



Article

A Mixed-Methods Approach to Identify Farmers' Perception and Practices Regarding Antibiotic Use in Vietnam

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Abstract: Antibiotic resistance (ABR) is one of the greatest global health concerns. The growth of food animal farming has challenged efforts to reduce unnecessary antibiotic use (ABU) and is linked to the rapid increases in ABR. This mixed-methods sociological study was conducted between 2016 and 2017, in a sample of 100 animal farmers in southern Vietnam, aiming to characterize their perception of ABU and identify factors influencing their practice. Data were collected from a structured questionnaire investigating characteristics of social demographics and farm style, farmers' ABU perception and practices, sources of ABU information and the intention to reduce ABU. Generalized linear models were built to investigate potential influencing factors associated with ABU perception and practices. The results show a majority of farmers had an unfavourable perception of ABU. Only 13% correctly knew antibiotics were used for treating bacterial infections. The inappropriate practice of ABU for non-therapeutic purposes was found in almost two-thirds of the farmers (59.4%). Data from the multivariate analysis showed: (1) a significant association between an unfavourable perception of ABU and inappropriate practices, (2) an inverse influence of participation in training workshops to a favourable perception of ABU, but also (3) an inverse influence of participation in training workshops to inappropriate practices of ABU. The results suggest that the local training events that are usually put on by commercial companies do not assist farmers to effectively reduce ABU. On the contrary, these events seem to promote their use. We recognize the complexity of effectively managing appropriate ABU on farms in order to reduce ABR in Vietnam. We conclude that legislation and enforcement needs to be tightened to reduce sale of antibiotics to farmers without veterinarian prescription, and advertising and influence of commercial stakeholders needs to be highly moderated so that they do not unduly promote the unregulated use of antibiotics on farms. Household farmers are important stakeholders in the efforts to reducing ABU and preventing ABR, and therefore should be engaged more effectively.

Keywords: antibiotic use; antibiotic resistance; Vietnam; farmers; animal health; perception; practices



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1. Introduction

The emergence of antibiotic resistance (ABR) threatening public health is one of the greatest global concerns (Boeckel et al. 2017). Some global regions, such as the European Union, the Eastern Mediterranean, or the Americas, have responded with policies limiting antibiotic usage (ABU) in farming (FAO 2016b; Marshall and Levy 2011; O'Neill 2014; OIE 2016). Despite the call for a sustained decrease without major impacts on productivity, smallholders were still seen to suffer losses due to the ban on all growth-promoting antibiotics in food-animal production (Kahn 2016). Around 80% of small and medium

Swedish and Danish farmers went out of business due to poor profitability over the 20 years spanning the ban between 1993 and 2013 (Kahn 2016).

Vietnam is a largely agricultural country with a developing animal husbandry system. It hosts many small-hold farms—defined as owning less than 20 pigs or 100 head of poultry for commercial purposes. Small-hold farms dominate the livestock sector (70% and 75% of all pig and chicken farms in the country, respectively) and contribute significantly to total livestock products (30%) in Vietnam (GSO 2016). However, there has been a lack of policies that manage farming risks and support livelihoods for farmers in general (Tuan 2010). In 2017, Vietnam's Ministry of Agriculture and Rural Development (MARD) promulgated the National Action Plan to combat the development of ABR. This included the plan to ban the use of antibiotics for growth promotion purpose and then for non-treatment purpose in animal husbandry, to take effect from 2020 (MARD 2017). However, implementation of the plan has been challenged by the sheer number of small-scale farms, and the fact that many household farms maintain unfavourable routines such as poor management practices or insufficient biosecurity (Tra et al. 2015). Furthermore, these farms also administer high levels of antibiotics for prophylactic purposes as a solution for poor productivity and the high incidence of infectious diseases (Carrique-Mas et al. 2015). To date, we have little understanding of farmers' perceptions of ABU and their motivations for ABU practices. There are limited studies of farming uses of antibiotics in Vietnam, a few of which conclude that farmers needed to improve their understanding on the appropriate use of antibiotics (Anh et al. 2020; Chi et al. 2017; Kim et al. 2013; Pham-Duc et al. 2019). However, the previous studies did not investigate the limitations of farmers' knowledge about ABU, or their relevant perceptions and practices on their farms. This study aims to characterize smallholder farmers' perception and practices towards ABU, and the factors influencing their practices of ABU for food animal production. Gaining this knowledge is an important step towards implementing feasible intervention strategies and supporting the enforcement of AB surveillance and stewardship in the animal sector in Vietnam.

2. Materials and Methods

2.1. Study Site

The study was implemented at Cho Gao district, Tien Giang province. This province located in the Mekong River Delta region in the South of Vietnam, where income is mainly from fruit plantations and animal husbandry (Pham et al. 2021). Between 2010 and 2019, Tien Giang province had higher pig and poultry populations and densities compared to other twelve provinces in the Mekong Delta (GSO 2019a). Cho Gao district is an area specializing in both pig and poultry production, with 160,000 pigs and 2,160,000 poultry accounting for 27% and 18% of those in Tien Giang in 2019. The density of pigs (679 heads/km²) and poultry (9160 heads/km²) in Cho Gao were more than double the provincial rates, which were estimated at 233 pigs and 4837 and chickens per km² (GSO 2019b).

2.2. Ethical Considerations

The study was approved by an ethics board at University of Oxford (OxTREC 38-15) and the People's Committee of Tien Giang province (2443/UBND-KTN). Written and verbal permission for recorded interviews was obtained from each respondent via the informed consent form and prior to each of the interviews, where appropriate.

2.3. The Study Population

The sample size was calculated using Slovin's formula for when there is uncertainty about a population's behaviour (Slovin 1960). According to data available from the statistical offices at the study site, there were about 7000 family farms in total ($N = 7000$). A 90 percent confidence level was used to establish the sample size ($e = 0.1$). The sample size was determined to be 100 farms, corresponding with 100 farmers who would participate in the study. A convenience sample approach was used to identify participants with an equal

number of pig and chicken farms at different farming sizes. Farm sizes were categorized as: household size (<500 chickens or <50 pigs), small size (<5000 chickens or <100 pigs) and medium size (<20,000 chickens or <1000 pigs). Recruitment criteria for selecting participants were: (1) individuals with primary responsibility for the selected farm; (2) more than 18 years old; (3) with three or more years of farming experience; and (4) giving written consent for participating in the research project.

All farmers in the communities were invited to pre-recruitment meetings, where the researchers introduced the project's aims and activities, and invited people to indicate whether they would like to join the study. The researchers collected primary information on farms type, farm size, and years of farming experience from the interesting farmers. One hundred farmers who met the inclusion criteria and completed the initial survey were recruited to participate with their written informed consent (Appendix A).

2.4. Data Collection

Prior to the survey, a pilot study was conducted to validate the questionnaire. Three groups of 8 farmers, who were not participants in the study, were asked to complete the pilot questionnaire and then provide comments and feedback on the appropriateness of language and structure of the questionnaire (Babbie 2020).

Structured interviews were carried out with 100 farmers. The questionnaire included a set of both closed- and open-ended questions to collect data on the socio-demographic characteristics of participants; farm characteristics; farmers' perceptions and practices of ABU; the information sources they sought in making decision on ABU; and their intention, if any, to apply alternatives to antibiotics for preventing animal infectious diseases (Appendix B).

The term "perception" was defined as the cognition, comprehension or understanding that individuals gained from their past-experience (McDonald 2012). In this study, the perception was measured as the level of perception that farmers had towards ABU. To assess farmers' perception of ABU, farmers' answers to the open-ended questions defining their comprehension or understanding of ABU (Austin and Sutton 2014). Statements were categorized as demonstrating favourable, moderate, or unfavourable perception of ABU via being compared to technical facts, which were considered as the correct knowledge, published by WHO, FAO and OIE as references (FAO 2016a; OIE 2016; WHO 2015).

The term "practice" in this study means the habits of ABU on farms for different purposes (FAO 2011). To investigate farmers' practices of ABU, the questionnaire focused on the situations that farmers using antibiotics for their food animals, such as when animals got sick, disease outbreaks or seasonal changes, for prevention or for growth promotion. To analyse the ABU practice, we used the classification of therapeutic and non-therapeutic as suggested by McEwen and Fedorka-Cray (2002). For therapeutic purposes, antibiotics were used for treating diseased individuals or groups, which might include some animals that were not yet sick or were sub-clinical. For non-therapeutic purposes, classified as disease prevention or growth promotion, antibiotics were used for healthy animals for routine disease prevention or promoting feed efficiency (Appendix C).

2.5. Data Modelling

Generalized linear models were built to investigate potential risk factors associated with the following two outcomes: ABU perception and the practice of ABU on farms (Appendix D). Variables were considered as a candidate for multivariate analysis based on their plausibility and a p -value < 0.1 in the univariate analyses. Candidate variables, including farmers' demographic information and farming characteristics, were ranked by their degree of significance, and were included in the models starting with the most significant and using a stepwise forward approach. In the final multivariate models, variables were retained if their p -value was < 0.1. All interactions between all significant variables in the model were assessed. The level of significant at less than 0.1 was chosen because the small sample size could influence the power of the analysis (Kim and Choi

2019). This study examines the interaction of different variables which may have significant influence on farmers' perceptions and practices. If the analysis adopted a conventional level of significance, such as at 0.05, which has commonly been proposed for use in studies with large sample sizes, some influencing factors may not be recognized and included in this study (Wasserstein and Lazar 2016).

3. Results

3.1. General Characteristics of Farms and Farmers

A total of 100 respondents, consisting of 53 and 47 chicken and pig farmers, respectively, were recruited in this study. In this cohort there was a range of farming scales and characteristics of respondents, such as social demographics, attitude towards the necessity of ABU and intention to reduce ABU. Most of the study farmers owned small, (44, 44%) or medium-sized commercial farms (37, 37%). More than half of them were male participants (65%), and more men were chicken farmers (39/53, 74%). The median number of years of animal farming experience was 7 and 12 among chicken and pig farmers, respectively. The majority of the 100 farmers were older than 40 years old (71, 71%), with a median age of 49 years old. Most farmers (77, 77%) had an educational level of secondary school or above. Over two-thirds of the participants (69, 69%) acknowledged that ABU was not very necessary in food animal husbandry, and a third of farmers (31, 31%) shared their intention to reduce ABU in their farming practice (Table 1).

Table 1. Participants' and farms' characteristics.

	Types of Farms		
	Total (n = 100)	Chicken (n = 53)	Pig (n = 47)
1. Gender			
Female	35	14 (26.4%)	21 (44.7%)
Male	65	39 (73.6%)	26 (55.3%)
2. Age (median, (IQR))	49 (39, 55)	47 (36, 54)	49 (40, 56)
≤40	29	17 (32.1%)	12 (25.5%)
>40	71	36 (67.9%)	35 (74.5%)
3. Education			
Secondary & above	77	43 (81.1%)	34 (72.3%)
Primary	23	10 (18.9%)	13 (27.7%)
4. Years of farming experience (median, IQR)	10 (5, 15)	7 (5, 13)	12 (9, 20)
3–6 years	31	25 (47.2%)	6 (12.8%)
≥7 years	69	28 (52.8%)	41 (87.2%)
5. Training participation in past 12 months	2 (1, 5)	3 (0, 4)	2 (1, 5)
n ≥ 2	65	36 (67.9%)	29 (67.1%)
n < 2	35	17 (32.1%)	18 (38.3%)
6. Farming scale			
Household size	19	12 (22.6%)	7 (14.9%)
Small size	44	26 (49.1%)	18 (38.3%)
Medium size	37	15 (28.3%)	22 (46.8%)
7. Assessing antibiotic need			
Not very necessary	69	33 (62.3%)	36 (76.6%)
Very necessary	26	18 (34%)	8 (17%)
No idea	5	2 (3.8%)	3 (6.4%)

Table 1. *Cont.*

	Types of Farms		
	Total (n = 100)	Chicken (n = 53)	Pig (n = 47)
8. ABU perception			
Favourable	13	6 (11.3%)	7 (14.9%)
Moderate	50	28 (52.8%)	22 (46.8%)
Unfavourable	37	19 (35.9%)	18 (38.3%)
9/ ABU practices			
Only used for therapeutic purposes	39	18 (33.9%)	21 (44.7%)
Used for non-therapeutic purposes	57	33 (62.3%)	24 (51.0%)
Not identified	4	2 (3.8 %)	2 (4.3%)
10. Intention to reduce ABU			
Yes	31	17 (32.1%)	14 (29.8%)
No	69	36 (67.9%)	33 (70.2%)

3.2. Local Training Events for Farmers

The Sub-Department of Animal Health and Husbandry (SDAH) of Tien Giang province reported that about 40 training events for farmers had taken place in the study area during the previous year. Of these, only 20% were led by SDAH to communicate with farmers about animal diseases and prevention, and the remaining were organized by veterinary drug companies for advertisement purposes. Three-quarters of the study farmers (76%) reported that they had participated in these training events. Sixty-five farmers (65%) took part in at least two training events in the previous year. Of these, more farmers were from small (63.6%) or medium (81.1%) farms rather than household (36.8%) farms. Farmers recalled being provided with information on farming skills, animal diseases, the effectiveness or benefits of veterinary medicines including antibiotics, on preventing animal diseases, treating infections, and promoting animal productivities. No farmers mentioned ABR or potential adverse effects of ABU as topics presented in the events. Farmers preferred to participate in events organized by vet-drug companies, because these companies invited experts in veterinary medicine or animal husbandry to give talks about animal disease symptoms and diagnosis, medicine for prevention and/or treatment. Moreover, they held the trainings in better venues and offered participants gifts, such as product samples or souvenirs, as incentives for participation.

3.3. Farmers' Perception of Antibiotic Use

Understanding of farmers' perception of ABU was built using questions asking them to give definitions of antibiotics and their understanding of the effects of ABU (Appendix B). Of the one hundred farmers in this study, eighteen farmers (18%) could not give any definition of antibiotics (Question 27). Of the other eighty-two farmers who did answer this question, a minority (16/82, 19.5%) could answer that "antibiotics are drugs to treat infectious diseases caused by bacteria". The majority of farmers defined antibiotics as substances "for treatment and prevention of animal diseases" (60/82, 73.2%). The six remaining farmers (7.3%) defined antibiotics as "health benefit supplements" or "vaccines". When asked about their understanding of the effects of ABU (Question 28), the majority of the 100 farmers described that antibiotics could be used for treatment (91%) and prevention (69%). A small group of farmers (20%) mentioned the use of antibiotics for growth promotion. There were two farmers who gave no answers because they had no ideas about ABU on their small farms.

The answers for these two questions were used to categorize all farmers into groups having favourable, moderate, and unfavourable perception of ABU (Appendix C). Thirteen farmers (13%) correctly defined antibiotics and described the effects of ABU in "killing bacteria" were categorised as those having a favourable perception of ABU. Half of partici-

pants (50%) were categorized into the group with moderate perception of ABU, defining antibiotics to be used for treatment or prevention for animal disease without any specific information on any type of disease or pathogen. The group with unfavourable perception of ABU included thirty-seven farmers (37%) who either could not provide a definition for antibiotics or a description of its effects, or describe the effects of antibiotics to be for promoting animal growth (Table 1).

3.4. The Practice of Using Antibiotics for Non-Treatment Purposes

In this study, four farmers (4%) reported not knowing about ABU for animals on their farms because that was decided by other people (their relatives or a local animal health worker). The other ninety-six farmers (96%) reported that ABU for animals in farms were for treatment (89, 89%), routine prevention (53, 53%) and growth promotion (12, 12%) purposes. Fifty-seven of ninety-six farmers used antibiotics for both treatment and non-treatment purposes (Table 1). These farmers described antibiotics being used monthly for “routine prevention” and with “sub-therapeutic dose” when no animal had any clinical signs of illness. For example, a farmer who had previously experienced ‘Fowl Cholera’ in his two-months old chickens said: “*I would use some kinds of antibiotics such as Enrofloxacin or Neomycin, combining with B-complex, vitamin C for an active prevention, to build up their antibodies against disease infections*”. Those reporting to use antibiotics for growth promotion explained that it was to improve feed efficiency and daily weight gain. We conclude that the use of antibiotics for non-treatment purposes was to reduce diseases and promote growth, and therefore maximize productivity.

3.5. Factors Related to Perception and Practices of Antibiotic Use

To identify the factors associated with an unfavourable perception of ABU and the practice of ABU for non-treatment purposes, nine variables related to farmers’ demographic information and farming characteristics were considered in the analysis. These were (1) gender, (2) age, (3) education level, (4) years of experience, (5) farming scale, (6) types of farms, (7) training participation, (8) assessing antibiotic need, and (9) intention to reduce ABU.

Five factors were identified via univariate analysis to associate with an unfavourable perception of ABU ($p < 0.1$) (Table 2). The results of the multivariate analysis suggested that three factors associated with this unfavourable perception were attending too few local training courses (up to two) [OR 2.91, 95% CI (1.08–7.82)], having the education at primary level [OR 2.96, 95% CI (1.02–8.50)], having the education at primary level [OR 2.93, 95% CI (1.07–8.02)] (Appendix D—Table A1).

Four factors were identified via univariate analysis to be associated with the practice of ABU for non-therapeutic purposes ($p < 0.1$). These factors also remained significant in multivariate analysis, including farming at small scale [OR 2.5, 95% CI (0.92–6.49)], attending two or more local training courses, [OR 2.4, 95% CI (1.4–11.2)], not intending to reduce ABU in farming practices [(OR 3.39, 95% CI (1.29–8.91)]; and having unfavourable ABU perception [(OR 2.73, 95% CI (1.0–7.52)] (Appendix D—Table A2).

Generally, the multivariate analysis showed two salient results. The first was a significant association between an unfavourable perception of ABU and inappropriate practices of ABU; and the second was an inverse influence of training-workshop participation to a favourable perception of ABU and inappropriate practices of ABU. The fewer farmers who participated in training events were found to be associated with the unfavourable ABU perception among farmers; however, the more they participated in these training events, the more they adopted practices of ABU for non-therapeutic purposes.

Table 2. Farmers’ perceptions of ABU as a function of potential influencing factors.

	Farmers’ Perception of ABU			Sig.
	Total (n = 100)	Unfavourable	Moderate to Favourable	
1. Gender				
Female	35	18 (51.4%)	17 (48.6%)	0.028
Male	65	19 (29.2%)	46 (70.8%)	
2. Age				
≤40	29	12 (41.4%)	17 (58.6%)	0.562
>40	71	25 (35.2%)	46 (64.8%)	
3. Education				
Secondary& above	77	24 (31.2%)	53 (68.8%)	0.027
Primary	23	13 (56.5%)	10 (43.5%)	
4. Year of experience				
3–6 years	31	12 (38.7%)	19 (61.3%)	0.812
≥7 years	69	25 (36.2%)	44 (63.8%)	
5. Farming scale				
Household size	19	11 (57.9%)	8 (42.1%)	0.05
Small size	44	17 (38.6%)	27 (61.4%)	
Medium size	37	9 (24.3%)	28 (75.7%)	
6. Training participation				
n ≥ 2	65	19 (29.2%)	46 (70.8%)	0.028
n < 2	35	18 (51.4%)	17 (48.6%)	
7. Assessing antibiotic need				
Not very necessary	69	28 (40.6%)	41 (59.4%)	0.159
Very necessary	26	6 (23.1%)	20 (76.9%)	
No idea	05	3 (60%)	2 (40%)	
8. Intention to reduce ABU				
No	69	26 (37.7%)	43 (62.3%)	0.833
Yes	31	11 (35.5%)	20 (64.5%)	
9. ABU practices				
Only using for theraputic purposes	26	5 (19.2%)	21 (80.8%)	0.037
Using for non-therapeutic purposes	70	29 (41.4%)	41 (58.6%)	
Not identified	4	3 (75%)	1 (25%)	

4. Discussion

Since the recognition that use of antibiotics in food animal production is an important contributor to human infections with ABR bacteria, the public health sector has called for action to reduce the widespread use of non-therapeutic antibiotics in animals to preserve antibiotic sources (Martin et al. 2015; Landers et al. 2012). One of the major recommendations is changes in ABU practices among farmers. However, our understanding of farmers’ knowledge of ABU and their ABU practices is still poor (Speksnijder and Wagenaar 2018). Therefore, the aim of this study was to characterize smallholder farmers’ perception and practices towards ABU to find feasible solutions for engaging them in efforts to reduce ABU on farms, especially in the context of small food animal farming in Vietnam.

The first finding is that the farmers had an unfavourable perception of ABU. A few of them (13%) correctly knew that antibiotics were used for the treatment of bacterial infections. Generally, they perceived that antibiotics were drugs to treat or prevent animal diseases, but not specific types of diseases. Some farmers even defined antibiotics as “health benefit supplements” used to increase antibodies in animals. Consequently, this

incorrect understanding implied that antibiotics were harmless and beneficial to animal health, which could encourage them to use antibiotics indiscriminately. This is similar to the case described in an anthropological study in the Philippines that the anti-tuberculosis drug isoniazid was believed to be a “vitamin for the lungs”, resulting in the common belief among fishermen and farmers that the medication was useful for weak lungs and promoted it for self-treatment (Nichter 1994). The study results indicated misconceptions among lay people, such as farmers, about the conditions requiring antibiotics (Sadiq et al. 2018).

Regarding ABU practices, the data in this study suggested that farmers still conducted inappropriate practices with the common use of ABs for non-therapeutic purposes (59.4%). Antibiotics have become a “quick-fix” approach to improve animal care and productivity (Willis and Chandler 2019). Data in this study showed a significant association between unfavourable perception of ABU and inappropriate ABU practices. Moreover, data showed inappropriate ABU practices were associated with no intention to reduce ABU. The literature suggests that poor understanding of ABR could lower farmers’ motivation to change their behaviour and to adopt prudent ABU (Eltayb et al. 2012; Friedman et al. 2007; Marvin et al. 2010; Visschers et al. 2015). Therefore, better equip farmers with appropriate/favourable and sufficient knowledge of ABU should be one of the first components for reducing the unnecessary and inappropriate ABU (Alarcon et al. 2014). Moreover, ‘learning from error’ could be a training approach to influence these farmers. The trainings should highlight examples of inappropriate ABU and the adverse effects of ABU to both animal and human health. The purpose is to let farmers recognize their own errors and remind them of the consequence.

The level of participation in the local training events could be an intermediate variable affecting a relationship between perception and practice. The results in this study showed that less participation in the local training events was associated with the unfavourable perception of ABU among farmers. However, conversely, the more they participated in these training events (more than two events), the more they adopted ABU for non-therapeutic purposes, suggesting that information provided by these training events was not favourable to reducing ABU, and may even promote it. Although offered to farmers as ‘training’ events, the feed companies use these platforms to promote products which often contain antibiotics. In a similar way to public health activists calling for restrictions on the content of tobacco advertising, the content of these industry-sponsored ‘training’ events should be monitored (Saffer and Chaloupka 1999). These events are important sources of information about animal care for farmers, but the content needs to be managed to ensure that they promote the safe and appropriate ABU as well as warning for the negative impact from any inappropriate ABU to the development of ABR.

Study Limitations

One limitation of this study was the analysis based on a combination of pig and chicken farms. In the initial study design, there was an assumption that the difference in animal type on farm could influence farmers’ perception and practices of ABU. However, data showed that there was not any association. It could be the outcome of farmers being flexible to often switch between rearing pigs or chickens or operate mix-farms to adapt with the fluctuation of the market’s price and demand. These lead to farmers having experiences in ABU for both chicken and pigs.

5. Conclusions

This study is one of the first to describe the perceptions and motivations of farmers in Vietnam in their use of antibiotics for food animal production.

In summary, the majority of farmers in this study had unfavourable perceptions of ABU, and they conducted inappropriate ABU practices on their animal farms. An unfavourable perception of ABU was found to be significantly associated with inappropriate ABU practices. Participation in the training events, which were mainly held by commercial companies, was identified as the risk factor for the inappropriate practices of ABU among

farmers. Although lower participation in these training events was associated with a worse understanding of ABU in farmers, the more they participated in these training events, the more they adopted ABU for non-therapeutic purposes.

Although there has been legislation since 1993 that veterinary medicine must be used with instructions or prescription of veterinarians, antibiotics are still commonly dispensed without prescription. More recently these activities have been regulated by MARD (MARD 2020). The fact that legislation is incomplete and largely overlooked by regulators, suppliers and users suggests that it may be a long journey to effectively manage ABU and phasing out the habit of self-medication on animal farms in Vietnam.

We conclude that in Vietnam, legislation and enforcement needs to be tightened to reduce sale of antibiotics to farmers without veterinarian prescription, and advertising and influence of commercial stakeholders needs to be highly moderated so that they do not unduly promote the unregulated use of antibiotics on farms.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of OXTREC (38-15) and the People's Committee of Tien Giang province (2443/UBND-KTN, 2016).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Quick Survey (For Sample Recruitment)

1. Name of informant:
2. Gender: ☐ Male ☐ Female
3. Years of birth:
4. Position: ☐ Farm owner ☐ Decision maker ☐ Worker on farm
5. Address:
6. Telephone:
7. Farm characteristics: ☐ Having pond(s) ☐ Nearby river ☐ Others
8. Types of livestock animals and (b)quantity:
 - ☐ Chicken (b)
 - ☐ Pig (b) Sow: Finisher: Piglet:

9. When do you want to start a new circle of farming?
10. How many animals will you keep in the next farming circle?
 - a. Chicken:
 - b. Pig:
11. Via the meeting, have you known well our project?
 - ☐ Yes
 - ☐ No
12. Are you aware of your benefits and potential harms if you participate in our project?
 - ☐ Yes
 - ☐ No
13. Are you aware of your benefits and potential harms if you participate in our project?
 - ☐ Yes
 - ☐ No
14. Are you aware of your benefits and potential harms if you participate in our project?
 - ☐ Yes
 - ☐ No
15. Are you aware of your benefits and potential harms if you participate in our project?
 - ☐ Yes
 - ☐ No
16. Are you aware of your benefits and potential harms if you participate in our project?
 - ☐ Yes
 - ☐ No
17. Are you aware of your benefits and potential harms if you participate in our project?
 - ☐ Yes
 - ☐ No
18. Are you aware of your benefits and potential harms if you participate in our project?
 - ☐ Yes
 - ☐ No
19. Are you aware of your benefits and potential harms if you participate in our project?
 - ☐ Yes
 - ☐ No
20. Are you aware of your benefits and potential harms if you participate in our project?
 - ☐ Yes
 - ☐ No
21. Are you aware of your benefits and potential harms if you participate in our project?
 - ☐ Yes
 - ☐ No
22. Are you aware of your benefits and potential harms if you participate in our project?
 - ☐ Yes
 - ☐ No
23. Would you like to be our project participant?
 - ☐ Yes
 - ☐ No
- a. Would you like to participating in our interviews?
 - ☐ Yes
 - ☐ No
- b. Would you like to consent for farm/animal sample collection?
 - ☐ Yes
 - ☐ No
- c. Would you like to participating in our art science activities (photographing, filming)
 - ☐ Yes
 - ☐ No
24. Do you have any question about our project?
 - ☐ Yes
 - ☐ No

Appendix B. Questionnaire

Part 1—Animal farming practices

- How long has your household been in the business of animal farming? [__|__] year
- What types of cattle or poultry do you currently farm?

No	Type of Cattle	Quantity	Scale	
1		[__ __ __ __ __ __]	☐ Family	☐ Business
2		[__ __ __ __ __ __]	☐ Family	☐ Business
3		[__ __ __ __ __ __]	☐ Family	☐ Business

- How many members are there in your household participating in animal farming activities? [__|__] person (s)
- How far is it from the housing area to the animal farm? [__|__|__|__] m
- What are the farming facilities?

Facilities		
1. Animal houses	☐ Yes	☐ No
2. Fences	☐ Yes	☐ No
3. Biogas cellar	☐ Yes	☐ No
4. Storehouse containing feed, vet drugs and other farming tools . . .	☐ Yes	☐ No
5. Farm diary	☐ Yes	☐ No
6. Others	☐ Yes	☐ No

- From which source do you often get animal breeds?

- From other household farms in the locality
- From company/wholesalers
- From own farms
- Other places _____

- Which factors influence farmers' choice in buying breed?

(Choosing in order of priority from 1–8, list the most preferred)

Factors	Priority Level
1. Low price	[__]
2. Self-experience, that place sells good breeds (Close connection)	[__]
3. Clear original source	[__]
4. Breeds with vaccination certification	[__]
5. Breeds with health certificate	[__]
6. Good conformation of livestock	[__]
7. Healthy countenance of livestock	[__]
8. Others	[__]

- What are your expectations in animal farming? _____

- Which factors do you concern and influence your decision in animal farming?

a. Factor	b. Important Level	
1. Production cost	[__]	[__]
2. Farming hygiene	[__]	[__]
3. Fate water and food source	[__]	[__]
4. Animal weight	[__]	[__]
5. Epidemic diseases	[__]	[__]
6. Selling price of finishing animals	[__]	[__]
7. Others	[__]	[__]

10. How often do you tidy your farm? (1—every day, 2—several times per week, 3—several times per month, 4—rarely, 5—never)

Place/Equipment of Hygiene Practice	Level				
	1	2	3	4	5
a. Animal house	☐	☐	☐	☐	☐
b. Farming tools	☐	☐	☐	☐	☐
c. Water drainage system	☐	☐	☐	☐	☐
d. Food storage	☐	☐	☐	☐	☐
e. Water tank	☐	☐	☐	☐	☐

11. What are the main sources of drinking water and running water for your farm? (Maximum 2 choices)

Sources of Water	Drinking Water	Running Water
a. Deep well water	☐	☐
b. Hollow well-water	☐	☐
c. Rain-water	☐	☐
d. River/lake/canal water	☐	☐
e. Others	☐	☐

12. How do you eliminate waste-water from animal farming?
- Waste-water goes out the garden
 - Waste-water goes out biogas cellar
 - Waste-water goes out canal without being processed.

13. Others: Do you often apply any of the following habits?

Farming Practices		
a. Wash hands with soap before and after interacting with livestock	☐ Yes	☐ No
b. Change clothes when entering holding pens	☐ Yes	☐ No
c. Change shoes when entering holding pens	☐ Yes	☐ No
d. Have special place to isolate suspected or sick livestock	☐ Yes	☐ No
e. Allow livestock go freely outside the holding pens	☐ Yes	☐ No
f. Slaughter livestock at home (to obtain meat)	☐ Yes	☐ No
g. Slaughter suspected sick livestock (to sell or to consume)	☐ Yes	☐ No
h. Sell out suspected sick livestock	☐ Yes	☐ No
i. Cremate/Bury diseased animals at home	☐ Yes	☐ No
j. When livestock get sick, purchase treatment drugs based on self-experience	☐ Yes	☐ No
k. Read carefully manuals before applying drugs for treatments of livestock	☐ Yes	☐ No
l. Ask the pharmacist carefully before applying drugs for treatment of livestock	☐ Yes	☐ No
m. Consult the veterinarians carefully before purchasing drugs for treatments	☐ Yes	☐ No
n. Vaccinate livestock right on schedule	☐ Yes	☐ No
o. Often stop using drugs (with antibiotics) immediately after noticing diseases in livestock	☐ Yes	☐ No

14. When do you often use antibiotics for your animal? (MA)

- When animal gets disease
- When outbreak of diseases
- Seasonal change
- Use often for prevention
- To promote animals' growth
- Others _____

15. When epidemic disease happens, what do you often do? (MA)

- | a. Individuals, Organizations, Unions | | b. Within 2 Years | |
|--|--|--------------------------|------------|
| | | 1.Choose | 2.Time (s) |
| a. Local veterinarians | | ☐ | |
| b. Hamlet Farmers Association | | ☐ | |
| c. Veterinary medicine store | | ☐ | |
| d. Livestock feed store | | ☐ | |
| e. Neighbors or friends with animal farming experience | | ☐ | |
| f. Self-study, research via magazines, books, Internet | | ☐ | |
| g. Other individuals/organization _____ | | ☐ | |
22. Last year, how many times did you participate in training events related to livestock farming? [] times/year
23. If yes, who did organize such training courses? (a)? Content (b)
 (a) _____
 (b) _____
24. Your level of agreement to the following evaluations: (1. Strongly agree; 2. Agree; 3. Both agree and disagree; 4. Disagree; 5. Strongly disagree; 99. No idea/Difficult to answer)

[illegible]

Part II—Safe Animal Farming Knowledge

A. Safe animal husbandry

25. In your opinion, what is safe animal farming? _____
26. In your opinion, what is the purpose of safe animal farming? (1—totally unimportant; 5—totally important)

	Level of Importance				
	1	2	3	4	5
a. To improve profit due to higher productivity	☐	☐	☐	☐	☐
b. To prevent disease outbreaks	☐	☐	☐	☐	☐
c. To improve quality and safety of products	☐	☐	☐	☐	☐
d. To improve animal welfare	☐	☐	☐	☐	☐
e. To satisfy consumers	☐	☐	☐	☐	☐
f. To fulfill demands of ensuring consumers' health	☐	☐	☐	☐	☐
g. To protect farmers' health	☐	☐	☐	☐	☐
h. To avoid penalties	☐	☐	☐	☐	☐
i. To fulfill conditions of being licensed for farming practices	☐	☐	☐	☐	☐
g. Others	☐	☐	☐	☐	☐

B. AMU

27. In your opinions, what are antibiotics? _____
28. In your opinion, what are the effects of antibiotic usage? _____
29. In your opinions, what effects does the overuse of antibiotics in animal farming bring to livestock, farmers and the health of consumers? (1. Completely no effects; 2. Little, uncountable effects; 3. Great effects; 99. No idea/Difficult to answer)—(Put code of choice in column 1)

Target	1. Level of Effects	2. State of Effects
a. Pigs/Chickens	[__]	_____
b. Farmers involved in animal husbandry	[__]	_____
c. Consumers of animal farming products	[__]	_____

30. Do you have any idea about the problems of antibiotic-resistance?
- ☐ Completely have no idea (to question 33)
 - ☐ Have heard of but have no understanding (to question 33)
 - ☐ Little understanding (to question 31)
 - ☐ Clear understanding of the problems of antibiotic-resistance (to question 31)
 - ☐ Others _____
31. If you do, in your opinion, what is antibiotic-resistance? _____
32. Reasons for antibiotic resistance?
- a. Wrong dose in applying antibiotics (higher or lower)
 - b. Wrong use in applying antibiotics
 - c. Prolong/Short-time use of antibiotics
 - d. Others (please specify): _____
 - e. No idea/Difficult to answer
33. Have you ever heard about any solutions for reducing antibiotic uses?
- ☐ Have heard and understand (to question 34)
 - ☐ Have heard but not understand much (to question 40)
 - ☐ Never (to question 40)
34. If you have heard about any solutions, what are they? what are their purposes?
- (a) _____
- (b) _____

35. Have you ever thought that you would adopt the solutions for reducing antibiotics?
☐ Yes (to question 47) ☐ Never (to question 48)
36. In this list, which are the solutions for reducing using antibiotic?

Contents			
Supplement organic acids into foods	☐ Correct	☐ Incorrect	☐ Do not know
a. Supplement enzymes	☐ Correct	☐ Incorrect	☐ Do not know
b. Supplement probiotics and prebiotics	☐ Correct	☐ Incorrect	☐ Do not know
c. Supplement foods rich in minerals content	☐ Correct	☐ Incorrect	☐ Do not know
d. Use herbal antibiotics	☐ Correct	☐ Incorrect	☐ Do not know

37. Do you have experienced about using alternatives to antibiotics?
☐ Yes
☐ Never
38. If already experienced, can you please share the effectiveness of applying such measures to reduce using antibiotic? (MA)
- Reduce production cost
 - Healthy animals, better growth
 - Selling animals at a better price
 - Effect but insignificant
 - Totally ineffective
 - Do not know how are the effects of such measures
 - Others
39. Are you willing to use alternatives to antibiotics use in animal farming?
☐ Very willing
☐ Reluctant over the high price of alternative measures
☐ Not sure how to apply alternative measures
☐ Not sure about the effectiveness of alternative measures
☐ Reluctant over the effects to farming productivity
☐ Others
40. How do you get information about safe farming? (MA)
- Self-experiments and applications
 - From newspaper, television (Public media)
 - From animal farming training sessions
 - From local media (leaflets, posters)
 - From exchanging information with friends, neighbors
 - Others

Part III—Attitude

A. *Safe animal husbandry*

41. How do you evaluate the level of safety at your household farm?
☐ Very safe ☐ Unsafe
☐ Safe ☐ Very unsafe
☐ Quite safe
42. Reasons for such evaluations? _____
43. Please share the current productivity level in animal husbandry?
☐ Very productive ☐ Not productive
☐ Productive ☐ Completely not productive
☐ Quite productive
44. Reasons for such evaluations?
45. Do you feel assured using products of animal farming in your local area?
☐ Very assured ☐ Unassured
☐ Assured ☐ Completely assured
☐ Quite assured ☐ Not idea/difficult to answer

Reasons for such evaluations? _____

B. AMU

46. In your opinions, how is the current need for using antibiotics in animal farming?
☐ Very necessary ☐ Necessary
☐ Not necessary ☐ Completely not necessary
☐ No idea/Difficult to answer
47. Reasons for such evaluations? _____
48. In your opinions, how popular is the use of antibiotics for animal farming?
☐ Very unpopular ☐ Not popular
☐ Popular ☐ Very popular
☐ No idea/Difficult to answer
49. Reasons for such evaluations?
50. What are the obstacles for taking measures in safe farming? (1—Totally not important; 5—very important)

Obstacles	1	2	3	4	5
1. Too expensive	☐	☐	☐	☐	☐
2. Too much administration	☐	☐	☐	☐	☐
3. Too much work	☐	☐	☐	☐	☐
4. Do not believe that this would be beneficial	☐	☐	☐	☐	☐
5. Do not believe that it would help to prevent animal diseases	☐	☐	☐	☐	☐
6. Not confident as refusing to use antimicrobial for animal	☐	☐	☐	☐	☐
7. I'm not willing to	☐	☐	☐	☐	☐
8. It is unnecessary to apply safe farming due to too small size of farming	☐	☐	☐	☐	☐
9. Not mandatory	☐	☐	☐	☐	☐
10. Others	☐	☐	☐	☐	☐

51. To what extent these individuals, organizations, and unions in supporting better animal farming for farmers? (1. Very necessary; 2. Necessary; 3. May be unsure about necessary; 4. Unnecessary; 5. Very unnecessary)

Individuals, Organizations, Unions	1	2	3	4	5
1. Local veterinarians	☐	☐	☐	☐	☐
2. Hamlet Farmers Association	☐	☐	☐	☐	☐
3. Veterinary medicine store	☐	☐	☐	☐	☐
4. Livestock feed store	☐	☐	☐	☐	☐
5. Neighbours or friends with animal farming experience	☐	☐	☐	☐	☐
6. Other individuals/organizations:	☐	☐	☐	☐	☐

52. For a safe and productive animal farming, what kind of supports do the farmers need? (MA)
- Guides for places to get good breeds
 - Guides for safe animal farming procedure
 - Guides for information to obtain feeds for livestock with good quality
 - Timely instructions for medicine usage in livestock prevention and treatments of diseases
 - In time information provided and updates on cattle and poultry disease outbreaks
 - Guides for antibiotic alternatives usage
 - Information regarding harmful effects of antibiotic overuse
 - Other
53. Please grade your satisfaction level with local veterinarians

Abilities and Qualification	Grade
1. Technical knowledge	/10
2. Abilities to convey knowledge to the people	/10
3. Abilities to convey production techniques to the people	/10
54. Frequency that local or regional veterinarian inspectors come to your household to inspect and evaluate the activities of animal farming? ... Times/year	
55. If there is a training course of safe animal farming, do you willing to participate?	
☐ Yes	
☐ No	
☐ Do not know	
56. If yes, how many days for such training course? ... Day(s)	
57. What contents do you expect to learn from such a training course?	
58. Which suitable months to organize such training course?	

Part IV—General information about respondent and household:

59. Gender:
- ☐ Male
- ☐ Female
60. Year of birth: [__ | __ | __ | __]
61. Ethnicity:
- ☐ Kinh
- ☐ Hoa
- ☐ Khmer
- ☐ Others _____
62. Education (Please specify)
- ☐ Not know how to read and write/know how to read and write
- ☐ Primary school
- ☐ Secondary school
- ☐ High school
- ☐ Post-secondary education (higher education)
- ☐ Tertiary education (College or University)
- ☐ Graduated degree
63. Who is responsible for the livestock? (take care of, feed, monitor diseases, ...) (record in relation to the respondents)
- ☐ Respondent
- ☐ Respondent's husband/wife
- ☐ Respondent's children
- ☐ Other (Please specify): _____
64. How many years in accumulated experiences does the person responsible for livestock in the household have? [__ | __] years
65. How many years in accumulated experiences does the interviewee have for livestock in the household? [__ | __] years

Appendix C. COREQ Checklist

Methods to evaluate farmers' perception of antibiotics, uses and resistance based on common knowledge defined by FAO, WHO and OIE

Antibiotics (ABs) were commonly defined as medicines used to prevent or treat bacterial infections (WHO 2018). In animal production, appropriate use of ABs is for treating sick animals caused by bacterial infectious diseases (FAO 2011). The use of ABs for both prophylaxis, without any clinical sign in the herd, and growth promotion was inappropriate because this practice was known to foster resistant emergence (FAO 2016a). Misuse and overuse of ABs in animal farming, such as using the wrong dose, wrong drug, and wrong duration of course in comparison to the indications and directions from manufactures, were recognized as drivers for acquisition of ABR (OIE 2015). To assess

the practice of using ABs on farms, this study was performed, since ABs are used in food animal production for two main purposes: therapeutic and non-therapeutic. For therapeutic purposes, classified as therapy or disease prophylaxis, ABs were used for treating diseased individuals or groups, which might include some animals that were not yet sick or were sub-clinical. For non-therapeutic purposes, classified as disease prevention or growth promotion, ABs were used for healthy animals for routine prevention or promoting feed efficiency (McEwen and Fedorka-Cray 2002). Both Food and Agriculture Organization (FAO) and the World Organization for Animal health (OIE) encourage the prudent use of ABs in animal production, including promoting good farming practices, reducing the need for ABs and supporting an end to ABU for non-therapeutic purposes (FAO 2016b; OIE 2016).

A checklist to evaluate farmers' perception of antibiotics and uses

No.	Questions	Farmers' Perception of Antibiotics and Uses		
		Favourable	Moderate	Unfavourable
1.	27. In your opinions, what are antibiotics?	"Antibiotics are medications for treating bacterial infections." "ABs are drugs to treat infectious diseases caused by bacteria."	"Antibiotics are medications for treating infections." "Antibiotics are substances for treatment and prevention of animal diseases."	"Antibiotics are health benefit supplements or vaccines for preventing animal diseases." Or Participants provided no answers
2.	28. In your opinion, what are the effects of antibiotic usage	To treat sick animals	To treat sick animals To prevent animal diseases	To promote animals' growth
3	14. When do you often use antibiotics for your animal? (MA)	For therapeutic purposes	For non-therapeutic purposes	
		Treatment	Prevention	Growth promotion
	a. When animal gets disease	x		
	b. When outbreak of diseases		x	
	c. Seasonal change		x	
	d. Use often for prevention		x	
	e. To promote animals' growth			x

Appendix D. Results from Univariate and Multivariate Analysis

Table A1. Factors influencing unfavourable perception of antibiotic use.

Item	Unfavourable Perception of ABU						
	Univariate Analysis				Multi-Variate Analysis		
	No. Part	OR	95% CI	p Value	OR	95% CI	p Value
1. Gender							
Female	18/35	2.56	1.09–6.0	0.03	2.3	0.82–6.32	0.1
Male	19/65	Ref			Ref		
2. Age							
>40	25/71	0.7	0.32–1.9	0.65			
≤40	12/29	Ref					
3. Education							
Primary	13/23	2.8	1.10–7.4	0.04	2.96	1.02–8.50	0.04
Secondary& above	24/77	Ref			Ref		

Table A1. *Cont.*

Item	Unfavourable Perception of ABU						
	No. Part	Univariate Analysis			Multi-Variate Analysis		
		OR	95% CI	<i>p</i> Value	OR	95% CI	<i>p</i> Value
4. Year of experience							
3–6 years	12/31	1.1	0.45–2.7	0.8			
≥7 years	25/69	Ref					
5. Farming scale							
Small size	28/63	2.48	1.01–6.1	0.05	1.3	0.48–3.84	0.6
Medium size	9/37	Ref			Ref		
6. Training participation							
<i>n</i> < 2	18/35	2.56	1.09–6.0	0.03	2.91	1.08–7.82	0.03
<i>n</i> ≥ 2	19/65	Ref			Ref		
7. Assessing antibiotic need							
Not very necessary	28/69	2.27	0.81–6.4	0.1	1.80	0.58–5.62	0.3
Very necessary	6/26	Ref			Ref		
8. Intention of reducing ABU							
No	26/69	1.1	0.45–2.7	1	0.68	0.23–1.97	0.5
Yes	11/31	Ref			Ref		
9. ABU practices							
For non-therapeutic purposes	24/57	2.1	0.86–5.1	0.1	2.93	1.07–8.02	0.04
For only therapeutic purposes	10/39	Ref			Ref		

Table A2. Factors influencing the practices of using antibiotics for non-treatment purposes.

Item	The Practices of ABU for Non-Treatment Purposes						
	No. Part	Univariate Analysis			Multi-Variate Analysis		
		OR	95% CI	<i>p</i> Value	OR	95% CI	<i>p</i> Value
1. Gender							
Female	19/32	1	0.42–2.37	1	0.7	0.27–2.02	0.5
Male	38/64	Ref			Ref		
2. Age							
>40	38/68	0.6	0.23–1.51	0.3			
≤40	19/28	Ref					
3. Education							
Primary	13/22	0.9	0.37–2.59	1	0.9	0.29–2.83	0.8
Secondary & above	44/74	Ref			Ref		
4. Year of experience							
3–6 years	20/29	1.8	0.70–4.50	0.2			
≥7 years	37/67	Ref					
5. Farming scale							
Small size	39/59	2.05	0.88–4.76	0.1	2.5	0.92–6.49	0.07
Medium size	18/37	Ref			Ref		

Table A2. Cont.

Item	The Practices of ABU for Non-Treatment Purposes						
	No. Part	Univariate Analysis			Multi-Variate Analysis		
		OR	95% CI	p Value	OR	95% CI	p Value
6. Training participation							
n < 2	16/33	Ref			Ref		
n ≥ 2	41/63	1.9	0.79–5.01	0.1	2.4	1.4–11.2	0.01
7. Assessing antibiotic need							
Not very necessary	17/26	0.7	0.21–1.81	0.5	0.62	0.21–1.87	0.33
Very necessary	39/69	Ref			Ref		
8. Intention of reducing ABU							
No	44/65	2.9	1.21–7.03	0.03	3.39	1.29–8.91	0.01
Yes	13/31	Ref			Ref		
9. ABU perception							
Unfavourable	24/34	2.1	0.86–5.13	0.1	2.73	0.99–7.45	0.05
Moderate to favourable	33/62	Ref			Ref		

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