

Research Article**Practices and perceptions on antibiotics among broiler farmers in three selected areas of Bangladesh****Debnath S^{1*}, Debnath M¹, Mittra PK²**^{1*}Department of Biochemistry and Molecular Biology, Faculty of Nutrition and Food Science, Patuakhali Science and Technology University, Patuakhali-8602, Bangladesh.¹Department of Biochemistry and Molecular Biology, Faculty of Nutrition and Food Science, Patuakhali Science and Technology University, Patuakhali-8602, Bangladesh.²Department of Basic Science, Faculty of Animal Science and Veterinary Medicine, Patuakhali Science and Technology University, Babugonj, Barisal-8210, Bangladesh.**ABSTRACT****Article History**

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The residual impact of antibiotics and their ineffectiveness against microorganisms has been identified as a global public health concern. This research involved 96 broiler farmers from three selected districts in Bangladesh, conducted between January to March 2024, to investigate the patterns of antibiotic use and farmers' perceptions of antibiotics. Data was collected using a semi-structured questionnaire. Farmers reported using antibiotics mainly for therapeutic purposes (88.5%), while more than one-third (33.3%) employed them preventively; nearly half (49.0%) relied on the advice of a registered veterinary doctor, whereas 44.8% made independent decisions regarding their use. Ciprofloxacin (46.6%), colistin sulphate (25.0%), and enrofloxacin (19.8%) emerged as the top three therapeutic drugs of choice. Almost half (46.9%) of the participants believed that malabsorption was the primary residual effect of antibiotics. A significant majority (93.8%) of poultry farmers were unaware of antibiotic resistance. The study area shows a common use of antibiotics in broiler farms. To address the issue, appropriate strategies need to be introduced to curb the unethical and self-medicated use of antibiotics in the study region.



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INTRODUCTION

Poultry ranks among the most rapidly expanding sources of protein globally (Apata, 2009). Despite this, poultry farming involves extensive antibiotic use, which could potentially pose health risks to consumers through antibiotic residues in animal-derived food products, especially meat (Jaber *et al.*, 2025). Antibiotics have been effectively utilized in both human and veterinary medicine for treatment, prevention, and as growth enhancers (Agada, 2014). Consumers are impacted by veterinary antibiotics due to residual risks (Chanda *et al.*, 2014). Furthermore, the extensive application of antibiotics in veterinary practices leads to the development of antibiotic-resistant bacterial strains (Hassan *et al.*, 2014). Antimicrobial resistance is increasingly becoming a global public health issue (Kaye *et al.*, 2004); (Agada, 2014).

Farmers have utilized antibiotics for disease prevention, treatment, and as growth enhancers (Wadoun *et al.*, 2016). In developing nations, the overprescription and excessive use of antimicrobials contribute to the development of resistance in humans (Coyne *et al.*, 2018). Furthermore, the easy availability of antibiotics in local shops without the need for a prescription has resulted in their widespread and improper use (Islam *et al.*, 2016). Research has shown that in the Philippines, farmers can easily purchase veterinary antimicrobial drugs at local agri/veterinary retail outlets even without a prescription (Pineda-Cortel *et al.*, 2024).

In Bangladesh, a significant quantity of antibiotics is utilized each year (M. Sarker *et al.*, 2016). Poultry farmers in the country often use antibiotics without seeking advice from veterinarians (Pineda-Cortel *et al.*, 2024); (Sirdar *et al.*,

2012). Similar to other developing nations, antibiotics in Bangladesh are widely employed in poultry farming to promote growth, manage diseases, and enhance feed efficiency and bird growth (Sarker *et al.*, 2016); (Gelband *et al.*, 2015). The indiscriminate use of antibiotics by farmers is driven by their lack of awareness, insufficient veterinary services in rural or remote areas, and the pursuit of higher profits (Sirdar *et al.*, 2012). In Bangladesh, the situation is significantly more dire (Foyosal *et al.*, 2024). There is minimal regulation over the use of antibiotics in livestock (WHO, 2002). Consequently, antimicrobial resistance is a global issue, with the rise of such resistance posing a worldwide public health threat (Kaye *et al.*, 2004). Even when antibiotics are used correctly in veterinary practices, their application is particularly concerning due to the risk of these drugs entering the human food supply. Additionally, since some reports suggest that drugs are administered by unqualified personnel, there is a possibility that their effectiveness will be diminished (Thakur & Bajaj, 2006). In countries like Bangladesh, people can easily buy antimicrobial drugs from local pharmacies without a prescription. This often results in their irrational use. This practice has resulted in the indiscriminate use of antibiotics, causing significant health risks due to the emergence of antibiotic resistance (Hassan *et al.*, 2014).

A study was carried out in selected broiler farms across Bangladesh to assess how antibiotics are being used. It was found that antibiotics were commonly used for treatment (43.8%) and prevention (31.5%). A total of twenty-eight different antibiotic usage patterns were identified, with most of the farmers using antibiotics without obtaining a prescription. Most frequently used antibiotics were fluoroquinolones, accounting for 68.4% (Islam *et al.*, 2016). This study aims to provide baseline data on therapeutic antibiotic use and farmers' perceptions in Bangladesh, addressing a critical knowledge gap. The study's goal was to explore farmers' perceptions of antibiotic use, which is crucial for ensuring the safety of poultry and consumers. To date, no comprehensive research has been documented on farmers' perceptions of antibiotic use in Bangladesh. Therefore, it is essential to gain a clear understanding of the current patterns of antimicrobial use and farmers' perceptions of antibiotic use.

MATERIALS AND METHODS

Study area

The research took place from January 2024 to March 2024 in Wazirpur Upazilla of Barishal, Fultola Upazilla of Khulna district, and Fokirhat Upazilla of Bagherhat district.

Study design

A cross-sectional study was carried out among broiler farmers to gather information. Ninety-six participants from three districts were chosen through a convenient sampling technique. Data collection was performed using a pre-designed, semi-structured questionnaire. Information was obtained through face-to-face interviews. Respondents were asked both closed and open-ended questions. The study's objectives and goals were thoroughly explained to the participants before data collection began. Only farmers who expressed interest were included in the study, while those

unwilling to share their opinions or absent during the survey were excluded.

Study variables

The questionnaire was divided into several key sections. It gathered socio-demographic details of the farmers, including their age, gender, educational background, family income, and farming experience. It also collected fundamental data on farming systems, biosecurity measures, issues affecting the poultry industry, and sources of information. Regarding antibiotic use, the survey covered the types and generations of antibiotics, the manufacturers, the qualifications of those prescribing them, the methods and reasons for their use, and the farmers' understanding and perceptions of antibiotics. Additionally, each farmer was asked about the primary challenges faced by broiler farms and where they obtain preventive information.

Statistical analysis

Calculations were performed to determine frequency distributions and descriptive statistics, including frequency, mean, median, and standard deviation, for key demographic variables. The Statistical Package for Social Sciences (SPSS) software facilitated this descriptive statistical analysis.

RESULTS

A total of 96 respondents were gathered from various Upazillas in the districts of Barishal, Khulna, and Bagherhat. As shown in Table 1, the respondents' ages range from 30-55 years. The participants included 86 males (89.6%) and 10 females (10.4%). A significant portion of the farmers, 79 individuals (82.3%), resided in rural areas. The majority, 38 people (39.6%), had completed primary education. More than 60% of the respondents, 61 individuals (63.5%), relied solely on farming for their income. Over half of them, 52 participants (54.1%), had more than five years of experience in farming. Most families, 70 in total (72.9%), consisted of more than four members. Approximately 57 respondents (59.4%) reported a monthly income of 10,000 BDT.

According to Table 2, nearly 87.5% of the farms were of the closed type. Over 65.6% of the farmers, totaling 63, utilized rice husk as bedding material. The majority of the farms, 69 in number (71.9%), housed between 500 and 1000 birds. About 38 (39.6%) birds mortality rate was more than twenty days. A significant portion, 91 respondents (94.8%), employed protective measures against germs. Disinfectants were the most commonly used safety tool by 39.6% of the farmers.

Table 3 indicates that over 61 (63.5%) of the participants considered spiritual treatment to be ultimately safer than antibiotics. A majority of 62 (64.6%) farmers had received spiritual treatment from the Ayat of a religious text. Nearly 82 (85.4%) respondents had undergone spiritual treatment more than five times. Most of the farmers, 66 (68.8%), reported that the recovery rate with spiritual treatment was approximately 30%. Only 5 (5.2%) farmers experienced very satisfactory outcomes from this spiritual treatment.

According to the survey, Table 4 indicates that 53 respondents, or 55.2%, were aware of antibiotics. A

significant portion, 74 farmers (77.1%), reported purchasing poultry feed that contained various chemicals, heavy metals, stones, and other additives. More than one-third, 34 respondents (35.4%), believed that the inclusion of antibiotics in feed negatively impacted poultry health. Additionally, 32 farmers (33.3%) administered antibiotics as a preventive measure. A substantial majority, 85 farmers (88.5%), used antibiotics for therapeutic purposes. Approximately 67 farmers (69.8%) added antibiotics to drinking water. Nearly 86 farmers (89.6%) were convinced that antibiotics effectively treated diseases.

In Table 5, it is evident that just 7 respondents, or 7.3%, were aware of the antibiotic withdrawal period. Nearly 85 participants, accounting for 88.5%, were unaware of the residual effects. Only a small group of 10 farmers, or 10.4%, understood the side effects of antibiotics. A significant majority, 87 individuals or 90.6%, lacked knowledge about the standard dosage of antibiotics. Over three-fifths, specifically 61 respondents or 63.5%, acknowledged that consuming poultry products with extended antibiotic use could pose health risks to humans. Merely 6 respondents, or 6.3%, were informed about antibiotic resistance. The majority, 74 farmers or 77.1%, believed that antibiotics were frequently necessary. Table 5 also indicates that a significant majority, 87 (90.6%), of participants utilized broad-spectrum antibiotics, while 91 (94.8%) opted for narrow-spectrum antibiotics. Among the antibiotics used, Ciprofloxacin was chosen by nearly 40.6% of farmers, with Colistin sulphate being used by 24 (25.0%), and Enrofloxacin by 19 (19.8%). Our research revealed that more than half (58.3%) of the farmers employed 2nd-generation antibiotics. In the first week, the highest proportion (61.5%) of farmers administered antibiotics to broilers.

Table 1: Demographic characteristics of farmers in three districts of Bangladesh.

Parameter	Categories	Frequency (N)	Percentages (%)
Gender	Male	86	89.6
	Female	10	10.4
Living place	Rural	79	82.3
	Semi Urban	17	17.7
Religion	Muslim	78	81.3
	Hindu	18	18.8
Education	Illiterate	12	12.5
	Primary	38	39.6
	Secondary	33	34.4
	Higher secondary and above	13	13.5
Occupation	Only Farmer	61	63.5
	Farmer and others	35	36.5
Experience	≤ 5	44	45.9
	>5	52	54.1
Family member	≤ 4	26	27.1
	>4	70	72.9
Family income	5500-8000	7	7.3
	8000-10000	25	26
	10000-15000	39	40.6
	16000-20000	19	19.8
	21000-Above	6	6.3

Table 2: Farming system and hygienic status of the farm.

Parameter	Categories	Frequency (N)	Percentages (%)
Farms type	Close	84	87.5
	Intensive	12	12.5
Litter types	Sawdust	26	27.1
	Rice husk	63	65.6
	Sand	1	1.00
No. Of Birds	500-1000	69	71.9
	1500-2000	21	21.9
	2000-5000	3	3.1
	5000-Above	3	3.1
Mortality	Less than ten	36	37.5
	More than ten	22	22.9
	More than twenty	38	39.6
Use of protective tools	Yes	91	94.8
	No	5	5.2
Safety tools	Disinfectants	38	39.6
	Water Purifier	28	29.2
	Hand gloves	6	6.3
	Farm cloths	9	9.4
	Farm shoes	15	15.6

Table 3: Farmers' conception of spiritual treatment

Parameter	Categories	N	%
Necessity of spiritual treatment	Very safe, not a concern	19	19.8
	Very safe, but minor concern	16	16.7
Mostly taken treatment	Safer treatment	61	63.5
	Water treated	3	3.1
	Leaf of any tree	14	14.6
	Ayat of religious books	62	64.6
	Stem of trees	6	6.3
	Others combination	11	11.5
Probable time of taking treatment	Less than three times	14	14.6
	More than five times	82	85.4
Recovery rate	Near about 30%	66	68.8
	More than 30%	13	13.5
	More than 50%	11	11.5
	Up to satisfactory level	6	6.3
Satisfaction level by taking treatment	Very satisfactory results	5	5.2
	Satisfactory	16	16.7
	Hopeful to satisfactory margin	75	78.1

N= Frequency; %= Percentage

Table 4: Antibiotics and other important issues related information.

Parameter	Categories	N	%
Knowledge about antibiotics	Yes	53	55.2
	No	43	44.8
Adding chemicals, heavy metals, and stones to poultry feed	Yes	74	77.1
	No	22	22.9
Injurious effects of antibiotics on poultry health	Yes	34	35.4
	No	62	64.6
Antibiotics used as a preventive dose	Yes	32	33.3
	No	64	66.7
Antibiotics used as a therapeutic dose	Yes	85	88.5
	No	11	11.5
Antibiotics used in ready feed	Yes	29	30.2
	No	67	69.8
Antibiotics used in drinking water	Yes	67	69.8
	No	29	30.2
Used antibiotics to cure the disease	Yes	86	89.6
	No	10	10.4

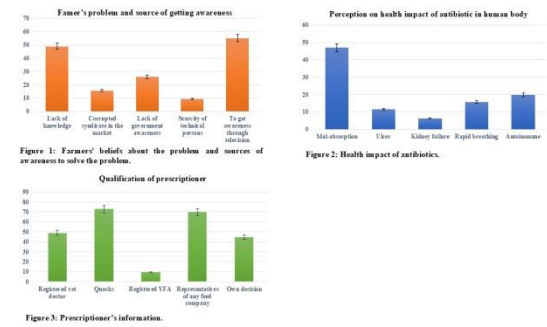
N= Frequency; %= Percentage

Table 5: Farmer perception about antibiotics and antibiotic use history.

Parameter (Farmer perception about antibiotics)	Categories	N	%
Knowledge about the withdrawal period	Yes	7	7.3
	No	89	92.7
Idea about residual effect	Yes	11	11.5
	No	85	88.5
Knowledge about side effect	Yes	10	10.4
	No	86	89.6
Idea about normal dose	Yes	9	9.4
	No	87	90.6
Health hazard due to consuming poultry products	Yes	61	63.5
	No	35	36.5
Idea about antibiotic resistance	Yes	6	6.3
	No	90	93.8
Farmer's conception of antibiotics needs	Always	3	3.1
	Mostly	74	77.1
	Sometimes	12	12.5
	Never	7	7.3
Parameter (Antibiotic use history)	Categories	N	%
Broad-spectrum antibiotic Use	Yes	87	90.6
	No	9	9.4
Narrow-spectrum antibiotic Use	Yes	91	94.8
	No	5	5.2
Repeatedly used antibiotics	Ciprofloxacin	39	40.6
	Enrofloxacin	19	19.8
	Colistin sulfate	24	25.0
	Doxycycline	14	14.6
Types of antibiotic generation	1 st generation	11	11.5
	2 nd generation	56	58.3
	3 rd generation	24	25.0
	4 th generation	5	5.2
Age of antibiotics used	Prior 1 st week complete	59	61.5
	After 2 nd weeks more	20	20.8
	At 3 rd weeks more	17	17.7

N= Frequency; %= Percentage

In Figure 1, it is illustrated that nearly half of the farmers, 47 in total (49.0%), identified a lack of knowledge as the primary issue in farming. Additionally, 26.0% of the farmers attributed the main problems to insufficient government awareness, while 15.6% pointed to a corrupt syndicate in the market as a significant cause. More than half, 53 farmers (55.2%), considered television to be the primary source of information for addressing issues in the poultry industry. The study indicates that Figure 2 reveals over one-third, 45 (46.9%), of malabsorption cases and 19.8% of autoimmune conditions in the body were impacted by the consumption of poultry meat. As indicated by this survey, Figure 3 reveals that over one-third, 47 (49%), of farmers administered antibiotics based on prescriptions from registered veterinary doctors. A larger portion, 70 (72.9%), followed prescriptions from quacks. Additionally, approximately 67 (69.8%) of the antibiotics were used following recommendations from representatives of various feed companies, while 43 (44.8%) of the respondents chose to use antibiotics based on their own judgment.



DISCUSSION

This study investigates the patterns of antibiotic use and the level of awareness among broiler farmers ($n = 96$). It was discovered that 88.5% of the farmers had administered antibiotics in the past three months. A significant portion (58.3%) of these farmers utilized second-generation antibiotics (Fluoroquinolones). A majority, 61 (63.5%), believed that spiritual healing was ultimately safer than using antibiotics. Over half, 53 (55.2%), of the participants were familiar with antibiotics. However, the majority, 62 (64.6%), lacked knowledge about their potential harmful effects. Most farmers (60.4%) administered antibiotics to broilers before the birds reached one week of age. This result was consistent with findings from other settings where limited farmer knowledge contributes to early and inappropriate antibiotic administration ([Mudenda et al., 2022](#)); ([Habiba et al., 2023](#)). About half of the farmers, 47 (49%), used antibiotics based on a prescription from a registered veterinarian. Meanwhile, 43 (44.8%) of the farmers made independent decisions regarding antibiotic use. Nearly half of the respondents, 45 (46.9%), believed that the primary side effect of antibiotic residue was malabsorption. Previous studies report that malabsorption often associated with digestive disturbances and poor feed conversion ([Chandrakar et al., 2023](#)). Among the participants, 46.6% had used Ciprofloxacin, 19.8% had used Enrofloxacin, 25.0% had used Colistin sulphate, and only 14.6% had used doxycycline in the past three months. The extensive use of antibiotics has contributed to the emergence of bacterial antibiotic resistance over time ([Apata, 2009](#)). This research indicated that over 80% of farmers had administered antibiotics on their farms within the last three months. The usage rate was 100% in Ogun State, Nigeria, Songkhla province ([Oluwasile et al., 2014](#)), and Thailand ([Lampang et al., 2007a](#)). The widespread application of antibiotics may have adverse effects on human and animal health as well as the environment ([Hassan et al., 2014](#)). In our study, a significant portion (88.5%) of farmers administered antibiotics for therapeutic reasons in the past three months, while 33.3% used them for preventive measures. This was considerably lower in Ogun State, Nigeria, where 21 farmers (36.2%) used antibiotics for treatment and only 17 (29.3%) for prophylactic purposes, this findings was found by ([Oluwasile et al., 2014](#)). Our research also revealed that a majority (58.3%) of farmers opted for 2nd-generation antibiotics. Norfloxacin and other fluoroquinolones are widely used in both human and veterinary medicine; their frequent application leads to environmental occurrence and potential ecological risk (Pauletto & De Liguoro, 2024).

. Research conducted in Ogun state in 2014 revealed that 29 poultry farmers, accounting for 50%, used antibiotics based on veterinary doctors' prescriptions, while 25 farmers, or 43.1%, decided independently to use antibiotics on their farms ([Oluwasile *et al.*, 2014](#)). In Pakistan found that a large proportion of poultry farm antibiotic use (and among poultry farmers) was done without prescriptions by either veterinarians or physicians ([Habiba *et al.*, 2023](#)). Farmers could freely buy any medication from retailers without needing a prescription. The misuse of antibiotics, including incorrect prescriptions, contributes to the development of resistant bacteria. Research findings suggest that 30% to 60% of prescribed antibiotics are either unnecessary, inappropriate, or not optimal ([Bergmans *et al.*, 1997](#)); ([Kollef & Fraser, 2001](#)). Excessive and inappropriate use of antibiotics is indisputably exacerbating the issue of antibiotic-resistant bacteria. Epidemiological research has clearly shown a direct link between antibiotic usage and the rise and spread of resistant strains ([Kollef & Fraser, 2001](#)). The presence of antibiotic residues in poultry farming can cause microbiome changes in human health ([Mehdi *et al.*, 2018](#)). In our research, a significant portion of farmers, 45 individuals (46.9%), believed that the primary side effect of antibiotic residues was malabsorption, while 19.8% of farmers identified a weakened self-immune system as another consequence. In a poultry farm in Pakistan, it was noted that approximately half of the gastrointestinal issues were attributed to antibiotic consumption. Additionally, skin rashes, dermatitis, and anaphylactic reactions in humans can result from consuming poultry products that contain antibiotic residues ([Habiba *et al.*, 2023](#)). Furthermore, penicillin residues in poultry may trigger severe anaphylactic responses, while eggs with antibiotic residues can cause skin allergies when eaten ([Mund *et al.*, 2017](#)). Our survey revealed various antibiotic usage patterns among poultry farms. The majority (40.6%) of participants reported using Ciprofloxacin, 19.8% used Enrofloxacin, 25.0% used Colistin sulfate, and only 14.6% used doxycycline in the past three months. In Bangladesh, Colistin Sulfate was the primary drug of choice at 30.14%, followed by Doxycycline at 20.6%, Ciprofloxacin at 19.2%, and Enrofloxacin at 19.2% ([Islam *et al.*, 2016](#)). In Ogun state, the most commonly used antibiotics were colistin sulphate (36.2%), Enrofloxacin (27.6%), and Furazolidone (20.7%) in the study area ([Oluwasile *et al.*, 2014](#)). In a study conducted on a broiler farm in Songkhla province, southern Thailand, it was found that the most commonly used medication was a combination of amoxicillin and enrofloxacin, accounting for 21.18% of usage ([Lampang *et al.*, 2007b](#)). The socio-economic profile of the respondents, who are farmers, reveals that 89.6% are male. The farmers have an average age of 35 years, with 45.9% having less than five years of farming experience. This average age suggests that most farmers in the area are relatively young. This demographic is in a physically active phase, which, with adequate support, could enhance agricultural productivity. Their prior farming experience provides a foundation for improving their farming practices. In West Cameroon, the majority of individuals involved in breeder farms are men (90%) with an average age of 36, and 46% of them have less than five years of experience ([Fouepe *et al.*, 2017](#)). Our findings indicate that 38 (39.6%) of these individuals have only primary education. A similar situation is observed in Nigeria, where 33.75% have a comparable level of education ([Ajewole & Akinwumi, 2014](#)). In Oyo State, Nigeria, a significant

portion (92.7%) of poultry farmers learned about recommended practices through radio, and 90.3% through television, while only a small fraction (18.9%) gained awareness from veterinary doctors and feed millers ([Oyeyinka *et al.*, 2011](#)). However, our study suggests that public awareness messages should be disseminated via daily newspapers (8.3%) and Facebook (13.5%). Television (55.2%) and radio (22.9%) are significant sources of information according to our study. Our survey revealed that biosecurity measures are essential in poultry farms. Among the safety tools identified, approximately 39.6% of farmers relied solely on disinfectants, while 29.2% used a water purifier. However, only 6.3% of farmers wore hand gloves, and 9.4% donned farm clothes as protection against germs. In poultry farms around Debre Markos, Amhara region, and Ethiopia, over 63.3% of producers wore protective clothing, but just 8.2% used hand gloves. Approximately 77.6% of the producers utilized the footpath located in front of their farm entrances ([Yitbarek *et al.*, 2016](#)). In addition, antibiotics were extensively employed across all farms involved in this study, with interviews and observations revealing that antibiotic practices were not regulated. We identify factors that led to the use of antibiotics and highlight concerns raised by participants regarding antibiotic use in food animals. This study does have some limitations. Although 100 farmers were targeted for interview, within the predefined areas, some farmers were not interested, so only those willing to participate were interviewed; this may limit the generalizability of the findings. Potential information bias may have occurred due to limitations in questionnaire design. However, the clear discussion of questions with the farmers enhanced the reliability of our results.

CONCLUSIONS

This research has offered insights into the application of therapeutic antibiotics in broiler chickens. Broiler farmers primarily utilized antibiotics for therapeutic reasons. Ciprofloxacin, Colistin sulphate, and Enrofloxacin were the preferred therapeutic drugs among farmers. A significant number of farmers opted for 2nd-generation antibiotics. Nearly half of the farmers purchased antibiotics based on the advice of a registered veterinarian, while over one-third made independent decisions regarding antibiotic use. Most poultry farmers were unaware of the residual effects of antibiotics as well as their role in the development of antibiotic resistance. The primary issue facing the poultry sector is the farmers' lack of knowledge. The biosecurity practices at poultry farms were found to be highly inadequate. There is an urgent need for education on the responsible use of antibiotics in food animals and for regulatory measures. The results of this study will aid in formulating strategies for the responsible use of antibiotics in the broiler industries of Bangladesh. Future research should focus on identifying effective policy interventions, enhancing farmer awareness, and promoting responsible antibiotic practices in poultry farming.

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CRedit authorship contribution statement

Conception and Design: Sourav Debnath; **Analysis and Interpretation of Result:** Sourav Debnath, Mira Debnath; **Writing-original draft preparation:** Sourav Debnath, Mira Debnath; **Writing -review and editing:** Sourav Debnath, Mira Debnath, Probir Kumar Mittra. All authors have reviewed and given their approval to the final manuscript.

Conflict of Interest

The authors confidently assert their impartiality, declaring that they have no conflicts of interest, which underscores the integrity and reliability of their research.

Ethical Approval

The animal welfare and ethical committee, Patuakhali Science and Technology University, approved the experimental procedures used in this study.

Data Availability

This article comprehensively presents all the necessary data.

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