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Research Article

Risk Factors Associated with the Emergence and Dissemination of Antibiotic-resistant Bacteria Among Poultry Farmers in South Togo

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Abstract

Background: Antimicrobial resistance is growing at an alarming rate to the point of outpacing the development of new means of infection control, thus threatening public health and the economics of agriculture. This study aims to explore poultry farmers' level of knowledge about the dangers of antibiotic resistance, and their attitude and behavior during the use of antibiotics in poultry. Methods: In November 2022, a semi-structured questionnaire was used to collect information from 153 poultry farms in the "Maritime Region" and "Grand-Lome District". The collected data concerned awareness of the behavioral gestures and dangers of antibiotic resistance that put poultry farmers in contact with resistant bacteria. *Results*: The findings revealed that 56.1% of poultry farmers (82 out of 146) were aware of antibiotic resistance, while 63% (70 out of 119) understood the risk of human contamination through poultry products. Despite this awareness, 55.6% (74 out of 133) of farms lacked protective measures during tasks such as handling droppings or administering antibiotics. A significant association was observed between animal health training and both awareness of antibiotic resistance and biosecurity practices ($p < 0.05$). However, no association was found between the training received and the poultry farmers' behavior regarding the use of antibiotics (p-value > 0.05). *Conclusion*: Poultry farmers' attitudes and behavior are favorable to the dissemination of resistant bacteria. It is necessary to continue sensitization by focusing on the risk factors that can put poultry farmers in contact with antibiotic-resistant bacteria.

Keywords

Resistance Bacteria, Poultry, Risk Factors, Dissemination, Togo

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1. Introduction

For many years, natural or synthetic antibiotics have been used to treat illnesses brought on by pathogenic bacteria, which are nearly ubiquitous in plants, animals, and people [1, 2]. However, abuse of antibiotics without adhering to the withdrawal period poses a risk to human health (e.g., allergic reactions, antimicrobial resistance (AMR), and imbalance of intestinal microbiota) when ingesting meat and meat products [3, 4]. AMR is a complex and multidimensional problem that threatens not just animal and human health but also the economy, national security, regional security, and international security. Out of an estimated 4.95 million fatalities globally in 2019, 1.27 million were directly related to bacterial resistance, according to the Global Research on Antimicrobial Resistance (GRAM) project report [5]. The issue is especially concerning since enterobacteria secrete carbapenemases and extended-spectrum beta-lactamases, which exacerbate infectious processes in both human and animal health [6, 7]. AMR is expanding at a startling rate, surpassing the creation of novel methods of infection control, endangering both public health and agricultural economy.

The non-therapeutic use of antibiotics in food-producing animals has grown widespread, if not required, in recent years to increase farm profitability [8]. The emergence and spread of antibiotic resistance are attributed to the uncritical use of antibiotics in human and animal health therapy, activated by the mobile genetic elements of the host bacteria [9-11]. Indeed, the use of animal droppings as a source of fertilizer in fields and gardens multiplies the possibilities and speed of the dissemination of infectious agents and their vectors. In addition, the loss of efficiency of the usual treatment products to treat human or animal pathologies, such as phytopharmaceuticals and biocides to treat pathogen vectors is a new factor in vulnerability [12].

Poultry breeding and marketing in Togo have taken on a new dimension due to the extensive use of antibiotics, disregard of biosecurity protocols, and inadequate hygiene [13]. In keeping with the goals of the World Health Organization's (WHO) global action plan on antimicrobial resistance, the purpose of this study is to investigate and evaluate the risk factors related to the spread of resistant bacteria among Togolese chicken farmers. Determining these risk indicators can assist in identifying vulnerable locations and offer insightful information to direct future awareness campaigns and instructional initiatives.

2. Materials and Methods

2.1. Study Area and Duration

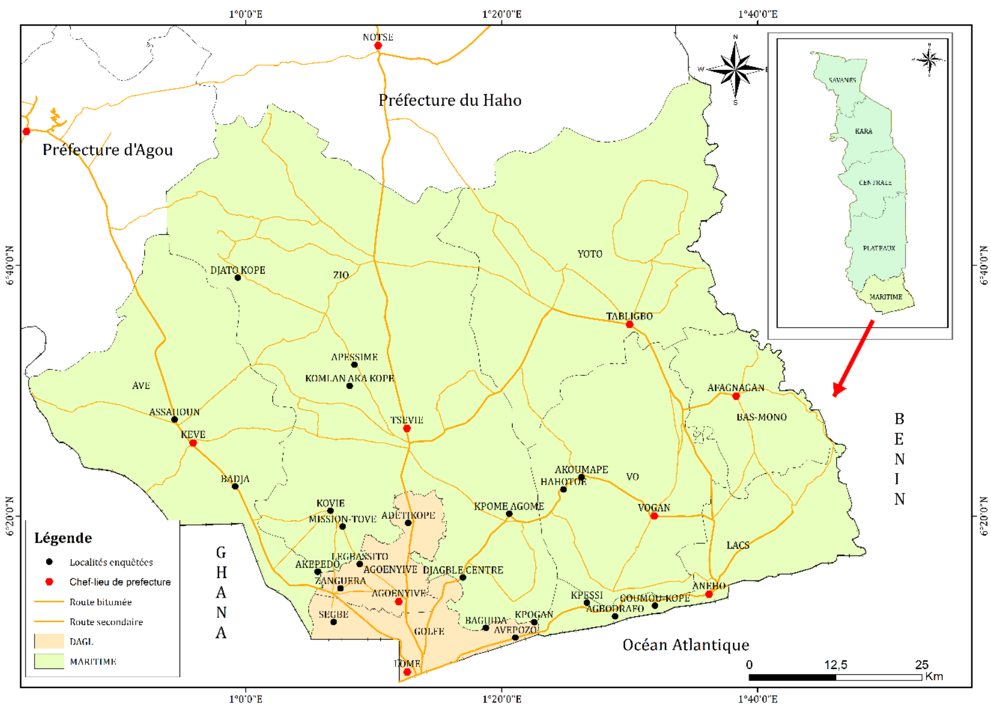

Figure 1. Epidemiological map of the "maritime region" showing the principals localities covered, modified by author [15].

The study took place in the “Maritime Region” and “Grand-Lome District” in November 2022 (Figure 1). These areas were selected due to their significant concentration of commercial poultry farms, accounting for 66.06% of the total in the country [14]. The Polaris GPS application was used to collect geographical coordinates. The map was modified using ArcGIS 10.8 software.

2.2. Selection of Study Poultry Farms and Poultry Farmers

A study was conducted to isolate multi-antibiotic-resistant bacteria from poultry droppings, including a descriptive questionnaire addressed to poultry farm owners. To determine the necessary sample size, the epidemiological formula $N = [Z^2(p(1-p))]/\Delta^2$ was used [16]. In this formula, Z represents the confidence level (1.96), Δ the margin of error (5%), and p the estimated proportion of bacteria in poultry feces (72.7%, based on a study in 2020 [17]. Applying these parameters, the required minimum sample size was calculated to be 305 chicken fecal samples.

National Association of Poultry Producers (ANPAT) of Togo data from 2017 listed 302 poultry farms in southern Togo, forming the study's sampling frame [14]. Given the assumption that two bacterial strains could be isolated per farm, the study needed to visit 153 farms to meet the sample size requirement of 305 samples (305/2). The primary goal of the study was to interview as many poultry farmers as possible from the sample, ideally all those within the identified group. Therefore, 153 poultry farmers were contacted to gauge their willingness to participate in the study, ensuring comprehensive data collection and a better understanding of antibiotic resistance in the poultry farms of the region. The snowball technique facilitated visits to all the farms in the sample [18].

2.3. Data Collection

Initially, a draft questionnaire was tested with a few farmers to assess their ability to clearly understand its content. Due to their difficulty in responding to some of the more in-depth questions, the questionnaire was then submitted to the department's scientific monitoring committee for revision, resulting in an improved final version. A finally semi-structured questionnaire was used to collect data from poultry farmers during the visits. The data collected were about their knowledge of dangerous gestures and behaviors bringing poultry farmers into contact with resistant bacteria. The questionnaire consisted of closed and open-ended questions including general information on the poultry on the farm (breeding system, number of poultry, use of antibiotics and, health management), the poultry farmers (gender, education level, training received) principal occupation, and the poultry farmers' knowledge of antibiotic resistance, droppings management, and other animal species raised in the area (their breeding system). The interviewers then scheduled face-to-face interviews with poultry farmers on their farms. Observations were made on the farm to appreciate good or bad hygiene practices. Local languages were used during the interviews to facilitate comprehension of the questionnaire by those respondents who did not speak French [19]. These solutions helped to mitigate biases in the understanding of the questionnaire.

2.4. Data Analysis

The collected data were systematically entered into an Excel 2016 database, and statistical analyses were performed using SPSS software. Descriptive statistics were used to summarize the characteristics of the poultry farmers and their farms. For bivariate analyses, ANOVA and Chi-square tests were utilized to explore the relationships between key variables. Specifically, these tests assessed the associations between socio-demographic characteristics (such as education level, training, and farm size) and poultry farmers' knowledge of antibiotic resistance, as well as their behaviors in using antibiotics and implementing biosecurity measures. The statistical significance of these associations was evaluated to identify the most critical factors influencing the spread of antibiotic-resistant bacteria.

3. Results

3.1. Characteristics of Poultry Farmers Surveyed

Of the 121 poultry farmers responding, 0.83% did not have formal education, 4.9% attended primary school, 38.02% attended secondary school, and 56.20% attended tertiary (Table 1). Eighty-two (56.1%) out of 146 had been trained in animal health.

Table 1. *Socio-economic characteristics of respondents.*

Variables	Responses	Respondents	Percentages (%)
Sex	Male	103	85.120
	Female	18	14.880

Variables	Responses	Respondents	Percentages (%)
	No formal education	1	0.830
Educational level of the manager	Primairy and Secondairy school	52	42.980
	Tertiary	68	56.200
	Breeders and farmers	51	42.150
Principal owner's occupation	Teachers, nurses, agronomists, Pensioners	34	28.100
	Shopkeepers, business	36	29.750
	0-4 years	45	37.200
Experience	05-10 years	47	38.840
	10 years more	29	23.960

3.2. Characteristics and Technical Monitoring of Poultry Farms Surveyed

During our survey, 18.04% of farmers had poultry that counted between 2,001 and 22,500 birds (Table 2). The survey identified a total of 266,217 poultry, all ages, included on 144 farms, with a mean of 1,849 poultry per farm and a standard deviation of 3,494.43. The survey study base involved 302 farms, yielding an estimate of 558,317 poultry at the time of the study. These numbers have seen a 5.7% regression per year over the period from 2019 to 2022. On the speculation question, a total of 34.4% of poultry farmers producing broiler chicken, 75.9% laying hens, and 7.8% rearing parent stock were found. Strains produced include Isa Brown, Leghorn, Goliath, Noiler, Cobb500, Black Delco, Nigerian Arco, Sasso, Local, and Wassachié. A percentage of 9.8% of 153 poultry farms are intensive producers (over 5,000 birds), 73.2% are semi-intensive (between 2,000 and 5,000 birds), and 16.99% practice improved system of production (less than 1,000 birds) (Tables 2 and 3). Of the 137 farms visited, 80 (58.4%) were managed by a technician, 26 (18.9%) by a laborer, and 31 (22.6%) by the farmer himself. Of the 80 technicians managing the farms, 51 (63.8%) were fixed and permanent on the farm, while 29 (36.2%) were mobile from one farm to another. Of the 134 farms, 129 (96.2%) did not have a fixed veterinarian due to low productivity, which made it impossible to bear the costs of hiring one.

As far as distance between farms is concerned, 68 (51.5%) out of 132 farms were located close to each other, while 118 (89.7%) were either located close to dwellings or cohabited with households. For 135 (98.5%) farms out of 137, the droppings collected were intended for spreading on agricultural soil without any prior treatment. Of 138 farms, 103 (74.6%) used boreholes as a source of water for their poultry, while 34 (24.6%) used wells.

Table 2. *Poultry count in ''Maritime Region'' and ''Grand-Lomé'' area.*

Number (N) of poultry	Staff	Percentages (%)
N< 100	07	04.860
100≤ N ≤ 500	54	37.500
501≤ N ≤ 1,000	30	20.830
1001≤ N ≤ 2,000	27	18.750
2001≤ N ≤ 5,000	15	10.410
5001≤ N ≤ 22,500	11	07.630
Total poultry farms	144	100
Poultry count average per farm	1,849	-

Table 3. Characteristics of poultry farms surveyed.

Variables	Responses	Respondents	Percentages (%)
Production type	Intensive	15	09.800
	Semi-intensive	112	73.200
	Improved	26	16.990
Management responsible	A technician and worker	13	09.490
	A technician	67	48.910
	A worker	26	18.980
	Himself	31	22.630
Is there a permanent technician on the farm?	Yes	76	63.870
	No	43	36.130
Is there a permanent veterinarian on the farm?	Yes	05	03.730
	No	129	96.270
Water source for poultry	National circuit (TDE)	01	0.720
	Drilling	103	74.640
	A well	34	24.640
Another poultry near the farm?	Yes	68	51.520
	No	64	48.480
Are there the houses near farm?	Yes	122	89.710
	No	14	10.290
A bunch of sick poultry on the farm?	Yes	18	14.880
	No	103	85.120
Faeces management	Thrown away	1	0.730
	Incinerated	1	0.730
	Used in agriculture and market gardening	135	98.540
	Used for biogas	0	0.000

3.3. Poultry Farmers' Awareness of Antibiotic Resistance Dangers and Their Behaviors During Antibiotics Use

One hundred and forty-three poultry farmers (93.7%) out of 153 knew what an antibiotic was. Among 142 farmers, 74 (52.1%) were able to give a specific example of an antibiotic. Eighty-two (56.1%) out of 146 have heard of antibiotic resistance. One hundred and twenty-five (89.9%) out of 139 farmers had a prophylaxis program containing antibiotics, and 14 (10.1%) of farmers had prophylaxis plans containing no antibiotics (Appendices: Table A1).

Regarding to the mode of administration, 134 (99.3%) administered antibiotics in oral form and 01 (0.7%) in injectable form in the event of symptomatic disease well observed in a small group of poultry. Ninety (75%) poultry farmers out of 120 were unaware that antibiotic resistance on poultry farms can be a cause of therapeutic failure and the mortality of sick people in hospitals. One hundred and fourteen (88.3%) out of 129 poultry farmers had a notion of biosecurity on a farm.

Regarding the mode of action of antibiotics, 139 (90.8%) poultry farmers out of 153 knew that the role of an antibiotic is to kill bacteria and that it can be found in the form of residues in animal by-products and droppings. The remaining fourteen (9.2%) used antibiotics unconsciously, without knowing their final action. The 153 (100%) poultry farmers surveyed were unaware of the existence of useful bacteria for animals' digestive tracts. Seventy-two (61%) out of 118 knew that a disease caused by a virus could not be treated. Eighty-three (69.1%) poultry farmers out of 120 knew that humans can be contaminated with resistant bacteria either by coming into contact with droppings or by consuming meat or milk from animals that have received antibiotic treatment.

3.4. Poultry Farmers' Attitude Toward Using Antibiotics

According to 125 (95.4%) out of 131 poultry farmers, it is very rare for them to purchase antibiotics from a human pharmacy for their own health without a medical prescription. Several reasons were given, including fear of intoxication for 13 (19.7%) and the absence of disease symptoms for 53 (80.3%) farmers out of 66. In contrast, 80 (59.2%) out of 135 poultry farmers reported that they sometimes request an antibiotic prescription even when the animals are not sick. Occasionally, six (4.9%) out of 114 poultry farmers used medications from human pharmacies to treat their animals when they were sick. Forty-nine (39.2%) out of 125 farmers sometimes altered the dosage and duration of antibiotic treatment. These modifications were made due to insufficient quantities of antibiotics, the progression of the disease, or the combination of the antibiotic with a vaccine.

Regarding hygiene and biosecurity practices, workers are not permanently present in 32 (23.3%) of the 137 poultry farms. In 74 (55.6%) out of 133 poultry farms, workers do not take protective measures during dropping collection. One hundred and twenty (96%) out of 125 poultry farmers acknowledged that they are interested in laboratory diagnostics in the event of animal illness before an antibiotic is prescribed (Appendices: Table A1).

3.5. Impact of Education Level on Farmers' Behavior

Among 79 poultry farmers respondent who had received training in animal health out of 82, 67 (84.81%) had knowledge of antimicrobial resistance ($p<0.05$). There was no significant association ($p>0.05$) between farmers' level of education and their attitudes toward antibiotic use. The Chi-square test has revealed 42 poultry farmers having received training in animal health versus 53 who gave the absence of disease as the reason for not using antibiotics for their health, with a p-value=0.63. Among 82 poultry farmers who have received animal health training, six (7.31%) know the concept of critically important antibiotics (p =0.76). Fifty-five (55) university-level poultry farmers versus 33 secondary-level farmers out of 94 have identified antibiotic toxicity or negative effects as the consequences of excessive use of ATB (Table 4). The chi-square test revealed a significant association between the manager's education level and their knowledge of antibiotic resistance.

Table 4. *Impact of training on knowledge level on ATB resistance and their behavior.*

Knowledge on anti-microbial resistance (RAM)					
Training on animal health	No	Yes	Total	p-value	Remarks
No	43	14	57		
Yes	26	53	79	<0.0001	Significant
Total	69	67	136		
Biosecurity knowledge					
Training on animal health	No	Yes	Total	p-value	Remarks
No	13	38	51		
Yes	02	75	77	<0.0001	Significant
Total	15	113	128		
Knowledge of "critically important" ATB					
Training on animal health	No	Yes	Total	p-value	Remarks
No	46	02	48		
Yes	73	04	77	0.760	Not significant
Total	119	06	125		
Biosecurity device at farm entrance					
Training on animal health	No	Yes	Total	p-value	Remarks
No	19	32	51	0.170	Not significant

Yes	20	57	77		
Total	39	89	138		
Reason for not asking a doctor for an antibiotic prescription					
Training on animal health	I'm not sick	Fear of intoxication	Total	p-value	Remarks
No	19	32	51	0.063	Not significant
Yes	20	57	77		
Total	39	89	138		

3.6. Impact of Poultry Farming Systems on Antibiotic Use

Table 5. *Impact of poultry farming system on antibiotic use.*

	Strain	Manager's level of education	Do you use antibiotics on your farm ?	Do you have a prophylaxis plan?	Do you have a fixed technician on the farm?	Do you have a biosecurity system at the farm entrance ?
Strain	1.000	-0.047	-0.147	-0.155	0.063	-0.080
Manager's level of education	-0.047	1.000	0.168	0.280	-0.116	0.090
Do you use antibiotics on your farm?	-0.147	0.168	1.000	0.532	-0.192	0.477
Do you have a prophylaxis plan?	-0.155	0.280	0.532	1.000	-0.095	0.387
Do you have a fixed technician on the farm?	0.063	-0.116	-0.192	-0.095	1.000	-0.185
Do you have a biosecurity system at the farm entrance?	-0.080	0.090	0.477	0.387	-0.185	1.000

Values closer to 1 or -1 suggest stronger correlations, and values near 0 indicate weak or no correlation between variables; positive values show a direct correlation, while negative values indicate an inverse relationship.

The correlation matrix (Table 5) indicated weak relationships between poultry breed and variables such as antibiotic usage (-0.147), prophylaxis plans (-0.155), and biosecurity (-0.080). However, there was a moderate positive correlation between the manager's education level and the presence of a prophylaxis plan (0.280) and biosecurity measures (0.090). Additionally, strong correlations were observed between antibiotic usage and the presence of prophylaxis plans (0.532). Interestingly, the presence of permanent technicians showed weak negative correlations with antibiotic use (-0.192) and biosecurity (-0.185), implying that poultry farms with permanent technical staff tend to rely less on these measures.

4. Discussion

4.1. Characteristics of Poultry Farmers Surveyed

Overall, 38.02% of the sample poultry farmers surveyed have a secondary educational degree, and 56.2% have higher-educational degrees. Some authors showed a positive correlation between the level of education and awareness regarding antibiotic use, indicating that awareness tends to increase with higher levels of education [20]. An investigation in 2019 on the sex and occupation of poultry farmers in the same localities, resulted in the classification of the owners as full-time agro-poultry farmers, civil servants (including teachers, nurses, agronomists, and retirees), occasional farmers, entrepreneurs, and traders [13].

4.2. Characteristics and Technical Monitoring of Poultry Farms Surveyed

The investigation counted a total of 266,217 poultry on 144 farms, and the survey base allowed to estimate around 558,317 head of poultry at the time of the investigation. Compared with 675,574 head of poultry counted in 2019, this survey shows an annual regression of 5.78% over the period 2019 to 2022. This is explained by the COVID-19 pandemic, the Ukrainian conflict and rising grain prices, which have led to poultry breeding discontinuation on some farms. A total of 36.1% of non-permanent poultry technicians could be mobile from one poultry farm to another, constituting a reservoir for the dissemination of bacterial germs from one poultry farm to another or from a poultry farm to a human population. One hundred and twenty-nine (96.2%) of poultry farms did not have a veterinarian due to low productivity and the inability to pay for the service provided. These trends are similar to those of Food and Agriculture Organization of the United Nations (FAO) and authors, which revealed that none of the breeders had access to a veterinarian for animal health monitoring [21, 22]. In sub-Saharan Africa and Ghana, respectively studies have demonstrated the importance of veterinarians in the control of infectious diseases [23, 24]. Depending on how the farmer-veterinarian connection is viewed, it may act as a barrier or a facilitator for decreased antimicrobial use. Promoting cooperation between veterinary professionals and farmers may result in a shared accountability for cutting back on the usage of antibiotics [25]. Reducing the use of antibiotics is a key step in preventing the emergence and spread of antimicrobial resistance (AMR). That's why some suggested increasing public awareness campaigns as antibiotic misuse becomes an increasingly recurrent practice [26]. Many poultry farms visited are set up close to dwellings or in cohabitation with households. Poultry dropping is collected and spread on farmland without any prior treatment. Globally, droppings are a common soil fertilizer utilized in agricultural activities. Antibiotic residues are not absorbed into the poultry body and released into the environment via poultry feces. All of which constitute channels for the emergence and dissemination of resistant infectious agents, both for humans and animals [27, 28]. These results are closer to those obtained in Togo in 2019, which showed that 93.6% of droppings are used for agricultural purposes and that 65.6% use boreholes as a source of water for poultry.

4.3. Poultry Farmers' Awareness of Antibiotic Resistance Dangers and Their Behaviors During Antibiotics Use

A total of 153 (93.7%) poultry farmers know what an antibiotic is. These results are similar to those reported in 2019, which showed that 93.8% of poultry farmers knew what an antibiotic was [13]. Although they said they knew about antibiotics, only 52.1% of farmers could give an example. About 56.16% have heard of antibiotic resistance. From 2019 to 2022, awareness-raising efforts have increased poultry farmers' knowledge of antibiotic resistance. Even if farmers' level of education is high, controlling all the dangers associated with antibiotic resistance still requires awareness-raising. For example, authors have highlighted to the WHO the low level of knowledge about antimicrobial resistance in the African region and emphasized the urgent need to strengthen context-specific educational efforts and interventions aimed at positively changing behaviors [29]. Poultry farming has witnessed progress in terms of sanitary prophylaxis associated with the preventive use of antibiotics. Only 10% had a prophylaxis program that did not contain an antibiotic. The FAO in 2015 reported that 69.73% of farmers had a prophylaxis program [21]. These results support those of other publications, which showed that modern poultry farming in Togo is generally carried out in close collaboration with Western firms that supply feed formulation, pre-mix, chicks, or breeding stock [30]. Concerning administration of antibiotics in poultry, the injectable form was rarely used except in the case of symptomatic diseases observed in a restricted group of poultry (we cite here the example of Tylosin injectable used by certain breeders in the case of respiratory problems frequently observed in their poultry). In 2012 et 2023, a study described the same situation, according to which the oral route was the only method of drug administration on poultry farms in Senegal [30, 31]. A few can who knew about the "critically important antibiotic" classification were farmers who had their professional careers in human medicine. Generally, almost all poultry farmers', even those who did not get any training in animal health, have empirical knowledge of biosecurity on a farm, but few can practice it systematically and rigorously. Regarding the role of antibiotics, most poultry farmers were aware that they are used to fight against bacterial infections [32] and that they can be found as residues in animal by-products and droppings. However, farmers did not know that there are bacteria that are useful for animals' digestive tracts and therefore must be preserved [33, 34]. The excessive use of antibiotics in a host can lead to dysbacteriosis, have a negative impact on its feed conversion, and upset its immune system [35, 36]. Many poultry farmers knew that an antibiotic could not kill a virus. However, the lack of communication ability in animals, combined with a lack of training and the absence of disease diagnostic laboratories in the livestock sector, are all factors that compel farmers to use antibiotics. In Burkina Faso the absence of microbiological diagnostic laboratories in the livestock sector was reported [37].

4.4. Poultry Farmers' Attitude Toward Using Antibiotics

For most poultry farmers, it was very difficult to go to the pharmacy to buy an antibiotic for their health without getting sick. On the other hand, they would sometimes ask for a prescription for antibiotics without the poultry being ill. An earlier study in Togo reported that farmers chose drugs and decided on their use without veterinary consultation or prior justification [38]. Once more, this is a proof of self-medication widely practiced in the country. However, World Organisation for Animal Health (WOAH/OIE) and some authors have mentioned in one of their recommendations that the most common reason for using antimicrobials is to treat a case of disease with a bacterial cause [39, 40-42]. The use of human pharmacy medicines by 04.9% of poultry farmers to treat their animals occasionally in case of illness confirms the abusive and unreasoned use of antibiotics in the animal sector in developing countries [37]. This requires policymakers to revise regulations, emphasizing the justified prescription and use of antibiotics. This attitude on the part of poultry farmers proves that food safety and ethics are not considered in animal production. Even though a good number of breeders said they never changed doses, few used precise measuring tools such as scales, with a crucial lack of respect for waiting times. This can lead to over- or under-dosing [29]. Whereas, according to others documents in 2016, these ways of antibiotics usage in livestock farming can not only have serious side effects on animals but also favor and exacerbate the selection of resistant bacteria [43]. The phenomenon can be further exacerbated by poultry farmers using antibiotics as a preventive measure or sometimes interrupting their treatment prematurely. This can lead to superinfection and sometimes to the appearance and spread of bacteria mutated against the new "critical" or "last resort" antibiotic molecules on the market. In terms of biosafety, workers are not permanently on the farms. The absence of protective masks when picking up litter is a dangerous factor that favors bacterial transmission from animals to humans. These results highlight the need to raise awareness among farmers about the importance of the issue. Furthermore, the establishment of a rapid bacteriological diagnostic framework and the implementation of antibiotic susceptibility testing in the animal sector in Togo would be a valuable asset for the precise selection of antibiotics and a more cost-effective treatment of targeted animal diseases.

4.5. Impact of Education on Farmers' Behavior and Knowledge

Poultry farmers were aware that there could be negative effects on poultry after antibiotic use. The Chi-square test showed that most poultry farmers who reasoned about antibiotic toxicity belonged to the university and high school levels. However, there was no evidence of a significant association between farmers' level of education and their attitudes toward antibiotic use. There was no significant association between training in animal health and the variables justifying the use or non-use of antibiotics by farmers, since those who had received training were lower than those who knew that one had to be sick before taking an antibiotic. Of the 77 farmers who had received animal health training, only six were aware of "critically important" antibiotics. There is no significant association between animal health training and knowledge of critically important antibiotics. These gaps in the rational use of antibiotics in poultry and awareness of the dangers of antimicrobial resistance for public’s call the training schools to include educational content about the risks of antimicrobial resistance in their curricula. This may be explained by the fact that modules on antibiotic resistance were not included in the training sessions. In 2017 author pointed out that in resource-limited West Africa, veterinary services do not have enough staff trained in infectiology, microbiology, or epidemiology capable of making a diagnosis and proposing an appropriate antibiotic treatment for bacterial infections [37]. There was also a significant association between farmers' training in animal health and their knowledge of biosecurity. However, there is no significant evidence of an association between training in animal health and the installation of biosecurity systems on the farm since there were farmers who had received training in animal health but did not have a biosafety device at the entrance to their henhouse. There is a significant association between animal health training and knowledge of antimicrobial resistance. Overall, the results are consistent with previous studies, showing that individuals with a high level of education and training in animal health tend to have a good understanding of the dangers of antimicrobial resistance and a positive attitude towards antibiotics [44]. But in all cases, there is no significant evidence to support the direction of the association.

4.6. Impact of Poultry Farming System on Antibiotic Use

The data reveals notable associations between farm management systems and antibiotic usage, with a particular link to education level, prophylaxis plans, and biosecurity systems. The correlation analysis further illustrates that poultry strain has a minimal influence on farm management decisions, such as the use of antibiotics and biosecurity practices. In contrast, the manager’s level of education played a more decisive role in decision-making and the implementation of measures. Farms managed by individuals with higher levels of education are more likely to adopt structured health management systems, including prophylaxis plans and biosecurity measures at farm entrances. Studies have shown the influence of factors such as farm size, available resources, and specific farm objectives on the development of management strategies and antibiotic use practices [45, 46].

One of the key findings is the strong association between a manager's education level and their knowledge of antibiotic resistance. Managers with higher education levels demonstrate a more comprehensive understanding of antibiotic resistance, as well as a greater likelihood of implementing preventive measures such as prophylaxis plans and biosecurity systems. Additionally, the strong correlation between antibiotic usage and both prophylaxis and biosecurity indicates that farms using antibiotics are more likely to have structured, organized health management practices. The chi-square test supports these findings by highlighting a significant association between a manager's education level and their awareness of antibiotic resistance. This reinforces the idea that education is a key factor in the adoption of responsible management practices that help to limit the emergence and spread of antibiotic-resistant bacteria. [47, 45]. The presence of a fixed technician on the farm shows weaker correlations with biosecurity practices. However, the finding indicates no significant differences in outcomes based on antibiotic use or not, technician assistance or not, or the implementation of protective measures. This suggests that these individual practices may not independently influence the spread of antibiotic resistance or that more data is necessary to detect meaningful patterns. Ultimately, education, biosecurity, and structured management practices are vital in addressing the dissemination of antibiotic-resistant bacteria in poultry farming [48, 49].

5. Conclusion

The findings of this study reveal important gaps in poultry farmers' knowledge and behaviors related to antibiotic use and antimicrobial resistance in the “Maritime Region” and “Grand-Lome District”. While over half of the farmers surveyed were aware of antibiotic resistance, unsafe practices such as handling poultry droppings without protection and using antibiotics without proper guidance remain prevalent. A significant association between training in animal health and increased awareness of antibiotic resistance and biosecurity practices indicates the positive impact of education. However, no significant link was found between farmers' behavior and their actual antibiotic use, suggesting that knowledge alone does not lead to safer practices. This calls for stronger, targeted interventions that go beyond raising awareness to enforce biosecurity measures and responsible antibiotic usage. Additionally, integrating routine veterinary support and implementing stricter policies on antibiotic distribution and use in poultry farming are essential steps to control emergence and the spread of antibiotic-resistant bacteria and protect public health.

Abbreviations

AMR	Antimicrobial Resistance
GRAM	Global Research on Antimicrobial Resistance
WHO	World Health Organization's
ANAPAT	National Association of Poultry Producers of Togo
FAO	Food and Agriculture Organization of the United Nations
WOAH	World Organisation for Animal Health

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Ethical Approval

The study was conducted in accordance with the ethical guidelines of the Bioethics Committee for Health Research of the University of Lome, Togo. The research protocol received approval from the Committee (Approval N° 012/2024/CBRS, dated May 16, 2024). All procedures adhered to the Committee's recommendations regarding confidentiality and the appropriate use of data, ensuring the protection of participants and the ethical management of the information collected during the study.

Resource Availability

The data that support the findings of this study are available from the corresponding author upon request.

Author Contributions

Malibida Dolou: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Software, Visualization, Writing - original draft

Claude Kpomasse: Conceptualization, Data curation, Formal Analysis, Software, Writing - review & editing

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Essodina Talaki: Conceptualization, Investigation, Validation, Writing - review & editing

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Conflicts of Interest

The authors declare no conflicts of interest.

Appendix

Table A1. *Summary of poultry farmers' awareness on antibiotic resistance dangers, and their behavior when using antibiotics.*

Variables	Responses	Respondents	Percentages (%)
Knowledge of an ATB	Yes	135	93.750
	No	09	06.250
Precise example of an ATB	Yes	74	52.110
	No	68	47.890
AMR knowledge	Yes	82	56.160
	No	64	43.840
Animal health training	Yes	82	56.160
	No	64	43.840
Existence of a Prophylactic plan	Yes	125	89.930
	No	14	10.070
Elaboration of a prophylactic plan	Veterinary	75	61.470
	Incubator	04	03.270
	A technician	43	35.240
ATB in the prophylactic plan	Yes	125	89.930
	No	14	10.070
Why is ATB in the prophylactic plan?	Avoid disease	120	96.000
	Because animal don’t talk	47	37.600
	Veterinary recommandation	5	04.000
ATB administration	Oral and injectable	2	01.480
	Oral	133	98.520
Training in the use of ATB	Yes	73	50.000
	No	73	50.000
Knowledge of ‘’critically important ATB’’	Yes	06	04.760
	No	120	95.240
Breeder informed of human mortality coming to ATB resistance	Yes	32	25.600
	No	93	74.400
Breeder informed of the decrease in the discovery of new ATB	Yes	29	24.170
	No	90	75.000
	I don’t know	01	0.830
Farmer informed of the non-sensibility of certain ATB on bacteria?	Yes	75	65.790
	No	39	34.210
Can a viral disease be treated?	Yes	24	20.340

Variables	Responses	Respondents	Percentages (%)
	No	72	61.020
	I don't know	22	18.640
Biosecurity knowledge	Yes	114	88.370
	No	15	11.630
On-farm biosecurity system	Yes	89	68.990
	No	40	31.010
Summary of poultry farmers' behavior when using antibiotics			
Breeder's request for ATB prescription for animals change in dose of ATB per day	Yes	80	59.260
	No	55	40.740
	Never	90	72.000
	Sometimes	35	28.000
Modification of the number of days in ATB treatment	Never	76	60.800
	Sometimes	49	39.200
Request for prescription of ATB by the breeder for his own health	Yes	06	04.580
	No	125	95.420
Reason for not requesting ATB prescription by the breeder for his own health	I'm not sick	53	80.300
	Fear of intoxication	13	19.700
Use of herbal medicines by farmers for their own health	Yes	71	60.170
	No	47	39.830
Knowledge of the dose of herbal medicines	Yes	06	08.820
	No	62	91.180
Evaluation of the cost of antibiotic prophylaxis on animals	Yes	23	19.010
	No	98	80.990
Breeder interested in antibiotic susceptibility testing before prescribing ATB to animals?	Yes	120	96.000
	No	05	04.000
Use of human drugs on animals?	Yes	06	04.940
	No	108	95.160
Workers on duty during droppings pick-up	Yes	105	76.640
	No	32	23.360
Wearing a mask when picking up droppings	Yes	59	44.360
	No	74	55.640

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