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Understanding veterinary drug shop workers' knowledge and practices to identify drivers of antibiotic use in Vietnamese livestock farms

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Abstract

Background: Antimicrobial resistance (AMR) is a One Health issue and a major threat to animal and human health. Antibiotic use (ABU) drives AMR development, and several hotspots for ABU, and AMR, in livestock have been identified in Southeast Asia, including Vietnam. There are often multiple drivers of ABU at farms, and to identify all of them there is a need to look beyond farm level.

Objectives: The overall aim of this study was to identify routines and/or competencies, related to antibiotic sales, among veterinary drug shop workers that may be improved in order to decrease the medically non-rational use of antibiotics in livestock production.

Methods: A questionnaire-based survey was conducted at 50 veterinary drug shops in northern Vietnam.

Results: Results showed high education and knowledge levels. According to the respondents, antibiotic treatment advice was almost always provided to the farmers, and the recommended treatment was most commonly based on recommendations for the specific disease. However, farmers had almost never had their animals properly diagnosed. Antibiotics were the most sold drug category, penicillins being the most common. Several broad-spectrum antibiotics were also quite frequently sold. Further, >50% of respondents recommended antibiotics for disease prevention.

Conclusions: Even though education and knowledge levels might be high, several challenges can prevent drug shop workers from contributing to more prudent ABU at farms, for example, lack of proper diagnosis, commercial interests and individual farmer motives, often in combination with poor compliance to regulations.

KEYWORDS
anti-bacterial agents, antibiotic sales, drug resistance, livestock, veterinary pharmacy, Vietnam

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1 | INTRODUCTION

Antimicrobial resistance (AMR), the ability in bacteria to resist antibiotic treatment, poses a major threat to human and animal health worldwide. It is estimated that in 2019, 1.3 million people died from resistant infections, and in this silent pandemic, low- and middle-income countries (LMICs) are the most severely affected (Antimicrobial Resistance Collaborators, 2022). As for humans, AMR negatively affects the health and welfare of animals and by extension, animal productivity (Bengtsson & Greko, 2014; World Bank, 2017).

That antibiotic use (ABU) is what drives AMR development is commonly acknowledged, as well as that this process is accelerated when antibiotics are over- or misused (FAO, 2016; Holmes et al., 2016). Such irrational use is frequently seen in livestock production when antibiotics are used for disease prevention and growth promotion (FAO, 2016; Marshall & Levy, 2011). On a global level, the use of antibiotics in food-producing animals exceeds the use in humans, and ABU in livestock is expected to increase even more as a result of increased demand for animal-source foods (Van Boeckel et al., 2015). Since AMR is a One Health issue, connecting human and animal health together, these circumstances make reducing ABU in the livestock sector critically important.

However, there are many challenges to reducing ABU in livestock, especially in LMICs, where regulations regarding antibiotic sales might not be in place, or more commonly, are not properly enforced for various reasons. For example, regulations regarding the need for a prescription to buy antibiotics are often in place, but over-the-counter (OTC) sales of antibiotics for both humans and animals have for a long time been, and still is common practice in many LMICs (Circular 12/2020/TT-BNNPTNT, 2020; Coyne et al., 2019; European Commission, Directorate-General for Health and Food Safety, 2018; Malijan et al., 2022; Puspitasari et al., 2011; Sakeena et al., 2018; Van Duong et al., 1997; Zellweger et al., 2017).

Another challenge in many LMICs is lack of access to professional animal health services and laboratory capacity, which together with easy access to OTC antibiotics, increases the risk for irrational ABU (Magnusson et al., 2021; Paul & Varghese, 2020). In these settings, veterinary drug shop workers become vastly important in order to mitigate this irrational use.

Vietnam is a relevant example of such a country, where livestock farmers to a large extent visit veterinary drug shops for buying OTC antibiotics, but also for other services. For example, studies have shown that farmers rely heavily on veterinary drug shop workers for advice on when and how to use antibiotics, as well as for diagnosing sick animals (Carrique-Mas et al., 2015; Luu et al., 2021; Nohrborg et al., 2024; Pham-Duc et al., 2019; Phu et al., 2019). A high dependence on veterinary drug shop workers for advice has also been reported from several other Asian countries (Hallenberg et al., 2020; Hassan et al., 2021; Heyman, 2020; Huber et al., 2021). Hence, in Vietnam and other LMICs, the knowledge and practices regarding animal disease symptoms, antibiotics and AMR among drug shop workers may have a significant impact on whether the chosen treatment regime is medically rational and prudent, or not, from an AMR perspective. Subsequently, these veterinary drug shop workers are potential key targets for interventions aiming towards a more rational ABU in livestock in many LMICs.

The overall objective of this study, conducted in Vietnam, was to identify routines and/or competencies, related to antibiotic sales to farmers, among veterinary drug shop workers that may be improved in order to decrease the non-rational use of antibiotics in livestock production. To reach this objective, the study aimed to increase the understanding about veterinary drug shop workers': (1) professional experience and education, (2) routines regarding antibiotic sales, and (3) knowledge about antibiotics, and AMR development and spread.

2 | MATERIALS AND METHODS

2.1 | Study area

Vietnam has a population of nearly 100 million people as of 2023, of which a large share reside in rural areas and is engaged in agriculture (General Statistics Office 2021, 2023; United Nations Population Fund, n.d.). Chicken and pig farming are two of the most important livestock raising activities in the country. Even though the number of large-scale farms is increasing for several livestock species, small-scale production is still dominating (General Statistics Office, 2021).

The current study was conducted in Thai Nguyen province in the northern midlands and mountain areas north of the Vietnamese capital Hanoi (Figure 1). The province is divided into nine districts, where some are mainly rural and others more urban. The human population of the province was 1.3 million in 2022 (General Statistics Office, 2023), and the number of households that kept chicken and pigs in 2016 was 173,000 and 92,000, respectively, which reflects about 2% and 3% of the chicken- and pig-keeping households in the country (General Statistics Office, 2018). In a previously conducted study among chicken farmers in the Thai Nguyen province, the province was selected based on its location, as well as size and distribution of the chicken population (Nohrborg et al., 2024).

The same districts as in the chicken farmers study were included in the current one: Thai Nguyen City, Dong Hy and Vo Nhai, with 360,000, 94,700 and 69,800 inhabitants, respectively, in 2022 (Thai Nguyen Statistics Office, 2023). As previously described (Nohrborg et al., 2024), the majority of the population in Thai Nguyen City lives in urban areas, while the rural population makes up the largest share in Dong Hy and Vo Nhai.

2.2 | Study population and sampling design

Official lists of all registered veterinary drug shops in Thai Nguyen City, Dong Hy and Vo Nhai were obtained from the local authorities in Thai Nguyen province, the sub-Department of Animal Health (sub-DAH). In total, there were 85 listed shops, 50 in Thai Nguyen City (59%), 18 in Dong Hy (21%) and 17 in Vo Nhai (20%).

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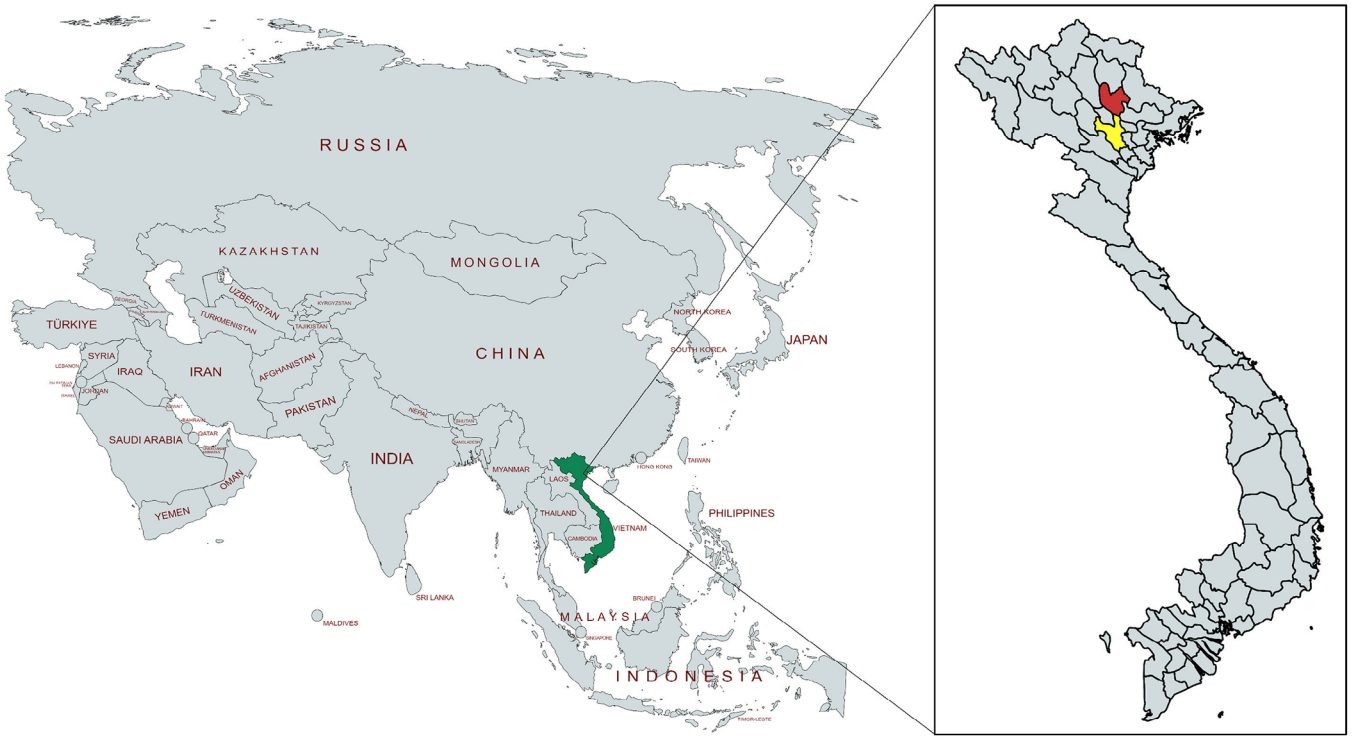

FIGURE 1 Map of the continent of Asia (left) with Vietnam marked in green, and map of Vietnam (right) with the province Thai Nguyen marked in red. Yellow marks the capital province of Hanoi for reference. *Source*: https://mapchart.net, retrieved 18 January 2024, license: https://creativecommons.org/licenses/by-sa/4.0/.

A random sample of 50 shops was taken from the official lists and the sample was stratified according to the proportion of shops in each district. The stratification resulted in 29 shops being selected from Thai Nguyen City, 11 from Dong Hy and 10 from Vo Nhai, using an online randomisation tool (Urbaniak & Plous, 2013).

For each district, a list of shops which were not included in the original sample was kept for possible replacements. In total, 11 shops (22%) needed to be replaced during the field work, due to reasons such as the shop being closed, several shops having the same owner, or the owner/staff not being present at the time of the visit. One shop needed to be replaced because the respondent did not want to finish the interview. If possible, a replacement shop in the same commune was chosen. Only nine shops, instead of 10, could be visited in Vo Nhai district, since there were not enough shops in the replacement list. Therefore, the number of shops visited in Dong Hy was increased from 11 to 12.

2.3 | Data collection

2.3.1 | Questionnaire

To investigate veterinary drug shop workers' sales practices, and knowledge regarding antibiotics and AMR, a structured questionnaire containing 44 questions was developed and divided into the following sections: (a) demographics and shop characteristics, (b) antibiotic sales and advice routines and (c) knowledge about antibiotics and AMR (Supporting Information S1). The questionnaire was developed in English and translated into Vietnamese.

The survey was conducted in face-to-face interview format by one experienced enumerator from the National Institute of Veterinary Research (NIVR), Hanoi. Before starting the field work, the enumerator went through a 1-day training to get familiar with the questionnaire. Two pilot interviews were also performed in the field, in veterinary drug shops not situated in the study area. Feedback on the questionnaire from the training and field test was taken into account and adjustments to the questionnaire were made. The field work took place between 20 February and 1 March 2023, with the first author of this article present. Completing an interview took approximately 15–20 min.

Six out of the 50 drug shop workers were interviewed in other locations than in their veterinary drug shop since they worked in several locations. Three shop workers were interviewed via telephone because they were not present at the shop by the time of visit. Answers were recorded on tablets through the online survey tool platform Netigate (Netigate, n.d.). Each respondent was given 100,000 VND (approximately 4 USD) after the interview, as a compensation for taking time away from their business. The respondents were not aware of the compensation beforehand.

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2.4 | Statistical methods

2.4.1 | Data processing and analyses

The survey data were downloaded from Netigate to Microsoft Excel for processing. Removal of the one unfinished interview was performed and free-text answers were translated from Vietnamese to English and entered to the dataset. The dataset was then imported to Stata version 18.0 (StataCorp, 2023), where descriptive statistics were compiled for all questions. For knowledge questions, number of correct answers, and proportion of correct answers, were generated for each respondent, as well as means for the whole respondent group.

3 | RESULTS

3.1 | Demographics and shop characteristics

In total, 50 veterinary drug shop workers in Thai Nguyen province answered the questionnaire. Respondents had a mean experience of work in a veterinary drug shop of approximately 15 years and the visited shops were small, with a mean number of staff of 1.8 (details for demographics and shop characteristics are in Table S1, Supporting Information S2).

Two thirds of the respondents had an education from college or university, and second most common was having vocational training. Of those who had a college or university education, or vocational training, >90% were trained within veterinary medicine. A little more than half of all respondents had received some training or education regarding animal diseases and treatment, and antibiotic mechanisms and antibiotic treatment recommendations in particular. Most commonly, this education or training had been provided for one or a few days by the sub-DAH or a drug company. Fewer had received any education regarding regulations concerning ABU and sales.

Chickens/hens were the most commonly owned species by farmers visiting the shop. Second most common was owning pigs.

3.2 | Veterinary drug shop worker–farmer relationship and advice routines

According to the drug shop workers, visiting farmers mainly come to them on their own initiative, and in almost 90% of the shops, farmers who come to buy antibiotics had never or seldom had their animals examined by an animal health professional prior to the visit (Table 1). In addition, in almost 90% of shops, farmers seldom or never brought a veterinary prescription when wanting to buy antibiotics. Further, half of the drug shop workers seldom or never asked for a prescription before selling antibiotics.

Treating sick animals was the purpose for recommending antibiotics for all respondents while half of the respondents also recommended antibiotic treatment for disease prevention. According to the respondents, recommending antibiotics for growth promotion was never occurring.

The most considered factors when recommending an antibiotic to a farmer that asks for advice regarding treatment of sick animals were: the treatment recommendations for the particular disease, price and previous feedback on effectiveness. The respondents said they never considered factors such as antibiotics kept most in stock, or having the shortest expiry date. Whether the antibiotic is critically important for human use was not considered either.

Advice regarding treatment length, dosage, administration procedure and preparation of the drug were always, or almost always, given. Also, information regarding withdrawal times was provided by four out of five respondents. Less common was to give advice regarding which animals to treat, how to handle leftover antibiotics or when to stop treatment, for example, in case of adverse effects.

Treatment length and dosage advice were for half of the respondents usually based on package recommendations. For dosage, it was almost equally common to recommend a higher dose than what was stated on the package. Information regarding the risk for/with AMR development was provided to farmers by almost all drug shop workers.

3.3 | Antibiotic sales, recommendations and disposal

The most commonly sold drugs in the shops were antibiotics, followed by vitamins (Table 2). Almost two thirds of respondents kept records of antibiotics sold.

The most commonly sold antibiotics overall, and to poultry farmers in particular, were penicillins and tetracyclines (Table 3). Details regarding specific antibiotic recommendations for poultry are found in Table S3, Supporting Information S2. Macrolides, quinolones, polypeptides and aminoglycosides, which belong to the highest or high priority critically important antimicrobial groups for human use (World Health Organization, 2019), were also among the most commonly sold antibiotics for 20%–25% of respondents.

When taking care of expired/leftover antibiotics in the shop, the most common practice was to throw them in the trash or latrine. It never occurred that those antibiotics were sold to farmers at a cheaper price.

3.4 | Experience and advice regarding ineffective treatment

Almost all respondents said that none, or less than 25%, of the farmers that buy antibiotics to treat sick animals come back and say that the treatment did not work. In case antibiotic treatment was not effective, the most commonly recommended action was to switch to another antibiotic (one third of respondents). To call a veterinarian or animal health worker for advice was less common. For details, see Table S2, Supporting Information S2.

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TABLE 1 Drug shop worker–farmer relationship and advice routines based on a survey among veterinary drug shop workers in Thai Nguyen City, Dong Hy and Vo Nhai districts, Thai Nguyen province, Vietnam.

Question	Option	Number (%)
When farmers come to buy antibiotics in your shop, on who's initiative do they usually come? $n = 50$	Their own initiative	34 (68.0)
	After recommendation from a veterinarian (governmental or private)	9 (18.0)
	After recommendation from other	7 (14.0)
Have farmers that come to you to buy antibiotics had their animals examined by an animal health professional (e.g., veterinarian or animal health worker)? $n = 50$	Always or mostly	3 (6.0)
	Sometimes	3 (6.0)
	Seldom or never	43 (86.0)
	I don't know	1 (2.0)
Do the farmers that want to buy antibiotics bring a veterinary prescription? $n = 50$	Always or mostly	0 (0.0)
	Sometimes	7 (14.0)
	Seldom or never	43 (86.0)
Do you ask for a veterinary prescription before selling antibiotics to farmers? $n = 50$	Always or mostly	9 (18.0)
	Sometimes	16 (32.0)
	Seldom or never	25 (50.0)
For which purposes do you recommend antibiotics to farmers? (multiple choice) $n = 50$	To treat sick animals	50 (100.0)
	To prevent animals from becoming sick	27 (54.0)
	To make animals grow faster/better	0 (0.0)
When recommending an antibiotic to a farmer that asks for advice regarding treatment of sick animals, which factors do you mainly consider? (up to three can be chosen) $n = 50$	Preference of the farmer	11 (22.0)
	Price	28 (56.0)
	That the antibiotic should have a broad treatment spectrum	7 (14.0)
	That the antibiotic should have an as narrow treatment spectrum as possible	10 (20.0)
	Administration route (e.g., mixed in feed, injection or tablets)	2 (4.0)
	Treatment recommendations for the particular disease	41 (82.0)
	What you have most in stock	0 (0.0)
	The antibiotic not being critically important for human use	0 (0.0)
	What has the shortest expiry date	0 (0.0)
	Previous feedback from farmers on effectiveness	23 (46.0)
	Other (specify)	9 (18.0)
Do you give the farmer advice on how to use and handle the antibiotics? $n = 50$	Yes, mostly	48 (96.0)
	Sometimes	2 (4.0)
	No	0 (0.0)
If yes or sometimes, which kind of advice? (multiple choice) $n = 50$	Preparation of the drug (e.g., mixing it with feed or water and preparing injections)	47 (94.0)
	Administration procedure (i.e., how to give the antibiotic)	50 (100.0)
	Treatment length	48 (96.0)
	When to stop treatment (e.g., if adverse effects occur)	4 (8.0)
	Withdrawal times (i.e., the time you should wait before consuming products like eggs, milk and meat from the treated animal(s))	40 (80.0)
	Dosage	49 (98.0)
	Handling of leftover antibiotics	17 (34.0)
	Which animals to treat (e.g., only the sick animals, the whole flock, or in contact animals)	27 (54.0)

(Continues)

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TABLE 1 (Continued)

Question	Option	Number (%)
If you give advice regarding treatment length, what do you usually recommend (when treating the disease for the first time)? $n = 48$	What is stated on the package	24 (50.0)
	What is recommended by veterinary professionals	13 (27.1)
	To treat until the animal(s) begin to recover	0 (0.0)
	To treat until the animal(s) completely cured	9 (18.8)
	Other (specify)	2 (4.2)
If you give advice regarding treatment dosage, what do you usually recommend (when treating the disease for the first time)? $n = 49$	What is stated on the package	24 (49.0)
	What is recommended by veterinary professionals	2 (4.1)
	A higher dose than what is stated on the package/recommended	22 (44.9)
	A lower dose than what is stated on the package/recommended	0 (0.0)
	Other (specify)	1 (2.0)
If you know about antibiotic resistance, do you inform farmers about the risk for/with resistance development? $n = 48$	Yes, often	47 (97.9)
	Sometimes	1 (2.1)
	No	0 (0.0)

TABLE 2 Antibiotic sales, recommendations and disposal in veterinary drug shops in Thai Nguyen City, Dong Hy and Vo Nhai districts, Thai Nguyen province, Vietnam.

Question	Option	Number (%)
What drug category is the most sold in your shop?	Antibiotics	29 (58.0)
	Anthelmintics	0 (0.0)
	Anti-inflammatory drugs	0 (0.0)
	Vitamins and probiotics	19 (38.0)
	Ectoparasiticides	0 (0.0)
	Vaccines	0 (0.0)
	I don't know	1 (2.0)
	Other (specify)	1 (2.0)
Do you keep records of antibiotics sold at your shop?	Yes	29 (58.0)
What do you usually do with expired/leftover veterinary antibiotics?	Throw in the trash/latrine	21 (42.0)
	Send for hazard destruction	4 (8.0)
	Sell to farmers at a cheaper price	0 (0.0)
	Return to drug company/wholesaler	0 (0.0)
	I have never experienced expired drugs	21 (42.0)
	Other (specify)	4 (8.0)

$n = 50$.

3.5 | Knowledge about antibiotics and AMR

Almost all respondents had heard about antibiotic, or antimicrobial, resistance, but the definition varied from a more general definition of drug resistance, to more elaborative explanations about underlying mechanisms such as over- or misuse of antibiotics.

One third of respondents believed that antibiotics are supposed to be used for treating sick animals. Almost twice as many believed that antibiotics should be used for disease treatment and disease prevention (Table 4).

Almost all respondents believed that antibiotics can treat bacterial disease and not all kinds of diseases or diseases caused by viruses. Further, almost all respondents knew that bacteria can become resistant to antibiotics if used in the wrong way or too often.

That antibiotic resistance can make it more difficult to succeed with antibiotic treatment in sick animals was understood by almost all drug

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TABLE 3 Antibiotic classes sold in veterinary drug shops in Thai Nguyen City, Dong Hy and Vo Nhai districts, Thai Nguyen province, Vietnam.

	Number (%)										
Question	TET	MAC	PEN	QLO	TRI/SU	POL	CEP34	CEP12	AMI	ACO	FT
Which are the **most commonly** sold antibiotics in your shop? (up to 3 can be chosen)	29 (58.0)	10 (20.0)	38 (76.0)	12 (24.0)	3 (6.0)	9 (18.0)	1 (2.0)	0 (0.0)	12 (24.0)	11 (22.0)	3 (6.0)
Which are the **most commonly** sold antibiotics to poultry farmers in your shop? (up to 3 can be chosen)	31 (62.0)	10 (20.0)	35 (70.0)	10 (20.0)	3 (6.0)	13 (26.0)	0 (0.0)	0 (0.0)	7 (14.0)	8 (16.0)	3 (6.0)

$n = 50$.

Abbreviations: ACO, amphenicols; AMI, aminoglycosides; CEP12, 1st to 2nd generation cephalosporins; CEP34, 3rd or 4th generation cephalosporins; FT, free text; MAC, macrolides; PEN, penicillins; POL, polypeptides; QLO, quinolones; TET, tetracyclines; TRI/SU, trimethoprim/sulphonamides.

shop workers. A majority of respondents knew that resistant bacteria can spread between animals and through manure, while fewer knew that spread can happen between animals and humans, and through animal-source foods.

The number of correct responses to the 15 knowledge questions varied from 7 to 15 with a mean close to 11. Converted to proportion correct answers, the mean was approximately 0.7. Almost 60% of respondents had a proportion of 0.6–0.8 correct answers.

4 | DISCUSSION

To understand the drivers behind ABU in livestock farms, there is a need to go beyond the practices at farms and look at the broader system in which farmers operate. Drivers may exist in the supply chain of antibiotics to the farmer, and therefore the current study focused on an important player along this chain: the veterinary drug shop workers. Thus, novel findings about Vietnamese veterinary drug shop workers' practices and knowledge related to antibiotics and AMR are presented here.

The visited drug shops were generally small, with few employees, and the main categories of customers were poultry and pig farmers. A majority of respondents had an education from college or university, and almost all respondents had received education in veterinary medicine. Only two previous studies have investigated education level among veterinary drug retailers in Southeast Asia (SEA), both conducted in Cambodia. The first one showed, similar to the current study, that a majority of respondents had a university education (Heyman, 2020), while the other showed that secondary school or high school education was the most common (Chea et al., 2023). Hence, the limited number of studies makes it difficult to put the results from the current study into perspective.

The current study showed that a majority of farmers that came to buy antibiotics did so on their own initiative, and that they almost never had their animals examined by a veterinarian prior to the visit. Another study performed among chicken farmers in the same districts echoes this picture, where the most common response to disease among the chickens was to give drugs from a veterinary drug shop (Nohrborg et al., 2024). To give antibiotics at the first sign of clinical disease was also documented as common practice in another study on Vietnamese chicken farms (Luu et al., 2021), as well as among small-scale pig farmers in Thailand (Hallenberg et al., 2020). In the study by Nohrborg et al., more than half of the farmers also stated that they usually diagnose their animals themselves. As previously described for many LMICs (Coyne et al., 2019; European Commission, Directorate-General for Health and Food Safety, 2018; Hallenberg et al., 2020; Malijan et al., 2022; Zellweger et al., 2017), the current study and the study among chicken farmers in the same districts (Nohrborg et al., 2024) confirm the picture that OTC sales of antibiotics are dominating. It is interesting to note that these OTC sales are commonly occurring in Vietnam even though regulations are in place that prohibit sales of veterinary drugs without a prescription (Circular 12/2020/TT-BNNPTNT, 2020), as well as regulations stating that veterinary drug shops must be officially registered and certified (Law on Veterinary Medicine, 2015). The circumstances of disease treatment without prior diagnosis from a veterinary professional, in combination with extensive sales of antibiotics OTC, increase the risk for incorrect treatment, and subsequently, the risk for resistance development.

Another general complicating factor, relating to the relationship between drug shop workers and farmers, is poor compliance to science-based treatment recommendations and instructions. In the current study, drug shop workers reported that they almost always provided instructions regarding treatment length, dosage, drug administration and preparation and withdrawal times. However, several respondents spontaneously, outside the structured questionnaire, expressed difficulties in getting farmers to follow their advice. The earlier study, conducted among poultry farmers in the same districts, also reflects this (Nohrborg et al., 2024). Even though taking advice from a veterinary drug shop worker was the most common, 20%–25% of farmers in that study did not think they needed any advice on when, and how, to use antibiotics. Similar difficulties with compliance to treatment recommendations have been expressed by veterinary drug shop workers in Cambodia (Heyman, 2020). Other results from a study on Vietnamese farms showed that reliance on veterinary drug shop workers for consultation regarding antibiotic treatment may differ between livestock species kept (Luu et al., 2021). In that study, the majority of chicken farmers used veterinary drug stores for advice, while pig farmers to a larger extent consulted veterinarians.

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TABLE 4 Knowledge about antibiotics and antimicrobial resistance among veterinary drug shop workers in Thai Nguyen City, Dong Hy and Vo Nhai districts, Thai Nguyen province, Vietnam.

Question	Option	Number (%)
What are antibiotics supposed to be used for? (single choice)	Prevent animals from becoming sick	0 (0.0)
	Treat sick animals	17 (34.0)
	Make animals grow faster/better	0 (0.0)
	Prevent animals from becoming sick and make animals grow faster/better	1 (2.0)
	Prevent animals from becoming sick and treat sick animals	32 (64.0)
	Treat sick animals and make animals grow faster/better	0 (0.0)
	Prevent animals from becoming sick, treat sick animals and to make animals grow faster/better	0 (0.0)
Do you think that the following statements are true or false? The correct option is presented.		
(a) Antibiotics can treat all kinds of diseases	False	46 (92.0)
(b) Antibiotics can treat diseases caused by viruses	False	48 (96.0)
(c) Antibiotics can treat diseases caused by bacteria	True	49 (98.0)
(d) Antibiotics are the same as anti-inflammatory drugs	False	31 (62.0)
(e) Animals can become resistant to antibiotics if antibiotics are used in the wrong way/too often	False	22 (44.0)
(f) Bacteria can become resistant to antibiotics if used in the wrong way/too often	True	48 (96.0)
(g) Viruses can become resistant to antibiotics if used in the wrong way/too often	False	49 (98.0)
(h) Resistance against antibiotics can make it more difficult to succeed with antibiotic treatment in animals when they get sick	True	49 (98.0)
(i) Bacteria resistant to antibiotics can spread from one animal to another	True	37 (74.0)
(j) Bacteria resistant to antibiotics can spread between animals and humans	True	28 (56.0)
(k) Bacteria resistant to antibiotics can spread from animals to humans through animal-source foods, for example, meat	True	13 (26.0)
(l) Leftovers of the antibiotic can be transferred to meat, milk or eggs	True	48 (96.0)
(m) Bacteria resistant to antibiotics can spread through manure from animals	True	32 (64.0)
(n) Antibiotic resistance in human bacteria is only linked to the use of antibiotics in humans and not in animals	False	18 (36.0)
Item	**Measure**	**Number (%)**
Correct responses to knowledge questions (maximum of 15)	Mean	10.7 (71.3)
	Median	11
	Range	7–15 (46.7–100.0)

$n = 50$.

Half of the drug shop workers believed that antibiotics are supposed to be used not only for disease treatment, but also for prevention. This was reflected in their practices, as half of the respondents reported that they recommend antibiotics for disease preventive purposes, which may increase ABU, and then AMR. The previous study among chicken farmers in the same districts also showed that antibiotics were used for disease prevention in two thirds of farms (Nohrborg et al., 2024). High use of antibiotics for disease prevention in the livestock sector has also been described in several other studies conducted in Vietnam and other SEA countries (Carrique-Mas et al., 2015; Coyne et al., 2019; Luu et al., 2021; Nguyen et al., 2016).

Treatment recommendations for the particular disease were the most commonly considered factor when recommending an antibiotic to a farmer that asks for advice regarding treatment of sick animals,

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which may obviously be beneficial from an AMR mitigation perspective. Nevertheless, choosing the accurate antibiotic is complicated by the lack of a proper diagnosis of the animal(s) prior to the veterinary drug shop visit. This situation is a recurring issue in many LMICs because of farmers' lack of access to, or use of, affordable professional animal health services and diagnostic testing (Dione et al., 2021; Magnusson et al., 2021; Nohrborg et al., 2024; Paul & Varghese, 2020). Without a specific diagnosis, the drug shop staff is likely prone to choose a broad-spectrum antibiotic that can treat a wide range of pathogens, but this practice unfortunately also drives AMR development to a larger extent than narrow-spectrum antibiotics (Modi et al., 2014; Rao, 1998; Spaulding et al., 2018). Even though penicillins, which are narrow-spectrum antibiotics, were the most commonly sold antibiotic class in this study, several broad-spectrum antibiotic classes were also frequently sold in many shops. This is worrisome, both for the increased risk of resistance development in treated animals, but also because several of these broad-spectrum antibiotic classes, macrolides, quinolones, aminoglycosides and polypeptides, are listed as critically important for human use by the World Health Organization (WHO; World Health Organization, 2019). Numerous studies in Vietnam and other SEA countries have also shown that use of critically important antimicrobials is frequently occurring in poultry farming (Carrique-Mas et al., 2015; Cuong et al., 2019; Luu et al., 2021; Malijan et al., 2022). In addition, the current study found that the most common recommendation when antibiotic treatment was not effective was to switch to another antibiotic, which may further increase the risk for AMR development. Contacting a veterinarian for further disease investigation and advice would have been more favourable, but was unfortunately uncommon.

The knowledge level among the drug shop workers about antibiotics and AMR in general seemed to be quite high, especially regarding antibiotic efficacy and the development and risks of AMR. Even so, it appears that knowledge regarding the One Health aspect of AMR, that is, the links between AMR in humans and animals, could be improved. Only a little more than half of respondents believed that AMR bacteria could spread between animals and humans, and only one out of four that AMR bacteria could spread to humans through animal-source foods. Further, about two thirds believed that AMR in humans is only linked to ABU in humans and not in animals. Lacking knowledge regarding the One Health aspect of AMR has previously been described among veterinary drug retailers in Cambodia, as well as veterinary practitioners in Uganda (Dione et al., 2021; Heyman, 2020). Compared to the knowledge level about antibiotics and AMR among poultry farmers in Thai Nguyen province (Nohrborg et al., 2024), the knowledge was generally higher among drug shop workers, as would be expected. However, as for the drug shop workers, the One Health aspect of AMR was where knowledge among the poultry farmers was lacking the most.

Antibiotics was the most commonly sold drug category in the visited shops, making them an important source of income for veterinary drug shops. It is reasonable to believe that this may create a conflict between commercial interests and what is considered responsible ABU from an AMR perspective. This means that even though the education level, and knowledge about antibiotics and AMR, was generally high among the drug shop workers, there is still a considerable risk that their sale practices contribute to over- and misuse of antibiotics at farms. Clearly, this conflict between interests is enabled by a system with lacking enforcement of regulations regarding the need for a prescription to buy antibiotics. The conflict is also further exacerbated by individual farmer drivers for ABU, for example, economic interests, which drug shop workers need to adapt to in order to keep their customers. Where to find the incitements for change towards a more prudent use of antibiotics in such a system is therefore a major challenge. However, by looking beyond farm level, and understanding more about common AMR-related practices in the antibiotic supply chain, it is hopefully possible to bring guidance towards successful interventions.

5 | CONCLUSION

In conclusion, this study shows that even though education level, and knowledge about antibiotics and AMR, may be high among Vietnamese veterinary drug shop workers, there are multiple challenges preventing them from effectively contributing to prudent use of antibiotics in livestock farms. Lack of proper diagnosis of sick animals and competing commercial interests, in a LMIC setting where implementation of regulations is insufficient, are some of the major challenges. As a result, antibiotics are sold OTC to a large extent, including broad-spectrum antibiotics critically important for human use, making this a One Health issue. This study highlights the need to take a broader approach when aiming for interventions to reduce, and apply a medically rational use of, antibiotics in farms, including other key actors than just farmers. It also shows that increasing knowledge among veterinary drug shop workers is not necessarily what is needed, but other interventions that help finding incitements for change.

5.1 | Limitations of the study

In this study, official registers of veterinary drug shops were used as sampling frames. When the field work was initiated, it was noticed that there were over-coverage in the frames since six shops had either closed, stopped selling drugs or were duplicates of other shops in the lists. In addition, six shops needed to be replaced due to the owner/staff not being present. This negatively impacted the randomness of the sample since replacements shops were not selected randomly.

Further, different kinds of biases need to be considered when interpreting results from a questionnaire-based survey, for example, desirability and recall bias.

AUTHOR CONTRIBUTIONS

Sandra Nohrborg: Conceptualisation; data curation; formal analysis; investigation; methodology; project administration; visualisation; writing—original draft; writing—review and editing. **Thinh Nguyen-Thi**: Investigation; methodology; project administration; resources; supervision; writing—review and editing. **Huyen Nguyen Xuan**: Investiga-

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tion; Project administration; Resources; Supervision; Writing—review & editing. **Yen Luu Thi Hai**: Investigation; writing—review and editing. **Johanna Lindahl**: Formal analysis; methodology; validation; writing—review and editing. **Sofia Boqvist**: Conceptualisation; methodology; validation; writing—review and editing. **Josef D. Järhult**: Conceptualisation; Methodology; Validation; Writing—review & editing. **Ulf Magnusson**: Conceptualisation; funding acquisition; methodology; project administration; resources; supervision; validation; writing—review and editing.

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CONFLICTS OF INTEREST STATEMENT

The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses or interpretation of data; in the writing of the manuscript or in the decision to publish the results.

DATA AVAILABILITY STATEMENT

The data have been submitted to the SND public repository at https://hdl.handle.net/20.500.12703/4973.

ETHICS STATEMENT

The study was conducted according to the guidelines of the declaration of Helsinki, and approved by the Institutional Review Board of Hanoi School of Public Health (HUPH; ref. no. 022–457/DD-YTCC). Informed consent was obtained from all respondents that participated in the study prior to the start of the interviews.

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PEER REVIEW

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