

Knowledge, Attitudes, and Practices of Antimicrobial Use and Resistance among Village Animal Health Workers and Veterinary Drug Retailers in Cambodia

Bunna Chea^{1,2}, Sokom Kong², Sokha Thim², Naiheak Ban², Rithy Chrun³, Vutey Venn², Cherry Fernandez-Colorado⁴, Kroesna Kang²

¹Graduate School, Royal University of Agriculture, Phnom Penh, Cambodia

²Faculty of Veterinary Medicine, Royal University of Agriculture, Phnom Penh, Cambodia

³Faculty of Agro-Industry, Royal University of Agriculture, Phnom Penh, Cambodia

⁴Department of Veterinary Paraclinical Sciences, College of Veterinary Medicine, University of the Philippines Los Baños, Los Baños, Philippines

Email: bunna_chea@rua.edu.kh

How to cite this paper: Chea, B., Kong, S., Thim, S., Ban, N., Chrun, R., Venn, V., Fernandez-Colorado, C. and Kang, K. (2023) Knowledge, Attitudes, and Practices of Antimicrobial Use and Resistance among Village Animal Health Workers and Veterinary Drug Retailers in Cambodia. *Open Journal of Animal Sciences*, 13, 98-113. <https://doi.org/10.4236/ojas.2023.131007>

Received: December 1, 2022

Accepted: January 7, 2023

Published: January 10, 2023

Copyright © 2023 by author(s) and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

Misuse, overuse, and missed prescription of antimicrobials are the driving factors to antimicrobial resistance (AMR) leading to a globally increasing public health concern. This study was conducted to assess the current knowledge, attitudes, and practices (KAP) of village animal health workers (VAHWs) and veterinary drug retailers (VDRs) on antimicrobial use (AMU) and antimicrobial resistance (AMR). The sample size was calculated following [1]. KAP data were scored and categorized following Bloom's cut-off score. A total of 108 study populations (66 VAHWs and 42 VDRs) were purposively surveyed using a validated KAP questionnaire in 5 provinces across Cambodia. This study found that VAHWs and VDRs have moderate levels of knowledge (61% to 65%) and good attitudes towards AMU (83% to 84%) but employed moderate practices (59% to 74%) on AMU. VAHWs had moderate (66%); while VDRs had poor knowledge (58%) on AMR. Thus, regular awareness education specifically on proper use, prudent use, and stewardships on AMU and AMR in the form of refresher training or awareness events must be provided to VAHWs and VDRs to avoid inappropriate use of antimicrobials and spreading the AMR knowledge across Cambodia.

Keywords

Antimicrobial Use, Antimicrobial Resistance, Attitudes, Knowledge, Practices

1. Introduction

Misuse and overuse of antimicrobials or antibiotics (ATBs) in agriculture and food production is a significant driver of antimicrobial/antibiotic resistance in humans. Resistant bacteria are transferred to humans through multiple pathways including direct contact with farmed animals; animal waste; the spreading of manure from livestock production as fertilizers on crops; and ingested food produced at the farm contaminated by resistant bacteria [2]. Rising levels of AMR are threatening key areas of global health, food security, economic growth and development. If no action is taken, AMR will impact human and animal health with excess deaths and suffering [3]. It is estimated that approximately 10 million people will die annually due to infection related to AMR by 2050 [4].

The demand for nutritious food animal sources is increasing with emerging economies in low- and middle-income countries (LMIC) and the highest antimicrobial use (AMU) to food-producing animals is seen in Asia, and a 10.3% increase is expected by 2030 [5]. In Cambodia, one of the LMIC, the increased public demand for animal products and the government's policy of self-sufficiency has led to an increase in livestock enterprises especially pig and poultry farming. This has led to increased use of antibiotics for therapeutic, prophylactic and metaphylactic treatments. All animal health services including medicines and drugs are provided by the village animal health workers (VAHWs) and veterinary drug retailers (VDRs) to the smallholder farmers [6] [7] [8]. Therefore, both VAHWs and VDRs play a critical role in the use of antibiotics in animals' smallholder farming.

It is reported that there are 11,747 of VAHWs present in Cambodia. However, only 4,150 of them have been reported to actively practicing the profession [9]. Most of the VAHWs (the government delegated training to diverse NGOs) received the short training provided by the private services in Cambodia such as Agronomes et Vétérinaires Sans Frontières (AVSF). So far 2,100 VAHWs are trained on technical skills related to animal health and production including disease prevention and treatment for chicken, pig and cattle, as well as animal production techniques and epidemiology and disease surveillance [10].

In Cambodia, VDRs open the shops under registration from the General Directorate of Animal Health and Production under Prakas No. 051 PRK.MAFF [11]. VDRs, generally, purchase drugs from two main sources; established Cambodian veterinary companies and informal middlemen supply products from foreign companies [12]. VDRs are not only selling veterinary medicine and vaccines, but also focus on selling fodder, equipment for raising animals and other agricultural inputs [12]. VDRs offer services to smallholder farmers, commercial farms, and VAHWs/veterinarians. VDRs advice medicine to smallholder farmers mainly on selection and application.

There are very few published studies regarding knowledge, attitudes and practices (KAP) on AMU and AMR among VAHWs and VDRs in Cambodia. The study by [13] indicated that VDRs had a low level of knowledge of AMR sug-

gesting a suitable target group for AMR awareness since they seem to be influential actors in the antimicrobial network. Another study by [6] showed that limited knowledge and poor biosecurity practices of VAHWs or district veterinarians (DVs) were found to include physical service material management and medicine storage. Studies from other countries indicate the importance of KAP for animal health workers to understand the level of their knowledge in judicious use of antibiotics and prevention of resistance development [14]. For instance, studies in Bhutan indicated that veterinarians and para-veterinarians have poor knowledge of AMU and AMR [15]. Similarly, a study in Nigeria showed that veterinarians have limited awareness on AMR and also the role and use of biosecurity and prophylactic antibiotic use in the prevention of infection was poorly understood [16]. These two studies suggested that regular awareness such as workshops or trainings must be intervened.

To the authors' knowledge, this is the first survey on KAP among VAHWs and VDRs in Cambodia. Therefore, the main objective of this study was to assess the current KAP associated with AMU and AMR among VAHWs and VDRs. The findings from this study will be useful to get information on antibiotic prescribing trends among VAHWs and VDRs, which will help in designing an evidence-based education and advocacy plan for the prevention of AMR in the country.

2. Materials and Methods

2.1. Study Location

The present study was carried out in the southern part of Cambodia (bordered by Vietnam) within five provinces including Kampong Speu, Takeo, Kandal, Prey Veng, and Svay Reing same areas as the study by [17] (Figure 1). The study was carried out during the rainy season with the average temperature ranging from 26 - 28 degree Celsius [18]. The study was conducted from August to November 2020.

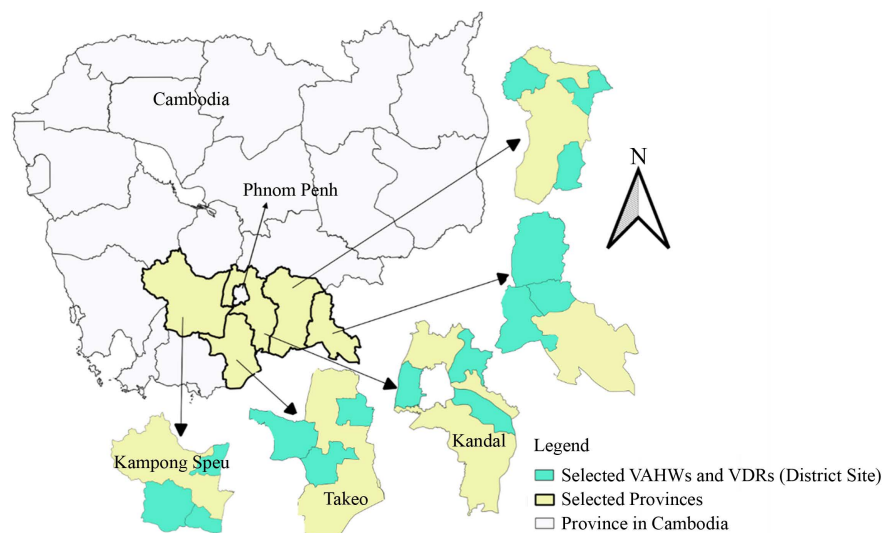


Figure 1. Geographical map of the 5 provinces where the study was conducted.

2.2. Sample Size and Respondent Selection

VAHWs and VDRs were selected for an interview using the KAP questionnaire to explicit their knowledge, attitudes, and practices with regards to AMU and AMR. A single proportion estimation was applied from sample size calculation based on [1], with a 95% confidence interval, 10% margin of error, and an assumption of that 50% ($p = 0.5$). The sample size required was 96 respondents. In the present study, a total of 108 VAHWs and VDRs (66 VAHWs and 42 VDRs) have been surveyed.

In each province, three districts, the same study areas by [17] were selected. Within those districts, the VAHWs and VDRs were selected based on volunteerism within an indication by the district/provincial veterinarian at each province. One additional district of Takeo was selected for the VDRs. Although Feed and veterinary drug retailers are common in Cambodia, feed retailers were excluded from the study.

2.3. Questionnaire Design and Data Collection

Survey questionnaires were designed in either Khmer or English containing both positive and negative statements to explore the individual KAP of respondent. A consensus regarding the contents and wording of the questionnaire was achieved during the consultative workshop of experts from research university, government, and NGO who work closely related to AMU and AMR sector. The questionnaire was orally administered by trained research team and students from the Faculty of Veterinary Medicine, Royal University of Agriculture (RUA), Phnom Penh, Cambodia.

The VAHWs and VDRs were selected based on volunteerism and coordination from district/provincial veterinarian of each province. The interview lasted for about 30 minutes. VAHWs were surveyed either at the VAHWs' house or district's house; while DVRs were surveyed at their shops. The questions on the survey include 1) general information (e.g. age, gender, education, and experience), 2) knowledge about AMU (e.g. key term about AMU, proper use, non-therapeutic use, and storage), 3) attitudes towards AMU (e.g. proper management, using vaccination, veterinarian supervision, proper use, and consequences of ATBs for VAHWs; store and product registration, prescription/veterinarian availability, proper use of ATBs for VDRs), 4) practice on AMU (e.g. proper use of ATBs and non-therapeutic use for VAHWs; proper dispensing ATBs practices, storage of ATBs, screening ATBs in accordance with local guideline for VDRs), 5) knowledge on AMR (e.g. misuse of ATBs in relation with AMR and the AMR consequences).

2.4. Data Analysis

Data obtained from interviews were entered into the MS Excel spread sheet for cleaning, processing, and further analysis. All data regarding demographic characteristics and current KAP on AMU and AMR were analyzed through descriptive statistics.

KAP key individual's answers were scored and categorized following Bloom's cut-off score as indicated in **Table 1**.

3. Results

A total of 66 VAHWs and 42 VDRs were interviewed with all being male for VAHWs and 43% being female for VDRs (**Table 2**). The average age of VAHWs and VDRs was 48-year-old and 41-year-old respectively. However, VAHWs had more experiences (15 years on average) compared to VDRs (8 years on average) in providing the service according to their jobs. In terms of education, about half of the VAHWs completed secondary school; while about one-fourth percent completed high school. About 10% of them completed primary or undergraduate program. Only 2% of VAHWs completed graduate program. For VDRs, 36% completed high school; while about 22% completed secondary or undergraduate program. Less than 10% completed primary and graduate program. Only 2% of VDRs never attended school.

VAHWs and VDRs had moderate knowledge of ATBs and their related use (**Table 3**). About 70% or more of VAHWs and VDRs could only identify correctly the use of ATBs. However, most of them (85% - 95%) missed the perception

Table 1. Awareness evaluation by bloom cut off point.

Awareness criteria	<60%	60% - 80%	>80%	Remarks
Knowledge	Low	Moderate	High	One mark was given for each correct answer and zero mark for each wrong or do not know response for the knowledge assessment.
Attitudes	Not concerned	Neutral	Concerned	The individual's attitude response assessment, positive statements were scored from five marks to one mark relatively ranging from "Strongly Agree" to "Strongly Disagree", while reverse scoring was used for negative statements.
Practices	Poor	Fair	Good	The individual's practices assessment, positive statement responses were rated from five to one mark ranging from "Very Often" to "Never". Reverse scoring was used for negative statement.

Table 2. Demographic information of VAHWs and VDRs in study area.

Description	VAHWs (N = 66)	VDRs (N = 42)
Gender		
<i>Male</i>	66 (100)	24 (57)
<i>Female</i>	0 (0)	18 (43)
Education		
<i>Never attended school</i>	0 (0)	1 (2)
<i>Completed Primary school</i>	8 (12)	4 (9.50)
<i>Completed Secondary school</i>	35 (53)	10 (24)
<i>Completed High school</i>	16 (24)	15 (36)
<i>Completed undergraduate program</i>	6 (9)	8 (19)
<i>Completed graduate program</i>	1 (2)	4 (9.50)
Age (year)		
	48.45 ± 8.32	41.07 ± 10.47
Raising experience (year)		
	15.76 ± 7.38	8.67 ± 5.80

Note: N = total number; () = percentage.

Table 3. Frequency of corrected responses of key individual's knowledge on AMU in the study.

Statement	Numbers of individual's corrected response	
	VAHWs (N = 66)	VDRs (N = 42)
Antibiotic drugs are used for treatment only bacterial disease.	50 (76)	29 (69)
Antibiotic is compound used for reduce inflammation.*	3 (5)	6 (14)
Using lower dosage than recommended effect to antibiotics efficiency.	22 (33)	12 (29)
Antibiotics can stop immediately when sick animals not show any signs.*	44 (67)	28 (67)
Antibiotics withdrawal periods should be adhered to avoid drug residues in meat and its products.	57 (86)	34 (81)
The non-therapeutic use of antibiotics does not cause any consequences.*	51 (77)	31 (74)
Antibiotics can cause antibiotic resistance bacteria.	55 (83)	31 (74)
Antibiotics can store at any place where easy to use.*	60 (91)	35 (83)
Rate of mean corrected responses	(65)	(61)

Note: N = total number; () = percentage. *Statement reverse respond score.

that the ATBs are used for the treatment of inflammation. More than 80% of VAHWs and VDRs were aware of withdrawal period when using ATBs. Between 70% to 80% of VAHWs and VDRs indicated that there will be consequences when the use of ATBs in the form of non-therapeutic and ATB resistant bacteria may be attributed from the use of ATBs. Most of VAHWs and VDRs understood correctly how to store ATB properly and full dosage and duration of ATBs used in animals should be applied (67%).

Table 4 provides the inclusive summary of the attitudes of VAHWs toward AMU and its related consequences. Overall, VAHWs were concerned about AMU and its consequences (83%). Interestingly, most of the VAHWs were much concerned that proper management, using vaccination, veterinarian's advice, and correct dosage of ATB are the key to preventing/proper use of ATB in

Table 4. Frequency of corrected responses of VAHWs' attitude on AMU in the study (N = 66).

Statement	Numbers of individual's agreement
You would suggest farmers to do proper management (including good biosecurity) rather than use antibiotics to protect/treatment animals from diseases.	62 (94)
You would suggest farmers to use vaccine on their animals in order to prevent/reduce antibiotics.	63 (95)
You would suggest farmers to consult with animal health professionals before using any antibiotic drugs.	62 (94)
Giving antibiotics in proper dosage and duration is important to do.	56 (85)
Giving antibiotics to animals that are not sick will prevent them from becoming sick in the future. *	42 (64)
Giving antibiotics to animals that are not sick can help them grow bigger, faster, fatter, boost egg production/size. *	56 (85)
You would suggest farmers to wait sometimes before they sell or consume the products from it, such as meat/eggs/milk after using antibiotics on an animal.	52 (79)
Improper/overusing antibiotic can cause adverse effect on animals, myself or others.	49 (74)
If you know that antibiotics that seems not work with the animals, you still use or recommend them.	41 (62)
You would always consult with animal health professional before you decided to use antibiotics.	56 (85)
You would consult with animal health professional if you could not decide which antibiotics to use for treating the animals.	62 (94)
Rate of mean in agreement	(83)

Note: N = total number; () = percentage. *Statement reverse respond score.

animals. VAHWs were likely neutral belief about the adverse effects on animals, human, and environment due to the misused of ATB (74%). Unlikely, the non-therapeutic use of ATB in prevention was not much concern (64%).

Table 5 indicated that the VDRs showed a relatively good attitude on the AMU. VDRs strongly belief that store and product registration, available prescription and veterinarian at the store were good criteria when considering dispensing ATBs. Furthermore, they were concerned about withdrawal period and other advice on using for only treatment. The non-therapeutic use as prevention and its consequences and for the improper use seems to be neutral attitude.

The practices of VAHWs on AMU appeared to be fair (**Table 6**). Most of the VAHWs applied good action regarding the AMU including the proper dosage, duration, route of administration, clinical evaluation prior to use ATBs, and use/recommend according to the recommendation on the label. About two-thirds of VAHWs practiced proper management of dead animals die under ATBs

Table 5. Frequency of corrected responses of VDRs' attitude on AMU in the study (N = 42).

Statement	Numbers of individual's agreement
You should register before you sell the veterinary drugs especially antibiotics.	39 (93)
You should have animal health professional at my store/as consultant if you want to sell the veterinary drugs especially antibiotics.	38 (90)
It is important to know registered antibiotics before you decided to order to your store.	41 (98)
Antibiotics should store in proper place according to the recommendation on label.	40 (95)
Dispensing antibiotic without prescription should be restricted.	36 (86)
It is important to obtain animal history and symptoms before dispense antibiotic.	40 (95)
Improper use of antibiotic in animals can cause health consequences to animal, human, and environment.	30 (71)
Giving antibiotics to animals that are not sick can help them grow bigger, faster, fatter, boost egg production/size. *	32 (76)
You would suggest your customer to pay attention about withdrawal period when using antibiotic.	36 (86)
In all cases where antibiotics are dispensed, it is essential that customers are advised that it should be used for treatment.	36 (86)
Antibiotics are usually dispended without prescription because your customers know how to use it.	18 (43)
Rate of mean in agreement	(84)

Note: N = total number; () = percentage. *Statement reverse respond score.

Table 6. Frequency of corrected responses of VAHWs' practices on AMU in the study (N = 66).

Statement	Numbers of individual's routines
You decide on the type of antibiotics use to treat farmer's animals, or to be used in your own farm base on recommendation on the label.	60 (91)
You make diagnostics/evaluate of clinical symptoms before deciding to use antibiotics.	59 (89)
You use self-made mixtures of more than one antibiotic for treatment of animals without indications.*	18 (27)
You decide on the amount of antibiotics to be used base on recommendation on the label.	63 (95)
You decide the route of antibiotic administration base on the recommendation on the label.	62 (94)
You decide on the length of antibiotic treatment base on the recommendation on the label.	58 (88)
You provide written instruction on antibiotic use given to the farmer.	19 (29)
You recommend antibiotics for poultry/pig (s) that are not sick to prevent disease or as growth promoters.*	51 (77)
You give advice to farmers when animal die under antibiotic treatment to burn or bury properly.	50 (76)
You give advice to farmers with poultry/pig (s) (still alive) with treatment of antibiotics under withdrawal period properly.	46 (70)
Rate of mean in routines	(74)

Note: N = total number; () = percentage. *Statement reverse respond score.

treatment or withdrawal period. However, about one fourth of VAHWs did not apply well either on the proper written prescriptions or use of self-made mixture of ATBs.

The practices of VDRs on AMU appeared to be low (**Table 7**). About 40% of them dispense ATBs without a prescription, while about 20% of them recommend using a mixture of more than one ATBs to their customers. About one-fourth of VDRs would dispense ATBs to customer as requested or change ATBs by their own decision. Most of VDRs practiced well with the screening of ATBs and asking for clinical history prior to purchased and dispense of ATBs. Most of VDRs applied well on proper storage of ATBs. About 60% of VDRs provide the written instruction on ATBs to customers.

The assessment of AMR knowledge of VAHWs and VDRs was mainly on mis-used and the consequences. All/almost all of VAHWs and VDRs have heard about AMR term. However, the knowledge of AMR appeared to be fair and low for VAHWs and VDRs respectively (**Table 8**). For VAHWs, more than 80% of

Table 7. Frequency of corrected responses of VDRs' practices on AMU in the study (N = 42).

Statement	Numbers of individual's routines	
You ask your customers for history and symptoms of animals before deciding to dispense antibiotics.	41	(98)
You dispense antibiotics without a prescription.*	16	(38)
Your recommendations on antibiotic use to your customers with the written instructions.	26	(62)
You store bottle or bag/package of antibiotics in cabinet where the sunlight can't be exposed.	35	(83)
You sell expired antibiotics.*	40	(95)
You recommend your customers to use mixture of more than one antibiotic.*	8	(19)
You dispense antibiotics according to your customers requested/ordered without a prescription.*	11	(26)
You change another antibiotic if your customer fails to cure their animals use with the first buying.*	11	(26)
You screen the antibiotic in accordance with local guideline before dispensing.	36	(86)
Rate of mean in routines	(59)	

Note: N = total number; () = percentage. *Statement reverse respond score.

Table 8. Rate of corrected responses of key individual's knowledge on AMR in the study.

Statement	Numbers of individual's corrected response	
	VAHWs (n = 65)	VDRs (n = 42)
Inappropriate antibiotics use can cause emergence of resistant bacteria.	54 (83)	33 (79)
More frequent use of antibiotics in animals will increase their adverse effects in the future.	54 (83)	29 (69)
There is no relationship between antibiotic use in animals and development of resistance.*	33 (51)	23 (55)
Antibiotic resistance in animals is not important for public health.*	41 (63)	18 (43)
Antibiotic resistance is linked from animal (and/or agriculture) to human and environment	34 (52)	19 (45)
Rate of mean corrected responses	(66)	(58)

Note: N = total number; () = percentage. *Statement reverse respond score.

them indicated that improper use and more frequent use of ATBs would cause adverse effects like emergence of resistant bacteria. More than half of VAHWs realized that ATB resistant bacteria found in animals could contribute for public health risk or even connected from animals to others including human and environment. Only half of the VAHWs were aware that the development of resistance comes from the use of ATBs in animals. For VDRs, about 74% of them indicated that improper use and more frequently use of ATBs would cause adverse effects like emergence of resistant bacteria. About 40% of VDRs realized that ATB resistant bacteria found in animals could contribute to public health risks or even connect animals to others including human and environment. Similar to VAHWs, half of VDRs were aware that the development of resistance comes from the use of ATBs in animals.

4. Discussion

The study was conducted to explore the KAP of AMU and AMR among VAHWs and VDRs in Cambodia. We found that knowledge regarding to AMU appeared to be moderate. Fair/Poor in practice on AMU but good attitude regarding to AMU among the VAHWs and VDRs. VAHWs had moderate knowledge on AMR, while VDRs had low knowledge on AMR.

Our study demonstrated that both VAHWs and VDRs had moderate knowledge on ATBs and its use (Table 3). Many of them could identify the use of ATBs for bacterial infection. However, most of them still perceive it as the inflammatory treatment. Although many VAHWs were trained in technical skills related to animal health and production—disease prevention and treatment for chicken, pig and cattle, as well as animal production techniques and epidemiology and disease surveillance [10]. Also, VDRs received the training/short course from the Department of Animal Health and Production or GDAH, provincial authorities, NGOs and private companies, these trainings or short courses may not be enough as new drugs and new diseases still occurred [12]. Thus, it is likely that the knowledge on AMU and AMR is not well attached to the training. Thus, the gap on technical knowledge on inflammatory treatment may be missed conception. Many VAHWs and VDRs were well aware of the withdrawal period when using/advising ATBs (Table 3) but not many VAHWs and VDRs applied written prescription to farmers (Table 6 and Table 7). However, ensuring farmers/producers followed the prescription or advice may not be applicable. Poor adherence to recommended instructions may increase the risk of AMR [19] [20] as well as drug residue [21]. Study by [17] [22] indicated that a proportion of pig and poultry farmers/producers were not well comprehended about withdrawal period when using ATBs even there is available product's instruction or veterinary prescription/advice. Both VAHWs and VDRs were well aware of proper storage of ATBs. This suggests that they have good knowledge of safe storage of ATBs. It is reported that 100% of VDRs in Cambodia kept vaccine as required as indication of the products and most of them had vaccines and medicines properly separated from other products [12]. However, the majority of VDRs (65%) store

the medicine in the cabinet that can be in sunlight for at least part of the day [6].

Both VAHWs and VDRs had a good attitude towards AMU (**Table 4** and **Table 5**). VAHWs believed that proper management, vaccination program, veterinary advice, and proper dosage of ATBs are the key to preventing/proper use of ATBs in animal production. Such good animal husbandry, effective biosecurity, and efficient and relevant vaccinations are the keys to preventing diseases without antimicrobials [23] [24]. If these have put into practices by VAHWs when providing the service, it would gradually decrease the use of antimicrobials and substantially reducing the AMR occurrence. VDRs strongly believed that registration of shop and medicine and availability of veterinarian/prescription are contributed to dispensing ATBs. This positive attitude has been compliant with the World Organization of Animal Health guideline recommendation [25]. However, this may need an effective national regulation to make sure all VDRs take this into practices.

The practice of VAHWs on AMU appears to be fair (**Table 6**). Most of them applied good practice regarding to ATBs administration including dosage, duration, and routes of administration. However, we found self-mixture of ATBs has been practiced by many VAHWs. This practice may contribute to the misuse of ATBs if there was no supervision or scientific support. Self-mixture of ATBs could be made if there are available scientific supports [26]. We also found not many VAHWs applied written prescription to the animal owners. This indicated that there are a knowledge gap and practice when prescribing the ATBs. It is recommended that animal practitioners should apply written prescription when considering using ATBs aiming to responsible use of ATBs [26]. The practice of VDRs appeared to be moderate (**Table 7**). About 40% of them dispense ATBs without a prescription while some of them recommended using mixture of more than one ATBs. These indicated that poor in practices by the VDRs. Distributors or VDRs should distributes ATBs base on the prescription of a veterinarian or other suitably trained person authorized in accordance with the national legislation and under the supervision of a veterinarian. Also, all products should be appropriately labelled and recorded and even when there is a mixture of ATBs [26].

VAHWs had moderate knowledge on AMR, while VDRs had low knowledge on AMR (**Table 8**). Similar study has been indicated by [15] for VAHWs and by [13] for VDRs. Not many of VDRs were aware of the relationship or consequences related to animal, human, or environmental health resulting from the AMR, although many of them understood about the relatively use or more frequently use of ATBs driven to AMR. Recent studies in low-income countries indicated that a knowledge gap on the subject of AMR, including among veterinarians and para-veterinarians [15] and pig and poultry farmer/producers [17] [21] [27] [28]. This highlights the fact that a lack of knowledge regarding AMR is not limited to the farmers/producers, but is widespread also among veterinary professionals. Although many of VDRs asked for the clinical signs from their clients, they still dispensed ATBs according the demands and substitution other

ATBs when the first treatment fail by the clients. These may consider as poor practices. Prescribing of ATBs based on the client demand without clinical observations of the animals and/or no prescription is considered a bad practice which may aggravate the AMR problem [15] [29]. In our study, although many VAHWs and VDRs were aware improper use and more frequently use of ATBs would cause adverse effects like emergence of resistant bacteria, not many of them had appropriate knowledge about consequences on animals, humans, and environment health resulting from AMR. This suggests that more training or awareness on AMR should be applied for them [15].

This study has some limitations. As KAP survey tool enables large amounts of data collection from participants for a short period of time, data collected may misrepresent true dispositions and practices. Data may sometimes bias if the subject matter concerns a contentious topic or practice as well as the level of understanding of the individual question.

5. Conclusion

Overall, we found that VAHWs and VDRs in Cambodia had moderate knowledge and good attitude in regard to AMU; however, they still applied moderate practices toward AMU. Furthermore, moderate/low level of knowledge of AMR has been investigated. This could lead to inappropriate use of antimicrobials. Thus, such interventions including regular awareness of proper use, prudent use and AMR stewardships of AMU and AMR via training/workshops must be taken into account for both VAHWs and VDRs throughout Cambodia.

Acknowledgements

The work was funded by Cambodia Higher Education Improvement Project (Credit No. 6221-KH). The author also would like to thank the veterinary graduate and undergraduate students who helped in conducting the survey. The author also thanks Mr. Ly Pitou for assisting with the survey and producing the map for the study.

Ethical Consideration

Respondents in this study were informed in writing about the study and its objectives in local language. The informed consent form was clearly read/explained to respondents. Only individual who agreed to participate and who signed the informed consent form was included in the study.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] Thrusfield, M. (2007) *Veterinary Epidemiology*. John Wiley & Sons, Hoboken.

- [2] Tang, K.L., Caffrey, N.P., Nóbrega, D.B., Cork, S.C., Ronksley, P.E., Barkema, H.W., Polachek, A.J., Ganshorn, H., Sharma, N., Kellner, J.D. and Ghali, W.A. (2017) Restricting the Use of Antibiotics in Food-Producing Animals and Its Associations with Antibiotic Resistance in Food-Producing Animals and Human Beings: A Systematic Review and Meta-Analysis. *The Lancet Planetary Health*, **1**, e316-e327. [https://doi.org/10.1016/S2542-5196\(17\)30141-9](https://doi.org/10.1016/S2542-5196(17)30141-9)
- [3] Murray, C.J., Ikuta, K.S., Sharara, F., Swetschinski, L., Aguilar, G.R., Gray, A., Han, C., Bisignano, C., Rao, P., Wool, E. and Johnson, S.C. (2022) Global Burden of Bacterial Antimicrobial Resistance in 2019: A Systematic Analysis. *The Lancet*, **399**, 629-655. [https://doi.org/10.1016/S0140-6736\(21\)02724-0](https://doi.org/10.1016/S0140-6736(21)02724-0)
- [4] O'Neill, J. (2016) Tackling Drug-Resistant Infections Globally: Final Report and Recommendations. Government of the United Kingdom, United Kingdom. <https://apo.org.au/node/63983>
- [5] Tiseo, K., Huber, L., Gilbert, M., Robinson, T.P. and Van Boeckel, T.P. (2020) Global Trends in Antimicrobial Use in Food Animals from 2017 to 2030. *Antibiotics*, **9**, Article 918. <https://doi.org/10.3390/antibiotics9120918>
- [6] Chea, B., Kang, K., Vipham, J., Tokach, L. and Tokach, M. (2020) Assessment of Pig Disease Prevention of Smallholder Farmers and Village Animal Health Workers in Rural and Peri-Urban Cambodia. *Open Journal of Animal Sciences*, **10**, 572-591. <https://doi.org/10.4236/ojas.2020.103037>
- [7] Tornimbene, B., Chhim, V., Sorn, S., Drew, T.W. and Guitian, J. (2014) Knowledge, Attitudes and Practices of Cambodian Swine Producers in Relation to Porcine Reproductive and Respiratory Syndrome (PRRS). *Preventive Veterinary Medicine*, **116**, 252-267. <https://doi.org/10.1016/j.prevetmed.2013.12.009>
- [8] Ministry of Agriculture Forestry and Fisheries (2011) Ministry of Agriculture Forestry and Fisheries Annual Report 2010-2011 and Work Plan 2011-2012. Ministry of Agriculture Forestry and Fisheries, Phnom Penh.
- [9] General Directorate of Animal Health and Production (2020) Annual Report on Animal Health and Production in 2019 and Annual Planning for 2020. General Directorate of Animal Health and Production, Khmer Language.
- [10] Village Animal Health Workers in Cambodia—Projects-AVSF (2022) https://www.avsf.org/en/posts/2166/full/Village_Animal_Health_Workers_in_Cambodia
- [11] Ministry of Agriculture, Fisheries, and Forestry (2018) Registration of Animal Feed Ingredients and Veterinary Drugs. Ministry of Agriculture, Fisheries, and Forestry, Khmer Version.
- [12] People in Need (2013) Business Competence Survey on Providers of Private Veterinary Services in Pusat and Kampong Chhnang Province, Cambodia. <https://www.clovekvtisni.cz/media/publications/736/file/1433429458-pin-cambodia-2013-veterinary-business-competence-survey.pdf>
- [13] Heyman, J. (2020) Antimicrobial Drugstore Supply for Cambodian Livestock Farmers. SLU, Department of Clinical Sciences. <https://stud.epsilon.slu.se/15855/>
- [14] Xiong, W., Sun, Y. and Zeng, Z. (2018) Antimicrobial Use and Antimicrobial Resistance in Food Animals. *Environmental Science and Pollution Research International*, **25**, 18377-18384. <https://doi.org/10.1007/s11356-018-1852-2>
- [15] Wangmo, K., Dorji, T., Pokhrel, N., Dorji, T., Dorji, J. and Tenzin, T. (2021) Knowledge, Attitude, and Practice on Antibiotic Use and Antibiotic Resistance among the Veterinarians and Para-Veterinarians in Bhutan. *PLOS ONE*, **16**, e0251327. <https://doi.org/10.1371/journal.pone.0251327>

- [16] Adekanye, U.O., Ekiri, A.B., Galipó, E., Muhammad, A.B., Mateus, A., La Ragione, R.M., Wakawa, A., Armson, B., Mijten, E., Alafiatayo, R., Varga, G. and Cook, A.J.C. (2020) Knowledge, Attitudes and Practices of Veterinarians towards Antimicrobial Resistance and Stewardship in Nigeria. *Antibiotics*, **9**, Article 453. <https://doi.org/10.3390/antibiotics9080453>
- [17] Chea, B., Kong, S., Thim, S., Ban, N., Seng, S., Fernandez-Colorado, C. and Kang, K. (2022) Knowledge, Attitudes, and Practices of Antimicrobial Use and Resistance among Livestock Producers in Cambodia. *Open Journal of Animal Sciences*, **12**, 454-466. <https://doi.org/10.4236/ojas.2022.123034>
- [18] World Bank Group and Asian Development Bank (2021) Cambodia Climate Risk Country Profile. https://climateknowledgeportal.worldbank.org/sites/default/files/2021-08/15849-W_B_Cambodia%20Country%20Profile-WEB.pdf
- [19] Guillemot, D., Carbon, C., Balkau, B., Geslin, P., Lecoeur, H., Vauzelle-Kervroëdan, F., Bouvenot, G. and Eschwège, E. (1998) Low Dosage and Long Treatment Duration of β -Lactam Risk Factors for Carriage of Penicillin-Resistant *Streptococcus Pneumoniae*. *JAMA*, **279**, 365-370. <https://doi.org/10.1001/jama.279.5.365>
- [20] Okeke, I.N., Lamikanra, A. and Edelman, R. (1999) Socioeconomic and Behavioral Factors Leading to Acquired Bacterial Resistance to Antibiotics in Developing Countries. *Emerging Infectious Diseases*, **5**, 18-27. <https://doi.org/10.3201/eid0501.990103>
- [21] Lee, M.H., Lee, H.J. and Ryu, P.D. (2001) Public Health Risks: Chemical and Antibiotic Residues-Review-. *Asian-Australasian Journal of Animal Sciences*, **14**, 402-413. <https://doi.org/10.5713/ajas.2001.402>
- [22] Ström, G., Boqvist, S., Albiñ, A., Fernström, L.-L., Djurfeldt, A.A., Sokerya, S., Sothyra, T. and Magnusson, U. (2018) Antimicrobials in Small-Scale Urban Pig Farming in a Lower Middle-Income Country-Arbitrary Use and High Resistance Levels. *Antimicrobial Resistance & Infection Control*, **7**, Article No. 35. <https://doi.org/10.1186/s13756-018-0328-y>
- [23] Nguyen, V.T. (2020) Handbook Responsible Use of Antibiotics in Livestock Production for Animal Health Workers in Viet Nam. FAO, Rome. <https://www.fao.org/publications/card/en/c/CB0593EN>
- [24] Magnusson, U., Sternberg, S., Eklund, G. and Rozstalnyy, A. (2019) Prudent and Efficient Use of Antimicrobials in Swines and Poultry: A Practical Manual. FAO, Rome. <https://www.fao.org/documents/card/en/c/ca6729en>
- [25] World Organisation for Animal Health (2022) <https://oie-antimicrobial.com/wholesalers-and-retailers/>
- [26] World Organisation for Animal Health (2015) OIE Standards, Guidelines and Resolution on Antimicrobial Resistance and the Use of Antimicrobial Agents. https://web.oie.int/delegatweb/eng/ebook/AF-book-AMR-ANG_FULL.pdf?WAHISPHPESSID=03152ead00d06990fa9066b7b71fcab
- [27] Nuangmek, A., Rojanasthien, S., Patchanee, P., Yano, T., Yamsakul, P., Chotinun, S. and Tadee, P. (2018) Knowledge, Attitudes and Practices toward Antimicrobial Usage: A Cross-Sectional Study of Layer and Pig Farm Owners/Managers in Chiang Mai, Lamphun and Chonburi Provinces, Thailand, May 2014 to February 2016. *Korean Journal of Veterinary Research*, **58**, 17-25. <https://doi.org/10.14405/kjvr.2018.58.1.17>
- [28] Pham-Duc, P., Cook, M.A., Cong-Hong, H., Nguyen-Thuy, H., Padungtod, P., Nguyen-Thi, H. and Dang-Xuan, S. (2019) Knowledge, Attitudes and Practices of Livestock and Aquaculture Producers Regarding Antimicrobial Use and Resistance

in Vietnam. *PLOS ONE*, **14**, e0223115.

<https://doi.org/10.1371/journal.pone.0223115>

- [29] Ekakoro, J.E. and Okafor, C.C. (2019) Antimicrobial Use Practices of Veterinary Clinicians at a Veterinary Teaching Hospital in the United States. *Veterinary and Animal Science*, **7**, Article ID: 100038. <https://doi.org/10.1016/j.vas.2018.09.002>