Community Poultry Farmer Knowledge, Attitudes and Practices Contributing to Antimicrobial Resistance in High Density Areas of Bulawayo, Zimbabwe

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ABSTRACT

Background: Antimicrobial use in poultry poses a risk of resistance and transmission thereof to human populations, and poses a global public health risk. No previous studies considered Knowledge, Attitudes and Practices of community (backyard) poultry farmers in dense settlement areas in Zimbabwe

Methods: We used self-administered questionnaires to assess knowledge, attitude and practice items in addition to general and demographic variables. We describe our findings and evaluate associations with practices.

Results: Fifty-six participants completed questionnaires. A range of practices (good and bad) was reported. Practices with risk for antimicrobial resistance developing were associated with males, having previously experienced an incident of high mortality among the poultry, and if knowledge and attitude scores were low. Individuals trained by church organisations and practicing chicken farming as their only occupation was associated with good practices.

Poor knowledge scores were predictive of poor practices in the study. The study also found that individuals who do chicken farming as their only occupation were more likely to adhere to international regulations than those who did it as a part time occupation. Factors associated with good practices were those that were trained by church organisations. Despite its limitations such as measurement bias, the study highlighted gaps in the one health concept which might reduce antimicrobial resistance in both clinical and community settings

INTRODUCTION

Antimicrobial resistance (AMR) occurs when bacteria, parasites, viruses and fungi become resistant to antimicrobial drugs given to treat the infections they caused [1]. AMR is a risk with each time an antimicrobial is used, whether to kill or preventing organisms from multiplying, or whether used in animal husbandry as prophylactic, metaphylacticor as growth promotor [2]. AMR is expanding at an alarming pace worldwide and presents a serious health risk, now being considered one of the top ten global public health threats [3-5]. The available treatment options for some pathogens are almost exhausted, and more action is needed to curb the trend toward this global pandemic [6,7]. Since the late 1980s, there have been very few new antimicrobials in the development pipeline [8,9]. Furthermore, AMR is currently responsible for an estimated 700,000 deaths annually [10].

Producing future mortality estimates is challenging and complex, but (with obvious assumptions) are reported to be in the region of 10 million people per year by 2050 [11], making AMR one of the leading future causes of death [1]. The irrational use of antibiotics, including self-medication, sub-optimal dosages, overuse, and the use of inappropriate antibiotics are considered major drivers for AMR emergence and spread worldwide [1-3]. A rapid and unprecedented increase in the consumption of antibiotics was reported globally over the last decade [6]. This increase was greatest in low-income countries, where antibiotics are more frequently dispensed without prescription [12].

Zimbabwe like most African countries has limited data on AMR. Barriers to effective AMR data collection and research include weak laboratory infrastructure and required resources like reagents and diagnostics, limited staff capacity inadequate training, communication issues, limited availability of resources, questionable quality assurance, and funding problems [13]. Most African countries therefore have very poor or no AMR surveillance systems in place. Zimbabwean data show increasing resistance to the most common and some priority antibiotics like Carbapenems [14].

Pathogens like salmonella and campylobacter may be attributed to consumption of poultry meat and derived products, and via direct contact with animals and via the animal environment [15-18]. High prevalence of resistance to doxycycline, ampicillin and norfloxacin were observed in broiler farms in Cameroon, as well as high resistance to ciprofloxacin, imipenem, levofloxacin and ceftriaxone (second line treatment in hospital settings in Cameroon) and classified as Watch group by the World Health Organisation [19]. Transmission of pathogens between animals and humans in fowl runs were due to poor waste management and hygiene practices regarding feeds and water supplies, inadequate cleaning and disinfection practices, poor barrier, separation and isolation practice [2]. It is estimated that antimicrobial use (AMU) will increase globally with 8% between 2020 and 2030, although; a higher relative increase of 25% is predicted for Africa [20]. Agricultural intensification will lead to an increase of 8% in antimicrobial usage by 2030, predominantly led by Low to Middle Income Countries (LMICs) [6].

Addressing this issue is of vital importance, particularly in LMICs, for two main reasons: Infectious diseases remain among the top disease burdens globally, disproportionally affecting LMICs [21, 22], and secondly, because the livestock sector comprises approximately 1 billion smallholder livestock farmers in developing countries, contributing approximately 40% of agricultural GDP and comprising almost 45% of all households [23]. Chickens can be produced very fast, with market-ready broiler production taking only six weeks. Poultry farming will continue to increase as countries shift from subsistence to commercial farming, which typically employs routine AMU. In contrast with other land-based farming animals, poultry is preferred by most, because of the small animal size, short production cycles, efficient conversion of food energy to product (meat or eggs), and ability to adapt to a variety of environments [24]. While small-scale household or back-yard poultry farming is extensively practiced in LMICs and it serves as an instrument to sustainable development, it is also considered by many as a high-risk environment for the potential incubation of regional outbreaks and global pandemics, including AMR [24].

Elton reviewed AMR preparedness in sub-Saharan African countries and identified the need for a multidisciplinary and multisectoral approach to addressing the problem [25].

The high-density suburbs in Zimbabwe have been characterised by outbreaks of various infectious diseases such as TB, malaria, HIV, respiratory infections, sexually transmitted infections (STIs), urinary tract infections (UTIs), meningitis and diarrheal diseases [26]. From September 2018 to March 2019, Zimbabwe experienced a large cholera outbreak mostly affecting high density suburbs such as Mbare, Glenview, Highfields, Kuwadzana and Chitungwiza (with 10,730 suspected cases and 69 deaths reported). The disease was particularly difficult to contain, as a result of AMR, including resistance to antibiotics commonly used in poultry [27].

The high AMU among poultry farmers elucidates to a need for investigating biose- 87 curity and infection prevention and control practices implemented by household farmers. Previous studies on AMR practices in sub-Saharan African countries, focused on approaches to tackling AMR and community engagement. Studies to explore the Knowledge, Attitudes and Practices (KAP) of household (backyard) poultry farmers in Zimbabwe that may contribute to AMR were limited.

Previous African studies on KAP contributing to AMR were done on large-scale and small-scale commercial poultry farmers in Burkina Faso, Cameroon, Nigeria, Ghana, Kenya, Tanzania, Zambia and Zimbabwe [28-32]. Studies on the KAP on backyard poultry farmers have previously been done in Egypt [33, 34], and in another study comprising Kenya and Tanzania [35]. There has however never been a study focusing on household

(backyard) poultry farming in dense settlement areas in Zimbabwe. Our study was therefore aimed at addressing the research gap of antibiotic use in poultry household farmers in high density settlements, by assesses sing knowledge desirable attitudes and practices towards AMU and AMR

This study was therefore aimed at addressing the research gap of antibiotic use in poultry household farmers in high density settlements, where recommended practices may not be known or followed and these poultry farmers may not have adequate knowledge or desirable attitudes towards AMU and AMR.

METHODS

Ethical clearance for the study was obtained from the Health Research Ethics Committee of Stellenbosch University (S22/08/161) and the research team observed the relevant international ethics principles and guidelines during the conduct on this study.

This was a cross-sectional study using a structured, self-administered questionnaire. Questions were based on findings and approaches used in previous studies and researcher knowledge of local conditions, and were presented in IsiNdebele, English and Shona. Knowledge was assessed by a set of 10 statements, which participants had to indicate as being true or false (or that they did not know). Attitudes were assessed by a set of 5 statements, which they had to indicate on a 5-point Likert scale to which extent the agreed with (strongly agree to strongly disagree), and practices were assessed by a list of 25 statements, that participants had to indicate whether they perform the action always, sometimes, or never. Knowledge, Attitude and Practice scores were calculated based on the number of items on the questionnaire that conformed to international recommendations (considered as “correct questionnaire responses”).

No pre-specified hypotheses were formulated for the study, with the main aim for the study being descriptive and exploratory in nature. The sample size was set at a minimum of 50 participants, to allow reasonable representation, while still being feasible. Inclusion criteria for the study required being a household (backyard) poultry farmer of any bird type, being over the age of 18 and living in the high-density areas of Bulawayo, Zimbabwe. Participants were excluded if they declined to sign the Informed Consent Forms (ICFs) or could not complete the questionnaire. The researcher provided ICFs and questionnaires and waited while these were self-administered by participants, who were sampled in the community and at farming shops in the city center.

The data was analysed using Microsoft Excel and SPSS, version 25. Numerical data are displayed as means (with standard deviations) or medians (with interquartile ranges) if the data is skewed. Categorical data are described as percentages. Population values are estimated using 95% confidence intervals.

To determine whether any factors are associated with participant practices being congruent with international guidelines or not, associations were evaluated by means of the Odds Ratio of contingency tables, comparing the study variables in the group with high congruence (Practice scores >20/25) with those whose practices were contrary to current guidelines. The Chi-square test was used to determine whether there were significant associations between poultry farmer knowledge, attitudes and practices. If individual cell frequency assumptions were violated, the Fisher’s Exact test was used. A significance level of 0.05 was used for all statistical tests.

RESULTS

A total of 56 community farmers participated in the study, with their demographics shown in Table 1. Most (62.5%) of the study participants were female and their education ranged from having received no formal education to having a master’s degree. Their average age was 39.9 (SD=12) years. Overall, the sample was quite well educated, with one quarter holding a bachelor’s degree. Approximately 40% of the study participants performed poultry farming as their only occupation, while the other participants were equally distributed between having another formal job (as employee) and having another business of their own. More than half (n=34; 61%) of the participants have been involved in poultry farming for less than five years.

Table 1 Sociodemographic characteristics of respondents in the study (N=56)

Variable	**Frequency (%)**
Household location	
Magwegwe	15 (26.8)
Emakhandeni	14 (25.0)
Cowdry Park	10 (17.9)
Luveve	10 (17.9)
Nkulumane	6 (10.7)
Entumbane	1 (1.8)
Sex	
Female	35 (62.5)
Male	21 (37.5)
Level of Education	
No formal education	2 (3.6)
Primary	3 (5.4)
Completed ordinary level	13 (23.2)
Completed advanced level	5 (8.9)
Diploma	10 (17.8)
Advanced diploma	7 (12.5)
Bachelor's degree	15 (26.8)
Master's degree	1 (1.8)
Other forms of work	
I just do poultry	22 (39.3)
I am also formally employed	18 (32.1)
I have another business of my own	16 (28.6)
Duration of poultry farming	
Less than one year	5 (8.9)
1-4 years	29 (51.8)
5-8 years	17 (30.4)
9-12 years	3 (5.4)
More than 12 years	2 (3.6)
Chick age currently	
Less than two weeks	8 (14.3)

2-4 weeks	17 (30.4)
4-6 weeks	16 (28.6)
6-8 weeks	4 (7.0)
More than 8 weeks	2 (4.0)
Mixed age groups	9 (16.1)
Ever had chickens dying in large numbers?	
Yes	27 (48.2)
No	29 (51.8)
If yes, how many chickens died?	
Less than 20	9 (16.1)
21-40	12 (21.4)
41-60	5 (8.9)
61-80	1 (1.8)
81-100+	1 (1.8)
N/A	28 (50.0)

All participants indicated that their poultry farming involved chickens, often a mixture of different types of birds, but most commonly (73.2%; n=41) involving broilers (see Figure 1)

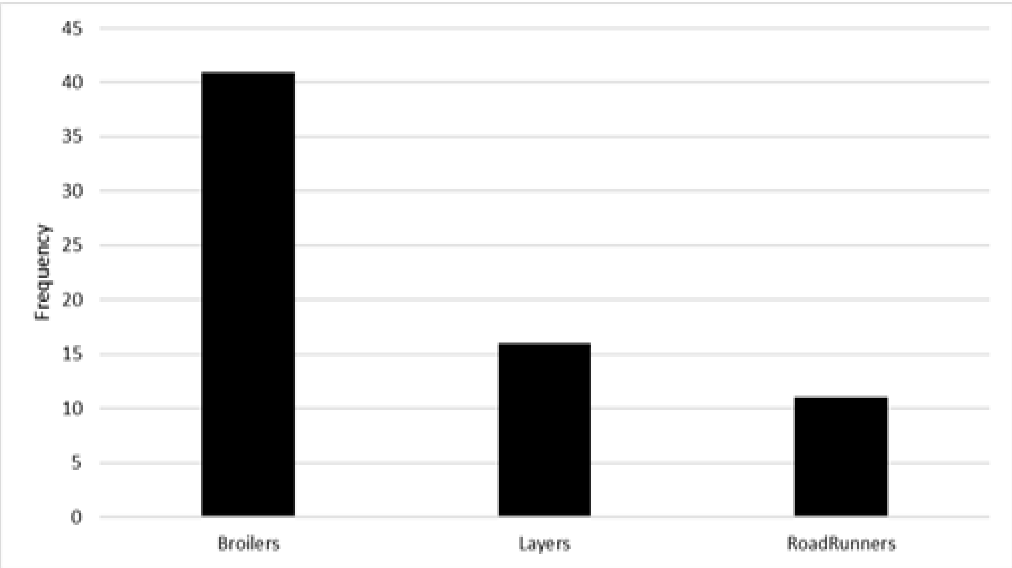

Figure 1 Types of chickens farmed by study participants

Participants were asked whether they received any training on cleaning a fowl run and the majority (n=48; 85.7%) answered positively. Respondents also provided information on the sources of their training provided, as shown in Figure 2. The majority (n=19; 33.9%) were trained by farming organisations. Other significant training providers included colleges/ universities and church organisations, constituting 12.5% (n=7) and 10.7% (n=6) respectively. Four participants (7.1%) indicated that they received training by a mix of different providers, that is by more than one organisation.

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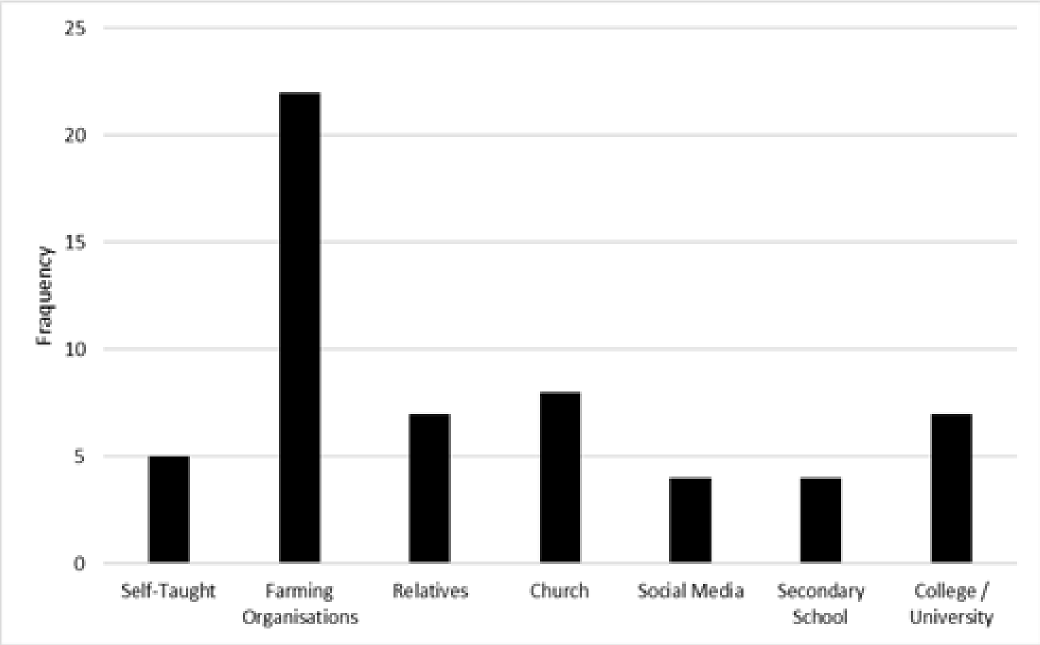

Figure 2 Sources of training received by study participants

The size of the household poultry farming operations varied. Most respondents farmed with birds numbering between 50 and 200, with some smaller and some having larger operations (see Figure 3 below).

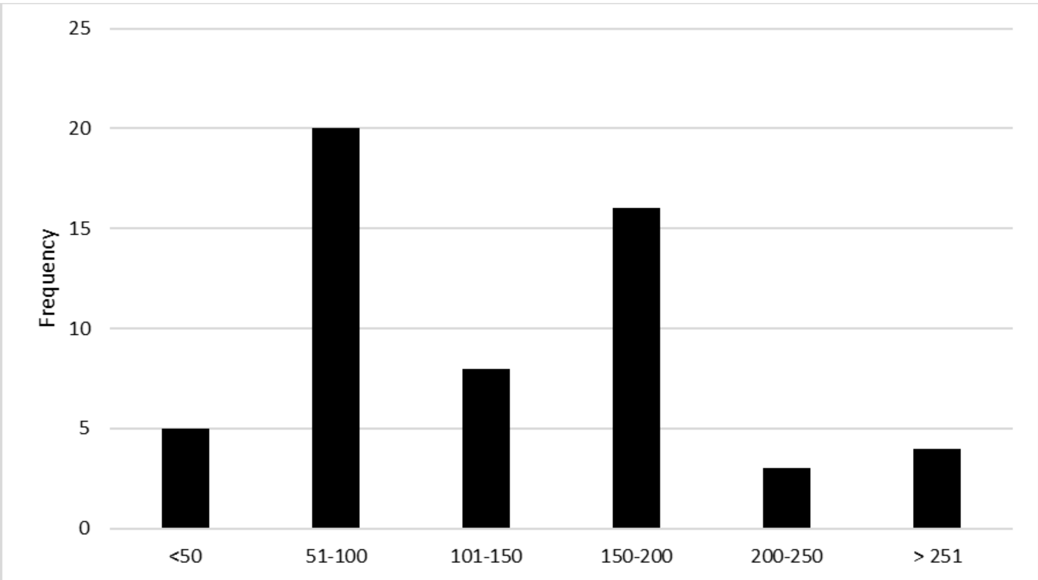

Figure 3 Number of birds farmed by study participants

Most respondents reported their poultry being of one age group at a time, with nine (16%) respondents indicating they had chickens of various ages. Having chickens of various ages was not associated with the size of the household farming operation – that is, the number of chickens on the property ($p = 0.990$). Many respondents (n=27; 48.21%) reported that they had chickens die in large numbers within a short time period. Most of these participants (18/27; 66.7%) ascribed these to equipment or environmental control (mainly temperature and ventilation) problems. Ascites was cited as a cause for high group mortality by four of these individuals (14.8%), and five participants (18.5%) specifically mentioned infection-related conditions as a cause.

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Knowledge of the household poultry farmers

The basic knowledge of study participants was reasonable (see figure 4), with a mean score for the group of 7.6 (SD=2.5) out of 10 and a median score of 8 (IQR= 7-9). There were however a few participants with poor knowledge levels, including one individual who scored zero.

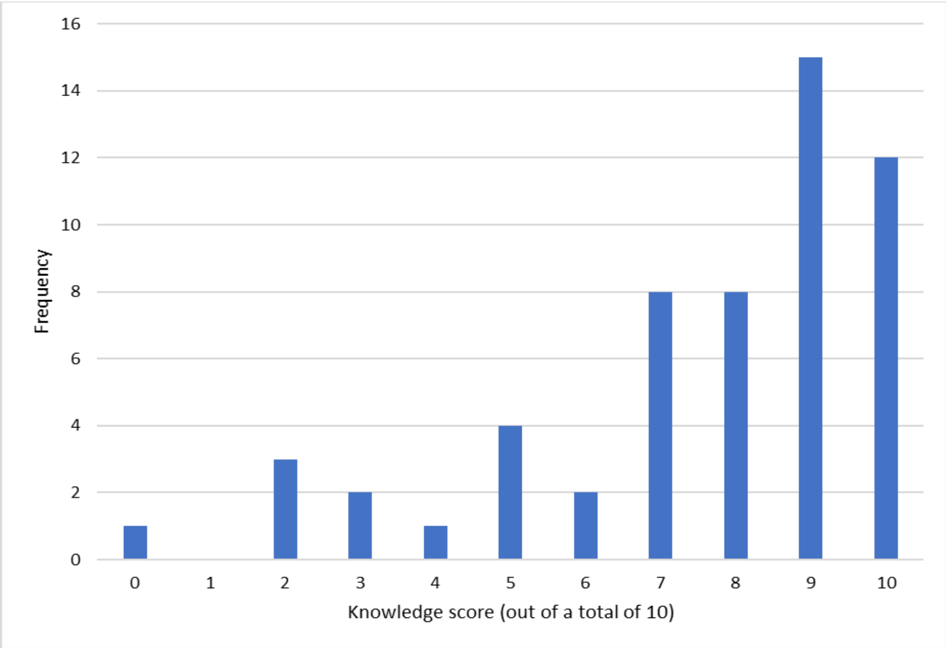

Figure 4 Knowledge scores of study participants

When considering the group's answers to specific questions, participants had variable knowledge regarding their interactions with poultry, the use of antibiotics and the effects of AMR. The percentage of participants that answered questions regarding these issues correct are shown in Table 2:

Table 2 Participant responses to knowledge questions in the questionnaire

Topic Questioned	**Correct answers**
Playing with fowl may lead to sickness in humans	52 (92.9)
Slaughtering should be done away from people and houses to prevent sickness	43 (76.8)
A veterinarian should be consulted if fowl are sick or not responding to treatment	53 (94.6)
Antibiotic resistance occurs when micro-organisms become resistant to antibiotics	50 (89.3)
Infections with resistant organisms are difficult to treat	45 (80.4)
Antimicrobial resistance is a worldwide problem	42 (75.0)
Antibiotic use in poultry could cause antibiotic resistance that may affect humans	28 (50%)

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Antibiotic resistance could affect me and my family	40 (71.4)
Overuse and misuse of antibiotics in animals may cause resistance in human bacteria	34 (60%)
Antibiotic resistance is NOT a problem when treating poultry birds	36 (64.3)

* Respondents had to indicate whether the statements are true or not (or whether they don't know).

Attitudes of the poultry farmers

The group's answers agreement with specific statements regarding hand hygiene, vaccination schedules and use of antibiotics in poultry is provided in Figure 5.

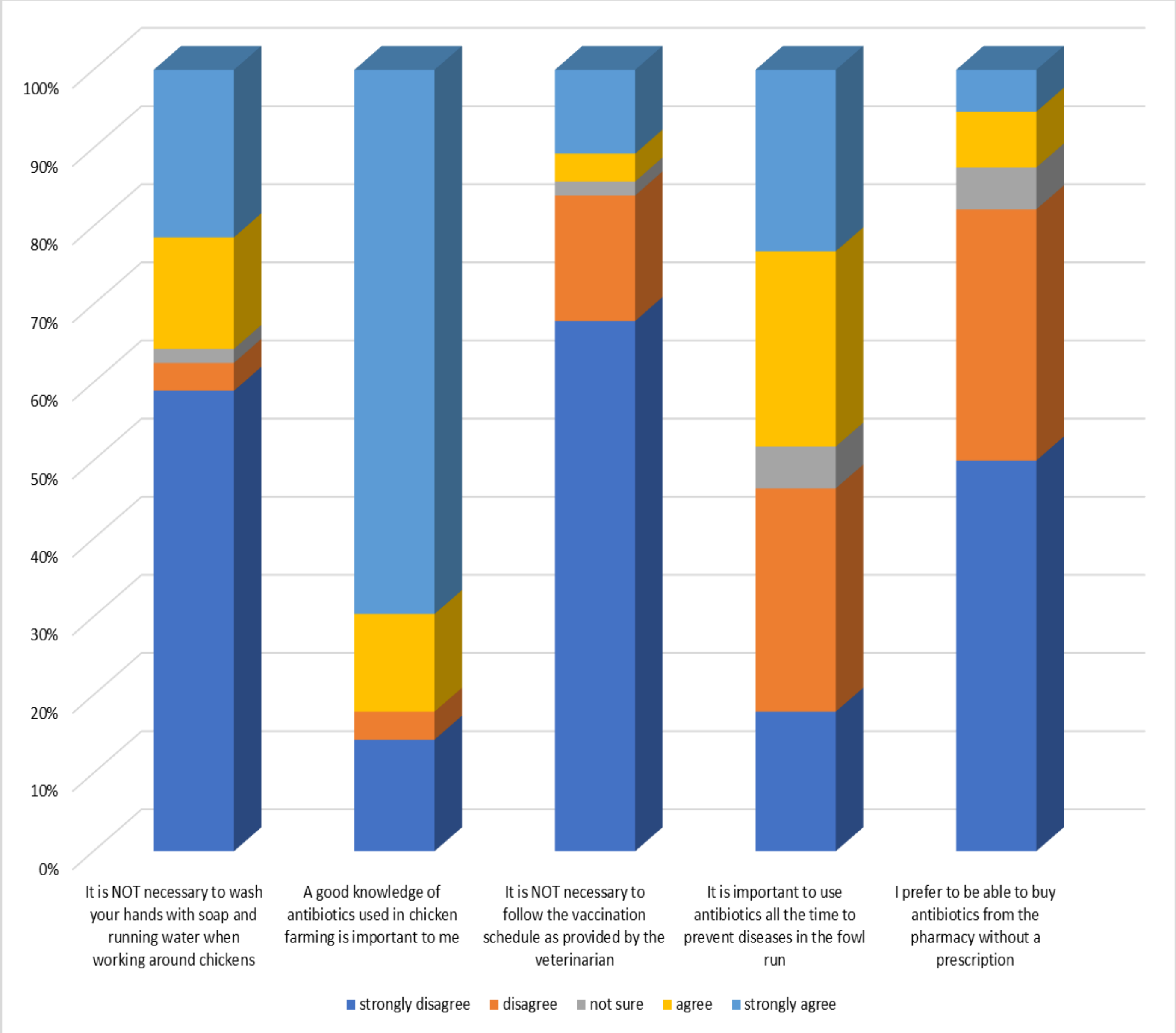

Figure 5 Participant agreement on hand hygiene, vaccinations and use of antibiotics in poultry

The responses indicated that participant attitudes towards hygiene, vaccinations and antimicrobial use were mostly in line with international recommendations. The average attitude score for the group was 3.6 (SD=1.1) out of 5, with a median of 4 (IQR = 3-4). There were however a small number of individuals with very low scores, including one individual with a score of zero (see figure 6)

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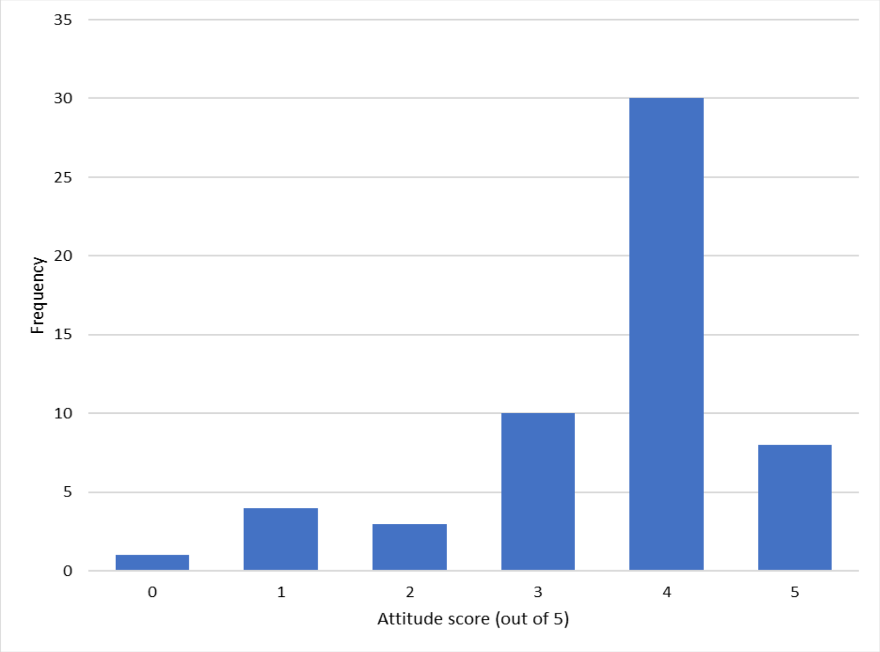
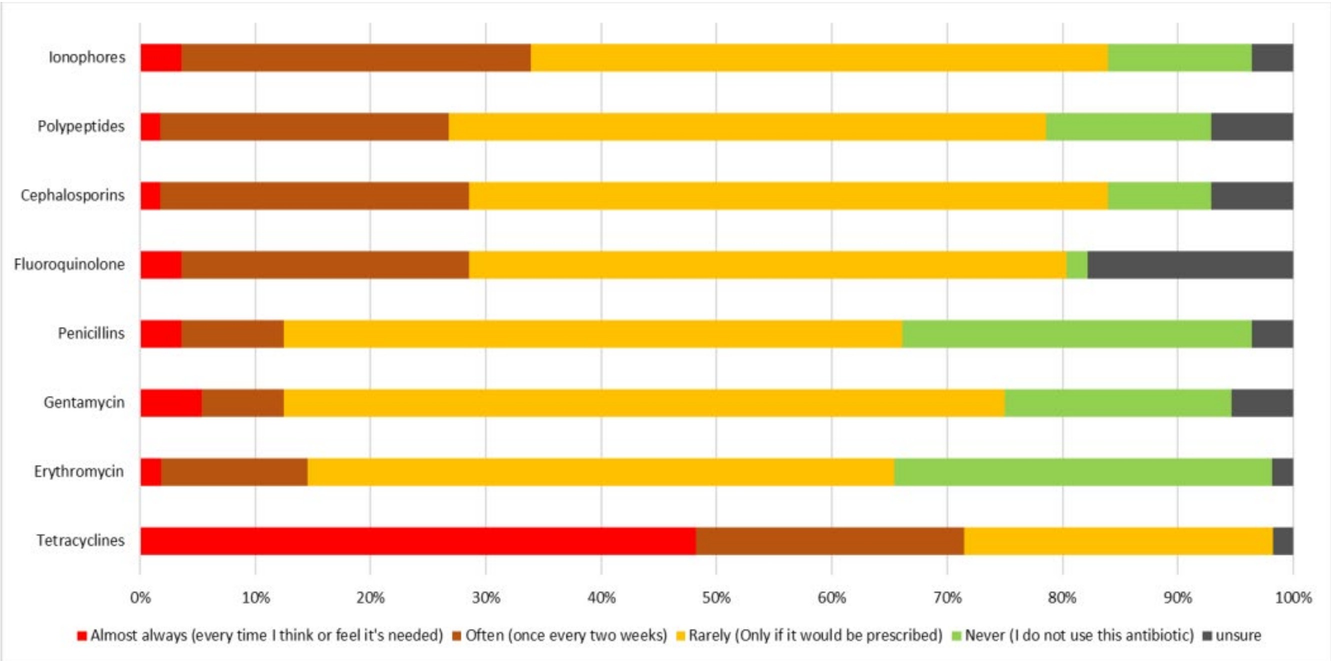


Figure 6 Attitude scores of the study participants

Participant use of specific antibiotics

In order to identify which specific antimicrobials are commonly used in this farming setting, participants were presented with a list of antibiotics and requested to indicate (using a Likert scale) how frequently they use these specific antimicrobials. Their responses indicated that the most used antibiotic was tetracyclines, and 48% of participants indicated that they use it "almost always" (every time they think or feel it's needed) and more than 70% would use it at least once every two weeks. Most of the other antibiotics would be used based on prescription by a veterinarian only.



Upon specific questioning, most (n=29; 51.8%) of participants indicated that the antibiotics they were using were procured by means of a prescription. However, a large proportion (n=20; 35.7%) indicated that this was prescribed "for routine prevention purposes" and only nine (16.1%) indicated it was for chickens that were sick or dying. One participant indicated that they were not using any antibiotics, but rather used "traditional medicines" only. More information on these traditional medicines was not provided in the questionnaire.

Practices of the poultry farmers

Almost all (n=55; 98%) participants reported they always clean the fowl run before receiving new chickens. Most (n=50; 89%) also clean and disinfect equipment before the new chickens arrive, first use soap and water (n=45; 80%), then use a disinfectant to clean the fowl run and put on a clean pair of gumboots or some protective clothing before handling chickens in the fowl run (n=38; 67%). Illnesses and death of poultry stock was however poorly reported to the veterinarian (see Figure 8)

Segregation, isolation and other separation practices

Most respondents (n=52; 93%) separate different kinds of birds, like road runners, broilers or layers. The majority (n=46; 82%) always separate sick birds from healthy birds, and two thirds (n=37; 66%) use separate equipment for sick and healthy birds. Many participants (n=35; 63%) do separate waste from their homes and the waste from their fowl runs. However, there are many (n=40; 71%) who reuse waste products from the fowl run in their garden (e.g. as fertilizer) and a there are some (up to 30%) who would sometimes keep poultry in their homes.

Leftover medication and disinfectants are commonly discarded down the municipal drain. Details of the isolation and separation practices are provided in Figure 9.

Antibiotic use and associated practices

In terms of practices associated with the use of antibiotics, the majority indicated that they never do the following inappropriate practices: stop the antibiotics without completing the course of treatment when the birds are better (n=46; 86%), buy or encourage antibiotics without prescription (n=40; 71%) and give antibiotics to birds for all types of illnesses (n=34; 61%). Most of the respondents always administer antibiotics according to the prescription on the label (n=42; 75%). Results are presented in Figure 10.

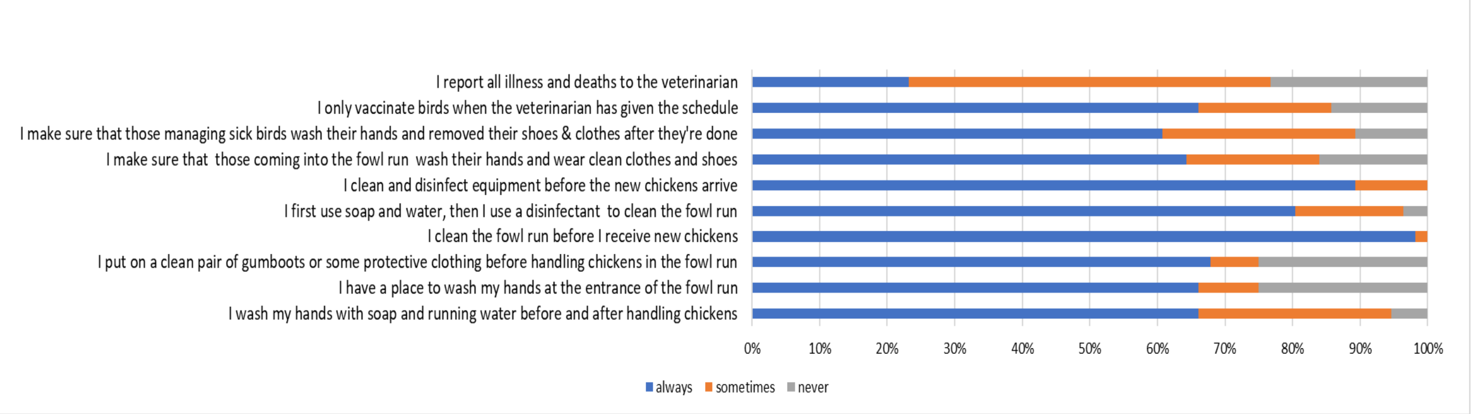


Figure 8 Hygiene and cleaning practices reported by study participants

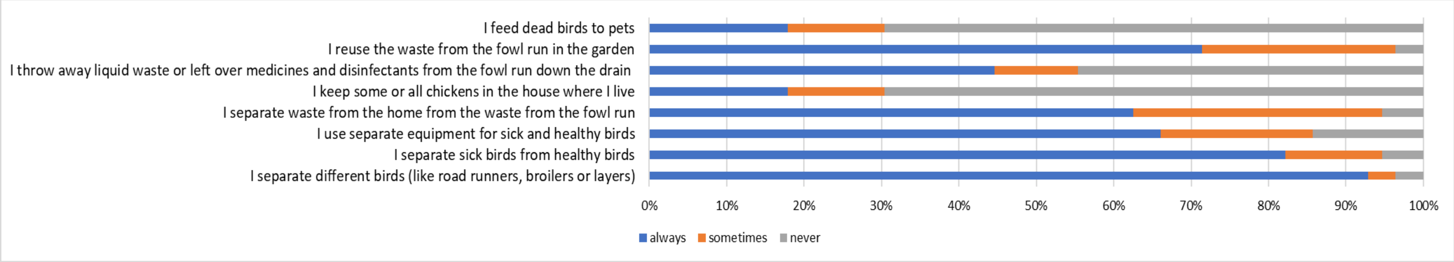


Figure 9 Segregation, isolation and separation practices reported by study participants

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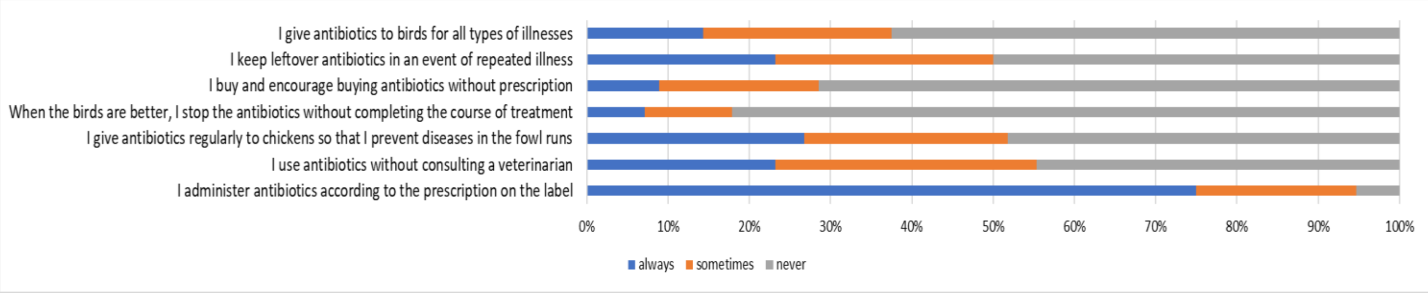

Figure 10 Practices associated with the use of antimicrobials reported by study participants

Analytical component

The findings of the descriptive analysis were used to determine knowledge and attitude cut-off values that would provide high specificity when performing the analytical component of the study, with the aim to determine whether there is any association between these knowledge and attitude scores and the practices of participants with regards to general infection control associated with poultry farming, their isolation and separation practices and their use and management of antimicrobials. The cut-off values that were ultimately used were knowledge score values below the median value of 8/10, and attitude score values below the median value of 4/5. In addition to the median knowledge and attitude scores, associations were considered for other demographic variables collected during the study.

Factors that were associated with a poor practice score (≤20/25) included being a male (OR = 4; 95%CI = 1.1 – 14.4; p=0.027) and having previously experienced many chickens die at one time or in a short period of time (OR

= 8.1; 95%CI = 2.2 – 29.7; p=0.001). A very strong association was also found with a knowledge score below the median (OR = 32.1; 95%CI = 6.1 – 168.1; p<0.001) and attitude score below the median (OR = 8; 95%CI = 1.6 – 39.7; p=0.005). Conversely, if individuals were doing household poultry farming as their sole occupation, they were more likely to have a practice score that was high (OR = 0.1; 95%CI = 0.0 – 0.5; p=0.001), representing good adherence to international guidelines and a lower risk for developing AMR. The age of the individual was not associated with differential practice, nor was their level of formal education (p > 0.05 for both).

The source of education regarding chicken farming practices yielded one protective factor, namely individuals that were trained by church organisations were more likely to report their farming practices to be in line with international guidelines (OR = 0.2; 95%CI= 0.0 – 0.8; p=0.018). Details regarding the univariate analyses are available in Table 3.

Table 3 Factors associated with participant practice scores below 20/25

Variables evaluated	**N (%)**	**OR (95%CI)**	**p-value**
Age > Average age	26 (46.4)	1.3 (0.4 - 3.7)	0.678
Age > Median age	26 (46.4)	1.3 (0.4 - 3.7)	0.678
Male sex	21 (37.5)	4.0 (1.1 - 14.4)	0.027
Having received a university education	16 (28.6)	2.2 (0.6 - 8.1)	0.222
Poultry farming as only occupation	22 (39.3)	0.1 (0.0 - 0.5)	0.001
Involved in poultry farming for <1 year	5 (8.9)	0.9 (0.1 - 5.8)	0.360
involved in poultry farming for <5 years	34 (60.7)	0.5 (0.1 - 1.5)	0.203

Received farming training from farming organisations	22 (39.3)	1.5 (0.5 - 4.6)	0.480
Received farming training for church organisations	8 (14.3)	0.2 (0.0 - 0.8)	0.018
Received farming taining by college or university	7 (12.5)	0.8 (0.2 - 3.9)	0.754
Farming with Broilers as opposed to other types of chickens	41 (73.2)	1.2 (0.3 - 3.9)	0.815
Experienced a previous incident where chickens died in large numbers	27 (48.2)	8.1 (2.2 - 29.7)	0.001
Farming with <100 chickens	25 (44.6)	1.5 (0.5 - 4.6)	0.445
Farming with >150 chickens	23 (41.1)	0.9 (0.3 - 2.7)	0.833
Farming with >200 chickens	7 (12.5)	0.2 (0.0 - 1.1)	0.052

DISCUSSION

This is the first study to describe the use of antibiotics in household (back-yard) poultry farmers in high-density settings in Zimbabwe, with a specific focus on the practices of these farmers. We found several practices that pose a risk for development of AMR, with a possibility of transmission between animals and humans. Many of our findings are congruent with findings of studies done elsewhere, including a recent meta-analysis [36].

Segregation and isolation are important components of biosecurity in poultry production [37]. Although respondents indicated that they frequently separated and isolated sick birds, there are still a number of practices that may contribute to transmission of AMR and transmission of zoonotic disease. This included the fact that a large proportion of participants indicated that birds were kept in their homes and they fed carcasses of dead birds to their pets. Other studies have similarly found that poultry droppings were commonly used as animal feed and that poultry were often housed with other species such as pigs or cattle [12]. Poultry droppings are also used as fertiliser in gardens, as reported by some of the participants in our study. A recent study in Sierra Leone found that 93% of samples of fresh chicken manure used as fertiliser for vegetables cultured *E. coli*. This *E. coli* was 100% resistant to three of the World Health Organisation "Watch list" drugs, namely erythromycin, cefoxitin and streptomycin, as well as to tetracycline [38].

There are several ways in which diverse AMR mechanisms can be acquired, transferred and spread between humans, animals and the environment [18, 39]. Most participants knew that interaction with poultry may lead to transmission of disease from the animals to humans. However, half of the respondents did not know that antibiotic use in poultry could result in antibiotic resistant organisms being transferred in this manner, or transfer of resistance via other mechanisms, such as via plasmids, a risk that has been demonstrated on poultry farms in countries like Nigeria and China [40, 41], and in slaughtered chickens in Burkina Faso [42]. Likewise, in Ethiopia, almost 30% of samples taken from chickens, chicken litter and farm workers tested positive for *Staphylococcus* species, of which 95% were found to be resistant to Penicillin G. When considering all the isolates (not just the Staphylococcus species), 95.3% were resistant to three or more antimicrobials, reflective of the excessive and/ or inappropriate use of antibiotics [43].

The tetracyclines are reported as the most used antibiotic among household poultry farmers in our study. Tetracyclines are indeed the most-commonly used animal antimicrobial in the world (33,305 tonnes in 2020), with a 9% usage increase predicted by 2030 [20]. A previous study evaluated antimicrobial resistance of *Salmonella spp* in Zimbabwean poultry farms, and found tetracycline-resistance in 10.5% of their isolates from large-scale commercial farms [44]. Most (93.8%) *E.coli* isolates in free-range backyard poultry in Ghana were also found to have tetracycline resistance, in addition to 100% having re- 371 sistance to cephalosporins, 66.7% to trimethoprim-sulfamethoxazole, and 35.8% to ciprofloxacin [45]. In France, after reporting high rates of tetracycline-resistance in *E. coli* isolates from broilers, they found a significant drop in this resistance between 2006 and 2016 after the use of tetracyclines in poultry was reduced by regulatory means [46].

Equipment and environmental-related conditions (e.g. cold exposure with defective infrared lighting) was perceived as the main cause of mass-group mortality among fowl stock. However, infections remain the second-most cited cause of mortality in our sample (cited by 20% of those affected by such losses). This explains the ubiquitous use of antibiotics to prevent such losses. Other studies similarly found that chickens raised in backyard systems consumed higher amounts of antimicrobials (34 ± 7 mg/kg) than poultry in other systems ($p = 0.02$) [40].

In our study a history of suffering an instance where many birds were lost at once or in a short time period was associated with poor adherence to international poultry farming practices. This association should however be interpreted with caution, since this study is cross-sectional in nature and causality cannot be established in this case [47]. It is not clear whether such a previous incident with great loss would lead to (cause) poor practices and misuse of antibiotics, or whether poor practices (poor biosafety procedures) may have led to large mortality rates. Prospective studies may be able to differentiate this chicken-and-egg dilemma inherent in cross-sectional study designs.

Our study found no association with age and participants' knowledge, attitudes and practices. In contrast, a study in Bangladesh found that age, level of education, years of experience, gender, and previous training on AMU and AMR were key influencing factors on their KAP [48]. In their study, age had a positive association with increased KAP, suggesting that increased age brought experience, which positively impact on knowledge regarding AMR. However, further studies are required to focus on this in more detail.

Our study found male sex to be a risk factor, associated with poor practices and a risk for developing AMR, although the 95% confidence interval was close to the null value. These results resonate with the study in Bangladesh, which also found this association [48]. In addition to age and gender, training on AMU and AMR tends to be important factor of KAP, however, our study did not find level of education to be an association, and we did not consider any other training provided.

Farming duration and type of birds being kept was also not associated with differential KAP, nor was the size of the household farm (number of chickens on the premises). It should be noted however that other studies have found that individuals typically draw upon their knowledge and experiences to make decisions regarding antimicrobial use and related practices [30]. Poor knowledge scores were predictive of poor practices in our study. This is an intuitive finding and congruent with other studies. Mixed-method approaches will be critical to developing the targeted awareness campaigns needed to limit the emergence and transmission of AMR [49].

A larger number (n=40; 71.4%) of participants still felt that AMR could affect them and their family personally. It is unclear whether they may have meant this effect to be direct (human infections that are difficult to treat), or indirectly (financial impact of infections in their poultry). This question warrants further investigation, since only 60% of respondents could correctly indicate that inappropriate use of antibiotics in animals may cause resistance in human bacteria and 64% believed that antibiotic resistance is not a problem when treating poultry birds. Knowledge varied greatly in other studies, ranging to as high as 98% in Tanzania [50]. Other studies have identified clear knowledge gaps that needed to be addressed [49, 51]. Self-reported knowledge assessments should therefore be interpreted with caution, and triangulation of results and assessment by means of qualitative study methods should be considered for an in-depth analysis, as has been done elsewhere [12, 52].

Individuals who do chicken farming in these dense settlement areas as their only occupation were more likely to adhere to international guidelines and practices. We hypothesize that this may be due to more time being available for hygiene procedures and adherence to recommendations, and developing appropriate skills and professionalism in the industry, while individuals doing this as a "side-line" may not master the knowledge and skills necessary to adhere to these guidelines and recommendations. It is a topic that warrants further study in household and backyard farm settings.

Factors associated with good IPC and AMR practice included participants reporting that they received farming training provided by church organisations. Our study did not evaluate this any further, but this is worthy of further study, to determine the roles that multidimensional and multidisciplinary teams may play in tackling health problems. This is in line with the biopsychosociospiritual model of health, representing a more holistic approach [53].

The strongest associations with poor practices in our study were found to be poor knowledge scores and poor attitude scores. This highlights the need for education initiatives that should be targeted at individuals in these areas. Appropriate community engagement processes, considering the local context and specific values and principles is important to consider [54, 55].

There are limitations to our study. As mentioned above, the cross-sectional nature of the study, means that causal inferences should be considered with caution and be explored in further studies. Furthermore, the results should be interpreted with caution, since these are self-reported, by means of a questionnaire without verification of actual practices by the research team. Reporting bias and obsequiousness bias may therefore affect the data. Additionally, measurement bias may play a role, since in order to shorten the length of the questionnaire, some questions were asked in more than one dimension ("I wash my hands with soap and running water before and after working with chickens"). Participants may therefore have indicated that they "always" perform these actions, while perhaps only performing this *after* handling, but not before. For increased accuracy observations may be conserved as part of future datasets evaluating practices.

CONCLUSIONS

This study found a range of knowledge, attitudes and practices in household poultry farmers in dense settlement areas in Bulawayo, Zimbabwe. Practice scores consistent with international guidelines were associated with individuals with higher levels of knowledge and positive attitudes towards biosafety practices and proper AMU. We also found that individuals who previously suffered an incident where they had lost a large number of chickens at one time or in a short time period are more likely those who also have poor practice scores, and are more likely to be male study participants. Good practice scores were reported by individuals who reported that they received training by church institutions.

There is a need for the development of standardised questionnaires (or components of questionnaires) that would facilitate comparison of data across studies and across countries. While our study provides some useful information regarding some of the practices associated with poultry farming, more detail could be explored, and triangulation of information by means of a mixed- methods study (e.g. incorporating interviews and focus groups) may add significant value, such as was done in recent studies in Kenya [12,52].

IPC procedures (e.g. vaccination) may have very specific challenges in the setting of backyard domestic poultry farming, where smaller quantities of birds are kept. Previous authors have pointed out that smaller packaging with smaller quantities of doses should be made available in such settings [12]. This was not a focus in our study, but it is worth considering specific challenges faced by these small-scale farmers in implementing recommended practices.

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