA and RG have participated in reviewing the content of the questionnaire. All authors have read and approved the manuscript.

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Availability of data and materials

Data will be shared upon request by the readers.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The author declares that he/she has no competing interests.

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