Effectiveness of Confirmatory Lab Diagnosis in Combating Antimicrobial Resistance (AMR) in Animals at Veterinary Hospitals in Chattogram and Dhaka, Bangladesh

A clinical report presented in partial fulfillment of the requirement for the degree of Doctor of Veterinary Medicine (DVM)

A clinical report submitted by

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A clinical report submitted as per approved styles and contents

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List of abbreviation

ABR	-	Antibiotic Resistance
AMR	-	Antimicrobial Resistance
CVASU	-	Chattogram Veterinary and Animal Sciences University
DLS	-	Department of Livestock Services
Etc.	-	Et cetera
Et al	-	et alia (and others)
WHO	-	World Health Organization
DVM	-	Doctor of Veterinary Medicine
USA	-	The United States of America
AST	-	Antimicrobial Susceptibility Test
AMU	-	Antimicrobial Use
OIE	-	Office International des Epizooties
UVH	-	Upazila Veterinary Hospitals
SAQTVH	-	Shahedul Alam Quadery Teaching Veterinary Hospital
TTPHRC	-	Teaching and Training Pet Hospital and Research Center
BDMC	-	Bacton-Dickinson Microbiology Company
OTC	-	Oxytetracycline
SXT	-	Potentiated sulfonamide
CLSI	-	Clinical and Laboratory Standards Institute
EUCAST	-	The European committee on Antimicrobial Susceptibility Testing

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Abstract

The indiscriminate and irrational usage of antimicrobials in animals might hasten the critical problem of AMR. In Bangladesh, the majority of diseases in animals are diagnosed and treated with antimicrobials based on clinical signs. As a result, the antimicrobial response has become poor, and AMR is spreading rapidly. The current study attempted to find the basis for diagnosis and justification of antimicrobial prescribing to animals, as well as the effects of diagnostic procedures on responses. A descriptive cross-sectional study was conducted with 354 patients at veterinary hospitals in Chattogram and Dhaka districts. Data on diagnosis types, antimicrobial use, the effect of diagnosis procedures on antimicrobial response, etc. were analyzed. Furthermore, the usage of antimicrobials was compared to 31 research publications on AMR in animals in Bangladesh. Data from SAQTVH (54%), TTPHRC (27%), Mirsarai UVH (13%), Pet Clinics of Dhaka (4%), and Chattogram (2%) indicate antimicrobials were prescribed in 84.5% of all cases based only on clinical signs. Besides, only 15.5% of patients had conducted lab tests. Antimicrobial treatment response by lab diagnosis (94.6%) is greater than no lab diagnosis (78.6%). In this situation, the P value is 0.019 ($p<0.05$). In cats (3%) and poultry (7.5%), more than two antimicrobials (6%) were used at once. In contrast to other categories, the response rate was greater (95.2%); the P value was 0.038 ($p<0.05$). Higher resistance of *Staphylococcus aureus* (65.9%) and *Streptococcus* spp. (83.4%) was seen in cattle treated with penicillin-streptomycin (34.7%). Ceftriaxone (31.9%) in cat cases showed significant resistance to *Streptococcus* spp., *E. coli*, and *Staphylococcus aureus*. *E. coli* (88.4%), Campylobacter spp. (85%), and *Staphylococcus aureus* (66%), all showed high resistance to sulfa drug (23.4%) in poultry. Based on this, it is recommended that antimicrobials be identified and used at veterinary hospitals after a correct lab diagnostic test, as well as AST.

Key words: AMR (Antimicrobial resistance), AST, livestock, veterinary.

Introduction

Antimicrobials have made significant contributions to the prevention and treatment of infectious diseases in livestock, and some of them have played critical roles in promoting animal production and feed efficiency (Sharma *et al*., 2018). Antimicrobial resistance (AMR) is one of the most serious threats to public health worldwide. AMR is primarily defined as a microbe's capacity to evade an antimicrobial's effects even after being given recommended dosages. Multiple mechanisms can lead to antibiotic resistance (AMR) in bacteria, such as genetic mutation, acquired resistance by environmental exposure, or the innate capacity of some bacteria to resist (Reygaert, 2018). It develops as a natural result of antimicrobial use (AMU) in a variety of sectors, including human health, animal health and production, aquaculture, and agriculture (Zellweger *et al.*, 2017). The irrational and improper use of antimicrobials in people, animals, poultry, and fish is an important trigger for the emergence of AMR (Khan *et al.*, 2020). The rising AMR pattern leads to treatment failure, resulting in considerable morbidity and death as well as increased healthcare expenses each year (Century *et al.*, 2003). The instant adverse effect of AMR on the livestock industry is lower production, which leads to reduced food security. Developing countries are particularly prone to AMR due to antibiotic misuse and abuse, low-quality drugs, non-human use of antibiotics, an inadequate drug monitoring and surveillance system, a lack of knowledge about AMR, and poverty (I. Ahmed *et al*., 2019).

Bangladesh is a developing country in Southeast Asia. According to DLS, it has 443 million terrestrial animals, including 24.86 million cattle, 26.95 million goats, and 319.68 million chickens. The industry contributes around 1.85% of the gross domestic product to the national economy. Additionally, it employs 20% of the workforce full-time and 50% of the workforce part-time across the nation (Livestock-Economy, 2023). In addition to livestock, this country has seen increased interest in raising pets. Dogs and cats are the most common types of pets reared. There are several benefits to owning dogs and cats, including playtime, companionship, house and child security, and financial gains (Parvez, 2014). Some specific responsibilities, such as housing, feeding, deworming, vaccinating, grooming, exercising, and so on, are also associated with proper pet care. Due to people and their pet dogs live in close proximity and share the same environment, there is a greater risk of spreading zoonotic diseases, which are the main public health issue (Robertson, 2000). According to Hossain, 2014, the total prevalence of clinical diseases in dogs, cats, and rabbits in the Dhaka city region was 2.39%, 3.72%, and 6.66%, respectively.

In Bangladesh, the veterinary services provided to livestock, pets, and poultry are inadequate. Because there is a less effective government animal healthcare system, farm owners have to depend on unregistered and inefficient healthcare practitioners to treat their animals (Roess *et al*., 2015). Laboratory tests and confirmatory diagnostic procedures were performed less often in veterinary clinics and hospitals. Only clinical signs were used to diagnose and prescribe antimicrobials in the majority of cases. It is difficult to find a prescription for an animal patient in Bangladesh with a fever who was not given an antimicrobial (Sarker, 2016). Antimicrobial sensitivity test is uncommon in the veterinary healthcare system. As opposed to the cultural sensitivity test, the most prevalent factor in developing nations such as Bangladesh when selecting an antibiotic is personal experience and perception (68%) (Akter, 2012). It is most likely caused by the lack of nearby veterinary diagnostic facilities and occasionally by refusal (Bhowmik *et al.*, 2018). As a result, antimicrobial response has decreased, and antimicrobial-restricted group antibiotics are used extensively.

The World Organization for Animal Health (OIE) proposed a list of antimicrobials for veterinary use. The third and fourth generations of cephalosporins and fluoroquinolones are regarded as crucial antimicrobials for human and animal health. Additionally, the OIE advised avoiding using antibiotics as a preventative measure when the animals showed no clinical signs (WOAH, 2021). A variety of antibiotic classes, including third and fourth generations of cephalosporins, fluoroquinolones, and macrolides, have been approved for veterinary use (Sarmah *et al*., 2006). Many veterinarians frequently give these antimicrobials in simple cases to obtain a quick outcome without considering the consequences and development of antimicrobial resistances (Sarker, 2016). In December

2000, Germany introduced mandatory recommendations for the cautious use of antimicrobials in animals (Ungemach *et al*., 2006). These recommendations specify the basic criteria that veterinarians must follow when prescribing antibiotics to animals. Such approaches have resulted in a significant reduction in antibiotic usage and resistance rates in such situations (Bhowmik *et al.*, 2018). However, in resource-constrained contexts such as Bangladesh, this has yet to be implemented.

The current investigation was conducted in several veterinary clinics and hospitals in Chattogram and Dhaka districts. During the author's clinical internship placement in these locations, he observed the basis of the diagnosis and the rationale for providing antimicrobials to livestock pets and poultry patients. The study was planned with the following objectives in mind:

1. To find out the rationale for prescribing antimicrobials to livestock, pet, and poultry patients in veterinary clinics and hospitals.

2. To assess the necessity for lab tests as well as antimicrobial susceptibility tests (AST) prior to prescribing antimicrobials to animals in combating against antimicrobial resistance (AMR).

Materials and methods

Informed consent

Before the study, selected patient owners were notified and clarified about the research. All patient owners of the study provided informed consent.

Study design

A descriptive cross-sectional study was conducted from April 2023 to September 2023 to figure out the rationale for prescribing antimicrobials, their responses, and resistances in animals (livestock, companion animals, and poultry). Chattogram and Dhaka districts were picked for their abundance of veterinary hospitals. A number of animal species were brought to the veterinary hospitals, including goats, cattle, cats, dogs, and poultry. Experienced registered veterinarians at veterinary hospitals and clinics used the clinical history, clinical symptoms, and pathognomonic lesion to diagnose cases. For confirmation, many rapid kit tests (e.g., Feline panleukopania virus, Feline infectious peritonitis, urine stripe test, canine distemper virus kit test) and lab analyses (e.g. blood test, urine analysis, giemsa staining) were carried out. Testing for antibiotic sensitivity was not commonly done. Antimicrobials weren't always effective, as the right antimicrobial wasn't chosen and the diagnosis wasn't confirmed. Here, the prescription practices for antimicrobials and their responses in patients were observed and compared to their resistances.

Study area

The study included three veterinary hospitals (Mirsarai Upazila Veterinary Hospital, Shahedul Alam Quadary Teaching Veterinary Hospital, CVASU, and Teaching and Training Pet Hospital and Research Centre, CVASU) and six pet clinics in Chattogram (3) and Dhaka city (Khilgaon, Mirpur, Uttara). These regions have a diverse variety of veterinary services where various sorts of patients are taken for treatment, particularly the majority of the country's pet and companion animals, which are treated in the region. The research area is located between longitudes 90°381' and 91°82' east and latitudes 22°35' and 23°89' north. Figure 1 depicts the location of the study area.

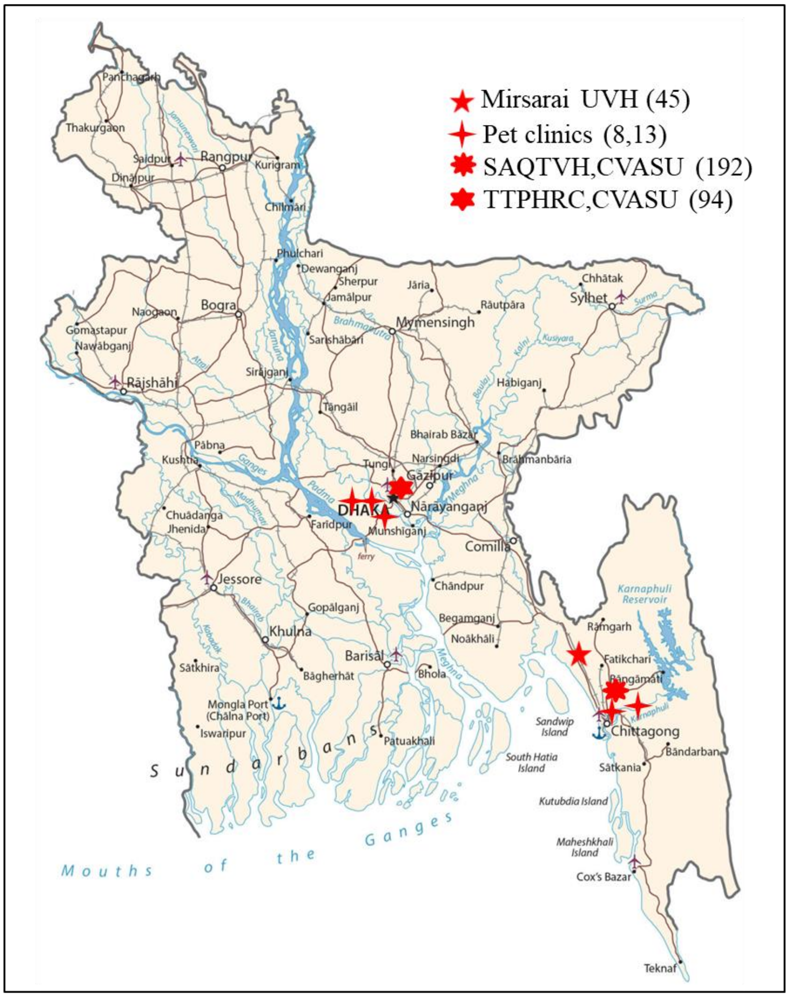

Figure 1: Study area in Chattogram and Dhaka districts.

Selection of cases

A total of 354 cases from selected veterinary hospitals and clinics were included in the research. Case sheets and antibiotic-prescribed patient's data were mostly collected. A total of 45, 8, 15, 192, and 94 cases of animals and poultry have been collected from Mirsarai UVH, pet clinics in Chattogram, pet clinics in Dhaka, SAQTVH-CVASU, and TTPHRC-CVASU, respectively.

Questionnaire preparation

A semi-structured questionnaire was developed to gather the information required for exploring the basis for prescribing antimicrobials to individuals and their responses in animals. The questionnaire was prepared in English. Every question in the questionnaire was pre-tested before it was finalized to be sure it was satisfactory for the intended audience.

Data collection and clinical examination

In order to achieve certain objectives, a structured questionnaire and a survey technique were initially developed. After a briefing about the purpose of the interview, respondents' written and verbal consents were acquired. The author performed physical examinations and lab diagnoses on the majority of the patients (about 60%) prior to data collection during his internship placement. Data was gathered on the clinico-epidemiological history, clinical signs, previously used medications, disease diagnosis, diagnosis process, lab diagnosis, kind of antimicrobial use, etc. Furthermore, face-to-face interviews or phone conversations with the owner were used to get information about the antimicrobial's response. Data collection took place from April to September of 2023. Clinical case data for one month was obtained from Mirsarai UVH, SAQTVH, CVASU, and TTPHRC, CVASU. Data on clinical cases was collected from pet clinics in Chattogram and Dhaka for one and two weeks, respectively. Every interview was thoroughly examined by the author to identify any missing information, and any necessary corrections were made.

Literature search strategy

Articles relating to antibiotic sensitivity tests in the veterinary profession of Bangladesh published between 2004 and August 24, 2023, have been searched for the study. Multiple searches were performed in Google Scholar, PubMed, and Bangladesh Journals Online, and ResearchGate using various relevant terms such as "Antimicrobial Sensitivity Test (AST) in the veterinary sector of Bangladesh", "Antimicrobial Resistance (AMR) situation in Bangladesh", "AMR in livestock of Bangladesh", "AST in pet animals of Bangladesh", and "AMR bacteria in poultry sector of Bangladesh", etc.

Selection of study

Studies on the AST of several pathogens in livestock, poultry, and pets were included in this study if they satisfied the following inclusion criteria: (1) described AMR in animals of Bangladesh; (2) researched ABR of zoonotic important pathogens; (3) were published after 2008; (4) the total number of samples and the proportion of resistant or susceptible strains were explicitly recorded; and (5) described the AST method was appropriately.

Data extraction and statistical analysis

The raw data were filled in Google Forms before being imported into Microsoft Excel 2010 (Microsoft Corporation, USA). Stata 15.1 (StataCorp LLC, College Station, Texas, USA) was used for additional descriptive analysis. The questionnaire responses are given in basic frequency order. Besides, each of the chosen papers was assessed in order to accumulate data on the pathogen, species, publication year, study time, study location, susceptibility testing method, susceptibility testing standard, etc. Additionally, quantitative information on ABR was collected. It is important to highlight that in this study, samples classified as intermediately resistant were considered resistant. After combining all of the studies, the resistance of each species of bacteria to various antibiotics is presented as the median resistance (MR) and the interquartile range (IQR) calculated using Stata 15.1. Microsoft Excel 2010 was used to evaluate the frequency and percentage, and Stata 15.1 was used to run the Pearson's chi square (chi^2) test. The statistical effects were calculated with a 95% confidence interval and a level of significance less than 0.05 ($P<0.05$). Graphs were prepared by Microsoft excel 2010 (Microsoft corporation, USA).

Result

A total of 354 patients' data were collected from veterinary clinics and hospitals in Chattogram and Dhaka in order to assess the necessity for lab test or antimicrobial sensitivity test while giving antimicrobials to patients.

Patient demographics in the research area

A total of 50.9% of livestock (13% cattle and 37.9% goats), 39.5% of pet animals (27.7% cats and 11.3% dogs), and 10.1% of poultry received antibiotic treatment throughout the research period, based on 354 clinical case data. Data are summarized in Table 1.

Table 1: Patients in the study area (N=354)

Source of data	**Type of patients N (%)**					**Total case**
	Cat	**Cattle**	**Dog**	**Goat**	**Poultry**	
Mirsarai UVH,Ctg	1	9	1	13	21	45
Pet clinics, Ctg	6	-	2	-	-	8
Pet clinics, Dhaka	12	-	3	-	-	15
SAQTVH,CVASU	16	37	3	121	15	192
TTPHRC,CVASU	63	-	31	-	-	94
Total (%)	98 (27.7)	46 (13.0)	40 (11.3)	134 (37.9)	36 (10.1)	354

(Note: Ctg= Chattogram)

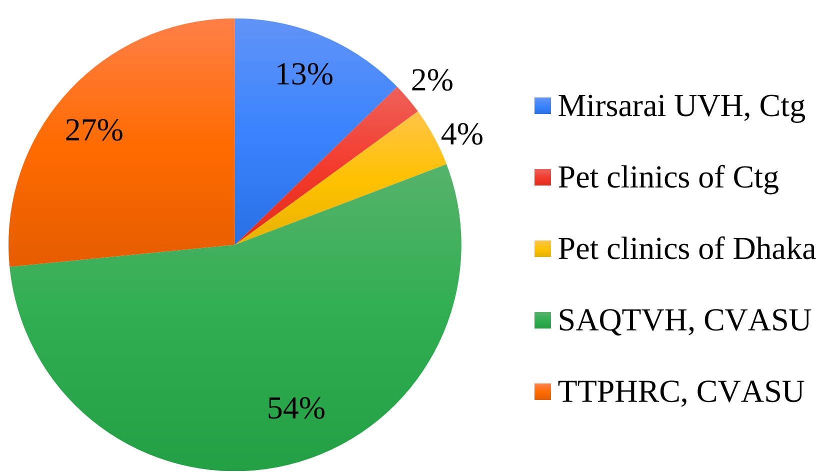

Figure 2: Percentage of patient in each part of the study area.

The majority of data were acquired from veterinary hospitals rather than clinics. SAQTVH;CVASU, TTPHRC;CVASU, Mirsarai UVH, pet clinics in Dhaka, and pet clinics in Chattogram contributed 54%, 27%, 13%, 4%, and 2% of the case data, respectively.

Diagnostic process in veterinary hospitals and clinics

The data gathered showed that 87.6% of the cases were diagnosed and treated solely based on clinical signs. Based on clinical signs and the rapid kit test, around 3.95% of cases were diagnosed. Lab tests were involved in 6.85% of cases. A lab diagnosis was performed in 1.75% of cases, along with clinical sign observation and a rapid kit test. Specific antibiotic selection is aided by these lab diagnostic and rapid kit tests. However, no antimicrobial sensitivity tests were performed in the research region during the study. Data are summarized in Table 2.

Table 2: Diagnostic procedures in the study area

		Process of	**diagnosis N (%)**	
Sources of data	**Clinical sign (C/s)**	**C/s+ Rapid kit test**	**C/s+ Lab test**	**C/s+ rapid kit test+ Lab test**
Mirsarai UVH, Ctg	45	-	-	-
Pet clinics, Ctg	8	-	-	-
Pet clinics, Dhaka	12	3	-	-
SAQTVH,CVASU	173	-	19	-
TTPHRC,CVASU	61	11	16	6
Total (%)	299 (84.5)	14 (3.9)	35 (9.9)	6 (1.7)

Antimicrobials used in the study area

According to the data, 413 antimicrobials of 29 types were used on animals in the research area's veterinary hospitals and clinics. Antimicrobials of 12, 10, 7, 16, and 12 types were employed in cats, cattle, goats, dogs, and poultry, respectively. Ceftriaxone was the most commonly used antibiotic (15.9%). Penicillin-streptomycin and sulfur drugs accounted for 11.9% and 8.7% of all antibiotics used, respectively. Data are summarized in Table 3.

Table 3: Antimicrobials used in the research area

Name of antimicrobials	Cat	Species of Cattle	patient N Dog	(%) Goat	Poultry	Total amount
Amoxicillin	13 (10.9)	0	4 (8.3)	6 (4.0)	3 (6.4)	26
Amox+ Clav.	9 (7.6)	0	11 (22.9)	8 (5.4)	0	28
Ampicillin	0	0	0	0	2 (4.3)	2
Cefixime	2 (1.7)	0	1 (2.1)	0	0	3
Cefuroxime	3 (2.5)	0	0	0	0	3
Ceftifur	0	2 (4.1)	0	10 (6.7)	0	12
Ceftriaxone	38 (31.9)	2 (4.1)	17 (35.4)	9 (6.0)	0	66
Cephalexin	0	0	0	0	2 (4.3)	2
Ciprofloxacin	0	5 (10.2)	0	12 (8.0)	5 (10.6)	22
Clavulanic acid	3 (2.5)	0	0	0	0	3
Clindamycin	6 (5.0)	0	3 (6.3)	0	0	9
Clioquinol	0	0	0	2 (1.3)	0	2
Colistin	0	0	0	0	1 (2.1)	1
Doxycycline	13 (10.9)	0	4 (8.3)	0	0	17
Enrofloxacin	0	0	0	0	9 (19.1)	9
Erythromycin	0	0	0	0	8 (17.0)	8
Gentamicin	0	0	0	5 (3.3)	2 (4.3)	7
Marbofloxacin	0	0	0	10 (6.7)	0	10
Metronidazole	26 (21.8)	5 (10.2)	0	2 (1.3)	0	33
Moxifloxacin	1 (0.9)	0	0	0	0	1
Mupirocin	4 (3.4)	0	8 (16.7)	8 (5.4)	0	20
Neomycin	0	0	0	0	1 (2.1)	1
OTC	0	8 (16.3)	0	11 (7.3)	3 (6.4)	22
Penicillin	0	4 (8.1)	0	2 (1.3)	0	6
P + S	0	17 (34.7)	0	32 (21.3)	0	49
Sulfar drug	1 (0.9)	2 (4.1)	0	30 (20.0)	3 (6.4)	36
Streptomycin	0	0	0	2 (1.3)	0	2
SXT	0	2(4.1)	0	1 (0.7)	8 (17.0)	11
Tulathromycin	0	2 (4.1)	0	0	0	2
Total	119	49	48	150	47	413

(Note: Amox+Clav.= Amoxicillin and Clavulanic acid, P+S= Penicillin and streptomycin)

Commonly used antimicrobials in livestock, pet animals and poultry

In the case of cattle, penicillin-streptomycin was the most commonly used antibiotic (34.7%). OTC was used in 16.3% of cases. Metronidazole and ciprofloxacin were both used in 10.2% of cases. In cases of goats, penicillin-streptomycin was used at 21.3%, sulfur drugs were used at 20.7%, ciprofloxacin was used at 8%, and OTC was used at 7.3%

of the antibiotics used in livestock. The use of penicillin-streptomycin in livestock treatment was prominent in the research region.

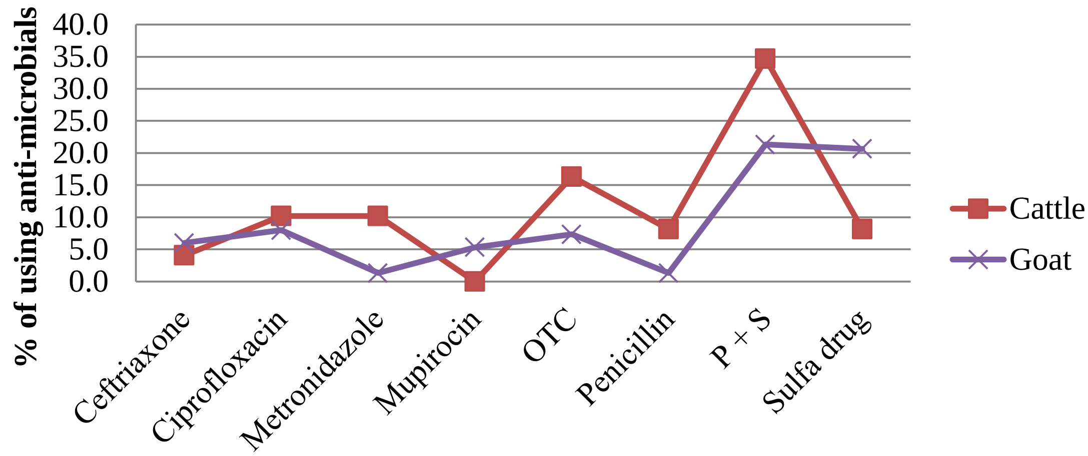

Figure 3: Commonly used antimicrobials in livestock in the study area

Ceftriaxone is widely used in pet animals. Ceftriaxone, metronidazole, doxycycline, and amoxicillin were prescribed to 31.9%, 21.8%, 10.9%, and 10.9% of cats, respectively. In the case of dogs, 35.4% of the antimicrobials used were ceftriaxone, 22.9% were amoxicillin-clavulanic acid, and 16.7% were mupirocin.

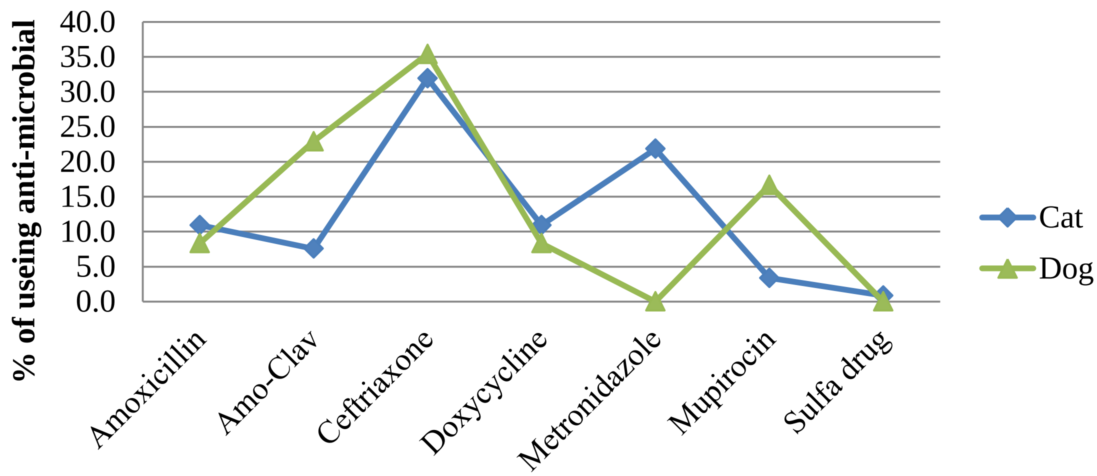

Figure 4: Commonly used antimicrobials in pet animals in the study area

Sulfa drugs were most commonly prescribed in poultry (23.4%). Enrofloxacin, erythromycin, ciprofloxacin, amoxicillin, and oxy-tetracycline were prescribed in 19.1%, 17%, 10.6% 6.4%, and 6.4% of the antimicrobials used in poultry, respectively.

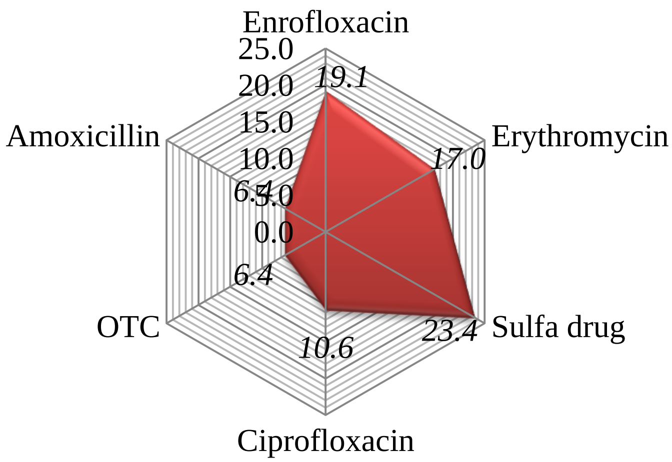

Figure 5: Mostly used antimicrobials in poultry in the study area.

Effects of laboratory diagnosis on antimicrobial treatment responses

Out of 354 disease cases, 15.5% were diagnosed and treated based on a confirmatory laboratory diagnosis. Approximately 94.6% of patients who received antimicrobials as a result of a lab diagnosis recovered. In contrast, 84.5% of patients were prescribed antimicrobials without a confirmatory diagnosis by lab testing. In that situation, the patient's antimicrobial response was 78.6%. The circumstance has a p value of 0.019.

Table 4: Antimicrobial responses as a result of the diagnostic process

Choosing process of antimicrobial	Response N (%)			Total (%)	P value
	Recovered	Unknown	Not recovered		
Lab diagnosis	52 (94.6)	1 (1.8)	2 (3.6)	55 (15.5)	0.019
No lab diagnosis	235 (78.6)	10 (3.3)	54 (18.1)	299 (84.5)	
Total	287 (81.1)	11 (3.1)	56 (15.8)	354	

Effects of the number of antibiotics used at once on treatment responses

During the study period, the majority of the animals (71.1%) were treated with a single antimicrobial agent. About 22.9% of patients were treated with two antimicrobials, and 6% were treated with more than two antimicrobials at once (Table 5). In the case of cattle and dogs, no more than two antimicrobials were found to be used. In poultry, however, 22.2% of cases were treated with more than two antimicrobials at the same time. More than two antibiotics were used in 7.5% and 3% of cases in cats and goats, respectively.

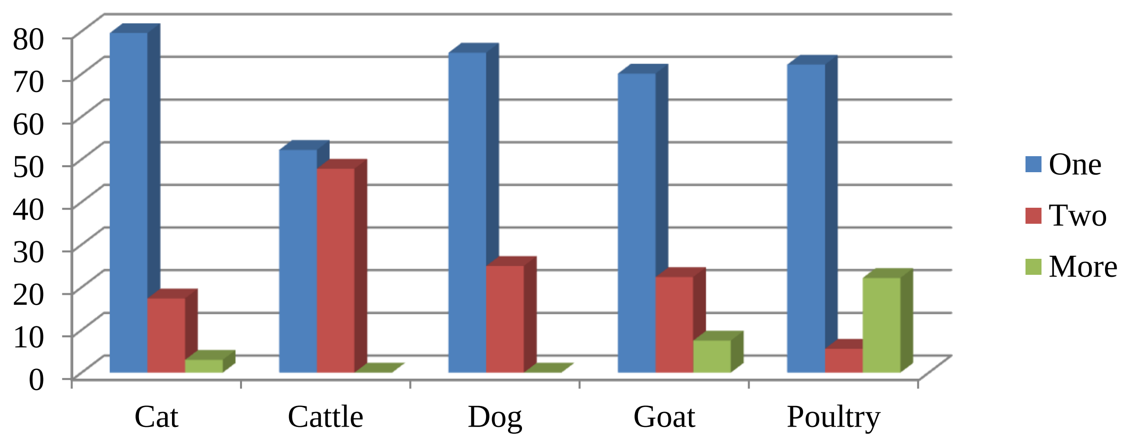

Figure 6: Several antimicrobial agents used concurrently in various species.

The response rate in the group that used one antibiotic was 77%. When using two antibiotics at a time, 90.1% of the patients were recovered, and when using more than two antimicrobials at once, 95.2% of the patients were recovered. In this situation, the P value is 0.038. Data are summarized in Table 5.

Table 5: Responses to treatment with several antimicrobials at once

No. of used antimicrobial	Response N (%) Recovered	Unknown	Not recovered	Total (%)	P value
One	194 (77)	9 (3.6)	49 (19.4)	252 (71.1)	0.038
Two	73 (90.1)	2 (2.5)	6 (7.4)	81 (22.9)	
More	20 (95.2)	0	1 (4.8)	21 (6.0)	
Total	287	11	56	354	

Characteristics of AST in the veterinary field of Bangladesh

We observed 31 studies that presented antimicrobial sensitivity tests (AST) in various samples from cattle, pet animals, poultry, feed samples, food sources (mostly derived from animal sources), and environmental material. All of the selected studies were published between 2008 and 2023, while the data was collected between 2004 and 2019. The majority of the research is conducted in Dhaka (32.6%). Cats (8.6 %), cattle (20%), dogs (11.4%), and poultry (60%) were among the species represented. The disk diffusion method was used in all studies for AST, and data interpretation relied mostly on Clinical and Laboratory Standards Institute (CLSI) standards (83.9%). Cloacal swabs of poultry (13.3%), milk samples of cattle (11.1%), and nasal and pharyngeal swabs of pet animals (8.9%) were the most prominent among all samples. In 31 studies, 16 different types of pathogens (10 different genera) were examined. In a number of tests, *E. coli* (25.8%) and *Salmonella* spp. (24.2%) were prevalent. Table 5 summarizes the characteristics of the studies considered in this assessment.

Table 6: The characteristics of the studies in this assessment (N=31)

Characteristics	N (%)	Reference
Publication year		
2008-2013	6 (19.4)	(Reza, 2009), (Ali *et al*., 2008), (Uddin *et al*., 2011), (Nandi *et al*., 2013), (K Begum *et al.*, 2010), (M. M. Ahmed *et al*., 2010),
2014-2018	15 (48.4)	(Tanzin *et al*., 2016), (Banik *et al.*, 2018), (M. A. Rahman *et al.*, 2018), (Jahan *et al*., 2015), (Habibullah *et al.*, 2017),(Hassan, 2014), (Hasan *et al.*, 2014), (Saifullah *et al.*, 2016), (Sultana *et al*., 2014), (Mahmud *et al.*, 2016), (Islam *et al.*, 2018), (Dey *et al*., 2014), (Md. *et al.*, 2018), (Marjan *et al.*, 2014), (M. M. Rahman *et al*., 2018),
2019-2023	10 (32.2)	(Siddiky *et al.*, 2021), (Kabir *et al.*, 2021), (Rafiq *et al.*, 2022), (Ibrahim *et al.*, 2023), (Nath, 2020), (Kakolee, 2022), (Al Azad *et al.*, 2019), (Parvin *et al.*, 2020), (Rana *et al.*, 2022), (Sobur *et al.*, 2019)

Table 6: Continued

Characteristics	N (%)	Reference
End of data collection		
2004-2010	2 (6.4)	
2011-2015	7 (22.6)	
2016-2019	8 (25.8)	
Did not mention	14 (45.2)	
Location [a]		
Cox's bazar	1 (2.3)	(Hasan *et al*., 2014)
Chattogram	6 (14.0)	(Nath, 2020), (Hassan, 2014), (Parvin *et al.*, 2020), (Hasan *et al.*, 2014), (Mahmud *et al*., 2016), (Rana *et al.*, 2022)
Dhaka city	14 (32.6)	(Reza, 2009), (Ali *et al*., 2008), (Siddiky *et al*., 2021), (Uddin *et al.*, 2011), (Kakolee, 2022), (Habibullah *et al*., 2017), (Al Azad *et al*., 2019), (Parvin *et al*., 2020), (Nandi *et al.*, 2013), (Sultana *et al.*, 2014), (K Begum *et al.*, 2010), (M. M. Ahmed *et al.*, 2010), (Islam *et al.*, 2018), (Marjan *et al.*, 2014),
Gazipur	2 (4.7)	(Banik *et al*., 2018), (M. A. Rahman *et al.*, 2018)
Jamalpur	1 (2.3)	(Md. *et al.*, 2018)
Kishorganj	1 (2.3)	(Md. *et al.*, 2018)
Mymensingh	9 (20.9)	(Tanzin *et al.*, 2016), (M. A. Rahman *et al.*, 2018), (Jahan *et al.*, 2015), (Al Azad *et al*., 2019), (Parvin *et al.*, 2020), (Saifullah *et al.*, 2016), (Dey *et al.*, 2014), (M. M. Rahman *et al*., 2018), (Abdus Sobur *et al.*, 2019)
Netrokona	1 (2.3)	(Md. *et al.*, 2018)
Rajshahi	3 (7.0)	(Kabir *et al***.**, 2021), (Parvin *et al.*, 2020), (Al Azad *et al.*, 2019)
Rangamati	1 (2.3)	(Hasan *et al.*, 2014)
Sylhet	1 (2.3)	(Parvin *et al*., 2020)
Tangail	1 (2.3)	(Md. *et al.*, 2018)
Other	2 (4.7)	(Rafiq *et al.*, 2022), (Ibrahim *et al*., 2023)
Species		
Cat	3 (8.6)	(Nath, 2020), (Kakolee, 2022), (Habibullah *et al*., 2017)
Cattle	7 (20)	(Tanzin *et al*., 2016), (Rafiq *et al*., 2022), (M. A. Rahman *et al*., 2018), (Jahan *et al*., 2015), (Uddin *et al.*, 2011), (Marjan *et al*., 2014), (Abdus Sobur *et al*., 2019)
Dog	4 (11.4)	(Kakolee, 2022), (Habibullah *et al.*, 2017), (M. M. Rahman *et al.*, 2018), (Rana *et al.*, 2022)

Table 6: Continued

Characteristics	N (%)	Reference
Poultry	21 (60)	(Banik *et al.*, 2018), (Reza, 2009), (Ali *et al.*, 2008), (Siddiky *et al.*, 2021), (Kabir *et al.*, 2021), (Rafiq *et al.*, 2022), (Ibrahim *et al.*, 2023), (M. A. Rahman *et al.*, 2018), (Hassan, 2014), (Al Azad *et al.*, 2019), (Parvin *et al.*, 2020), (Hasan *et al.*, 2014), (Saifullah *et al.*, 2016), (Nandi *et al.*, 2013), (Sultana *et al.*, 2014), (K Begum *et al.*, 2010), (M. M Ahmed *et al.*, 2010), (Mahmud *et al.*, 2016), (Islam *et al.*, 2018), (Dey e*t al.*, 2014), (Md. *et al.*, 2018)
Test method		
Disk diffusion	31 (100)	
Test standard		
CLSI	26 (83.9)	
EUCAST	1 (3.2)	(Hasan *et al.*, 2014)
CLSI + EUCAST	1 (3.2)	(Ibrahim *et al.*, 2023)
BDMC, USA	2 (6.5)	(Reza, 2009), (Ali *et al.*, 2008)
Not mentioned	1 (3.2)	(Banik *et al.*, 2018)
Sample type		
Cecal / intestinal content	4 (8.5)	(Reza, 2009), (Ali *et al.*, 2008), (Siddiky *et al.*, 2021), (K Begum *et al.*, 2010),
Cloacal swab	7 (15.0)	(Reza, 2009), (Ali *et al.*, 2008), (Al Azad *et al.*, 2019), (Hasan et al., 2014), (Saifullah et al., 2016), (Nandi *et al.*, 2013), (Dey *et al.*, 2014)
Egg sample	5 (10.6)	(Reza, 2009), (Ali *et al.*, 2008), (K Begum *et al.*, 2010), (M. M. Ahmed *et al.*, 2010), (Mahmud *et al.*, 2016)
Environmental sample	3 (6.4)	(Ali *et al.*, 2008), (Ibrahim *et al.*, 2023), (Abdus Sobur *et al.*, 2019)
Fecal sample/dung	6 (12.8)	(Reza, 2009), (Ibrahim *et al.*, 2023), (Kakolee, 2022), (K Begum *et al.*, 2010), (Dey *et al.*, 2014), (Abdus Sobur *et al.*, 2019)
Feeds and by products	1 (2.1)	(Rafiq *et al.*, 2022)
Food pad	1 (2.1)	(Dey *et al.*, 2014)
Frozen meat/ food	1 (2.1)	(Parvin *et al.*, 2020), (Sultana *et al.*, 2014),
Handler's sample	3 (6.4)	(Reza, 2009),(Ali *et al.*, 2008), (Sobur *et al.*, 2019)
Liver/ slpeen	2 (4.3)	(Kabir *et al.*, 2021), (Hassan, 2014),
Meat/ beef	4 (8.5)	(Banik *et al.*, 2018), (M. A. Rahman *et al.*, 2018), (Islam *et al.*, 2018), (Md. *et al.*, 2018)
Milk	5 (10.6)	(Tanzin *et al.*, 2016), (Jahan *et al.*, 2015), (Uddin *et al.*, 2011), (Marjan *et al.*, 2014), (Abdus Sobur *et al.*, 2019)

Table 6: Continued

Characteristics	N (%)	Reference
Nasal, Pharyngeal swab	4 (8.5)	(Nath, 2020), (Habibullah *et al*., 2017), (Saifullah *et al*., 2016), (M. M. Rahman *et al*., 2018)
Pus and wound (pets)	1 (2.1)	(Habibullah *et al*., 2017)
Pathogen identified		
Alcaligens spp.	1 (1.9)	(Sultana *et al*., 2014)
Campylobacter spp.	2 (3.8)	(Rafiq *et al*., 2022), (Md. *et al*., 2018)
Enterobacter spp.	1 (1.9)	(Nandi *et al*., 2013)
Enterococcus spp.	1 (1.9)	(Banik *et al*., 2018)
Escherichia coli	16 (30.9)	(Tanzin *et al*., 2016), (Reza, 2009), (Rafiq *et al*., 2022), (Ibrahim *et al*., 2023), (M. A. Rahman *et al*., 2018), (Uddin *et al*., 2011), (Kakolee, 2022), (Hassan, 2014), (Al Azad *et al*., 2019), (Parvin *et al*., 2020), (Hasan *et al*., 2014), (Islam *et al*., 2018), (Dey *et al*., 2014), (Md. *et al*., 2018), (Marjan *et al*., 2014), (Abdus Sobur *et al*., 2019)
Klebsiella spp	3 (5.8)	(Uddin *et al*., 2011), (Sultana *et al*., 2014), (Marjan *et al*., 2014)
Salmonella spp.	11 (21.2)	(Siddiky *et al*., 2021), (Rafiq *et al*., 2022), (Hassan, 2014), (Saifullah *et al*., 2016), (K Begum *et al*., 2010), (M. M. Ahmed *et al*., 2010), (Mahmud *et al*., 2016), (Islam *et al*., 2018), (Md. *et al*., 2018), (Marjan *et al*., 2014), (Abdus Sobur *et al*., 2019)
Staphylococcus spp.	11 (21.2)	(Tanzin *et al*., 2016), (Rafiq *et al*., 2022), (Nath, 2020), (Jahan *et al*., 2015), (Uddin *et al*., 2011), (Habibullah *et al*., 2017), (Sultana *et al*., 2014), (Islam *et al*., 2018), (Marjan *et al*., 2014), (M. M. Rahman *et al*., 2018), (Rana *et al*., 2022)
S. pseudintermedius	1 (1.9)	(Rana *et al*., 2022)
Streptococcus spp.	2 (3.8)	(Rafiq *et al*., 2022), (Nath, 2020)
Vibrio spp.	2 (3.8)	(Ali *et al*., 2008), (Marjan *et al*., 2014)
Unknown	1 (1.9)	(Kabir *et al*., 2021)

([a] Studies involving multiple locations, CLSI= Clinical and Laboratory Standards Institute; EUCAST= The European committee on Antimicrobial Susceptibility Testing)

Antimicrobial resistance pattern in livestock (cattle)

Among all species of bacteria, *Escherichia coli* was studied in six articles relevant to antibiotic sensitivity test in cattle. It was highly resistant to rifampicin (MR 100%), tetracycline (MR 94.7%), vancomycin (MR 82%), oxytetracycline (MR 74.9%), and streptomycin (69.9%). Data are summarized in Table 7.

Table 7: Antimicrobial resistance pattern in cattle (N=7)

Antimicrobial agents	*E. coli* MR (IQR)	*Klebsiella* spp MR (IQR)	*Salmonella* spp MR (IQR)	*S. aureus* MR (IQR)	*Streptococcus* spp MR(IQR)	*Vibrio* spp MR (IQR)
Amoxicillin	50 (42.7-86.9)	-	73.1	92.7 (85.4- 100)	73.2	-
Ampicillin	66.5 (62.5-80.4)	65.4 (60-70)	79 (77-85.7)	72.5 (70-75.6)	78.9	85 (82-89)
Azithromycin	36 (28.6-46)	16 (13-17)	28 (20.5-67.5)	18 (15-19)	-	17 (12-21)
Ceftriaxone	54 (48.7-56)	38 (34-46)	39.5 (39-40.6)	46 (36-50.3)	59.2	77 (70-80)
Chloramphenicol	34 (33.9-38)	33.5 (32.5-45)	37.5 (33.3-43.5)	38.5 (18.5-40)		45 (40-49)
Ciprofloxacin	38.1 (10.3-63.3)	77 (70-80)	57 (42.7-64)	50.5 (5-60)	29.6	73 (70-75)
Erythromycin	44 (40.6-85.7)	35 (31-39)	39.5 (39-63.75)	10.5 (9.5-43)	-	20 (19-22)
Gentamicin	33.5 (0-45)	15 (13-17)	17 (12-17.1)	15 (12-21)	57.7	23 (20-30)
Imipenem	12 (10-15.9)	10 (10-11)	20 (16.6-22.5)	36.5 (17.5-39)	-	60 (52-60)
Kanamycin	40.6 (33.9-46.6)	49 (45-50)	32.5 (30.3-34)	42 (40-45)	-	9 (7-12)
Meropenem	27.2	-	22.8	-	-	-
Nalidixic acid	50	80		100	-	-
Nitrofuratoin	7	30	-	0	-	-
OTC	74.9 (52.4-78.6)	-	79 (75.7-82.2)	67.7	84.5	-
Penicillin	37 (27.5-67.6)	49 (45-50)	35.5 (32-67.1)	87 (85.3-89)	87.8	50 (45-50)
Rifampicin	100	-	-	100	-	-
SXT	18 (15-46.9)	16.5 (12.5-19)	13 (11.5-38.1)	16 (13-19)	69	55 (53-57)
Streptomycin	69.9	10	47.5	44.7 (10-79.5)	78.9	-
Tetracycline	94.7 (89.4-100)	90	86.8	75	-	-
Vancomycin	82 (75-85)	70 (66-73)	67 (62-75)	66 (63-72)	-	70 (70-75)

(Note: MR= Median resistance, IQR= Interquartile range. Due to distribution is skewed the result present as median resistance and Interquartile range).

In the case of *Staphylococcus aureus*, there were four articles that demonstrated resistance to nalidixic acid (MR 100%), rifampicin (MR 100%), amoxicillin (MR 92.7%), penicillin (MR 87%), tetracycline (MR 75%), and ampicillin (MR 72.5%). Overall, *E. coli*, *Klebsiella* spp., *Salmonella* spp., and *S. aureus* were less resistant to potentiated sulfonamides.

Antimicrobial resistance pattern in pet animals

Table 8: Antimicrobial resistance pattern in pet animal (cat and dog, N=7))

Name of anti-microbial	**Cat**			**Dog**		
	***E. coli* MR (IQR)**	***S. aureus* MR (IQR)**	***Strep.* spp MR (IQR)**	***E. coli* MR (IQR)**	***S. aureus* MR (IQR)**	***Strep. pseudintermedius* MR (IQR)**
Amoxicillin	60	-	-	44	-	-
Amoxiclav	-	-	-	-	30.5	32.3
Ampicillin	-	44.4	35	-	37	30
Azithromycin	30	11.1	10	22	-	-
Cefixime	30	-	-	11	-	-
Cefradol	-	33.3	22.5		-	-
Ceftriaxone	50	50	35	11	-	-
Cefuroxime	20		-	33	-	-
Ciprofloxacin	20	0	0	44	15.2	25.6
Cotrimoxazole	30	-	-	55	-	-
Doxycycline	-	0	5	-	-	-
Erythromycin		22.2	25	-	89.3	84.7
Gentamicin	20	5.6	0	33	48	43.7
Metronidazole	50	-	-	66	-	-
Nalidixic acid	-	66.7	62.5	-	95.2	91
OTC	-	16.7	10	-	-	-
Oxacillin	-	100	-	-	100 (73-100)	79.3
Penicillin	-	38.9	62.5	-	71	80
SXT	-	50	52.5	-	35.5	32.1
Streptomycin	30		-	22	70	78
Tetracycline	-	30	-	-	48.9 (30-67.7)	65.5
Vancomycin	-	25	-	-	44 (25-44)	65

(Note: MR= Median resistance, IQR= Interquartile range)

Cats have a higher prevalence of Staphylococcus spp., according to three papers cited in Table 6. It was resistant to nalidixic acid (MR 66.7%) and SXT (potentiated sulfa drug; MR 50%). Methicillin-resistant *Staphylococcus aureus* (MRSA) is completely resistant to oxacillin (MR100%). *Streptococcus* spp. was also resistant to nalidixic acid and penicillin (MR 62.5%). Ciprofloxacin showed to be less resistant to all three types of isolates, and doxycycline is susceptible to both *Staphylococcus* spp. and *Streptococcus* spp. As shown in Table 8. In case of dog, *Staphylococcus aureus* was studied in three publications listed in Table 8. It exhibited high levels of resistance to nalidixic acid (MR 95.2%), erythromycin (MR 89.3%), penicillin (MR 71%), and streptomycin (MR 70%). MRSA developed increased oxacillin resistance (MR 100%, IQR 73–100). *Streptococcus pseudintermedius* also demonstrated resistance to nalidixic acid (MR 91%), erythromycin (MR 84.7%), penicillin (MR 80%), oxacillin (MR 79.3%), and streptomycin (MR 78%).

Antimicrobial resistance pattern in poultry

Escherichia coli was studied in 11 AMR-related research papers out of 21 shown in Table 6. It demonstrated strong resistance to enrofloxacin (MR 95.8%, IQR 91.6-100%), oxytetracycline (MR 92%, IQR 91.9-93%), tetracycline (MR 90.9%, IQR 72.4-99%), pefloxacin (MR 90.1%, IQR 88.1-95.9%), amoxicillin (MR 89.9%, IQR 80.3-91.9%), and ampicillin (MR 89.4%, IQR 58-93%), as shown in Table 9. *Campylobacter* spp. was resistant to amoxicillin (91%), potentiated sulfur drugs (85%), and ampicillin (62.5%), whereas *Klebsiella* spp. were resistant to cefixime (72%), nailidixic acid (70.2%), and chloramphenicol (66.7%). *Salmonella* spp. exhibited resistance to oxytetracycline (MR 89.1%), amoxicillin (MR 87.5% IQR 83.4-97.3%), ampicillin (MR 79.4% IQR 55-91.1%), enrofloxacin (MR 75.9% IQR 46.2-87.5%), and streptomycin (MR 72.5% IQR 50-100%). *Staphylococcus aureus* was resistant to amoxicillin (MR 95.2%), streptomycin (95.2%), amikacin (MR 92.2% IQR 90.5-93.9%), tetracycline (MR 91.8% IQR 83.6-100%), and erythromycin (MR 81.1%). *Campylobacter* spp., *Enterobacte*r spp., *E. coli*, and *Vibrio* spp. all showed high sensitivity to gentamicin. Imipenem was effective against *Alcaligens* spp., *Enterococcu*s spp., *Klebsiella* spp., and *Staphylococcus aureus.*

Table 9: Antimicrobial resistance pattern in poultry (N=21)

Antimicrobial	***Alcaligens* spp (MR) (IQR)**	***Campylobacter* spp (MR)(IQR)**	***Enterobacter* spp (MR)(IQR)**	***Enterococcus* spp (MR)(IQR)**	***E. coli* (MR)(IQR)**
Amikacin	-	-	-	-	0
Amoxicillin	-	91 (81.2-100)	-	-	89.9 (80.3-91.9)
Ampicillin	-	62.5	94.4	-	89.4 (58-93)
Azithromycin	57	10 (0-18.2)	-	39.6 (13-66.7)	32 (23.08-65)
Cefepime	-	-	11.1	-	76.6 (72.1-81.1)
Cefixime	72	-	-	-	68
Cefotaxime	-	-	-	-	3 (0-7.7)
Cefradol	-	-	-	-	30
Ceftazidime	-	-	-	-	1.5 (1-2)
Ceftriaxone	14	-	-	-	5 (2.3-7.7)
Cefuroxim	49.1	-	-	-	-
Chl	66.7	-	-	30 (28-3)	28.85 (20-38)
Ciprofloxacin	54.4	9.1 (0-85)	-	10.5 (8-13.1)	67 (25-93)
Clindamycin	-	-	94.4	-	-
Colistin	-	-	-	-	19.3 (11-40.2)
Doxycycline	-	27.5	33.3	-	62(50.9-74.1)
Enrofloxacin	-	37.5		-	95.8 (91.6-100)
Erythromycin	-	25 (18.2-100)	94.4	20.5 (20-21)	67.3(60-97.7)
Gentamicin	-	0 (0-50)	5.6	-	13 (0-46.2)
Imipenem	1.7	-	66.6	0	47.5
Kanamycin	-	-	-	-	62.5 (27.9-72.7)
Levofloxacin	0	60	-	-	83
Mecillinam	-	-	-	-	30
Meropenem	-	-	-	-	20.95(0-41.9)
Nalidixic acid	70.2	-	-	49.3 (43-55.6)	47 (30.8-65)
Neomycin	-	50	-	-	21.5 (14-52.7)
Nitrofuratoin	-	-	33.3	-	16
Norfloxacin	-	4.6	-	-	3 (0-5.9)
OTC	-	50	-	-	92 (91.9-93)
Pefloxacin	-	-	-	-	90.1 (88.1-95.9)
Penicillin	-	-	100	88	-
Rifampicin	-	-	100	80	-
SXT	-	85	-	41.1 (30-52.1)	88.4 (83.3-90)
Streptomycin	-	43.2 (36.4-50)	55.6	-	70 (20-76.9)
Tetracycline	-	54.6 (50-75)	33.3	19.9 (19.8-20)	90.9 (72.4-99)
Tigecycline	-	-	-	-	7.7 (2.3-13)
Vancomycin	-	-	88.9	-	-

(Note: MR= Median resistance, IQR= Interquartile range.)

Table 9: Antimicrobial resistance pattern in poultry (continued)

Drug	***Klebsiella* spp** **(MR)(IQR)**	***Salmonella* spp** **(MR)(IQR)**	***Staphylococcus aureus*** **(MR)(IQR)**	***Vibrio* spp** **(MR)(IQR)**
Amikacin	-	13.3 (9.1-20)	92.2(90.5-93.9)	-
Amoxicillin	-	87.5 (83.4-97.3)	95.2	-
Ampicillin	-	79.4 (55-91.1)	-	100
Azithromycin	57	22.9 (15.7-28.2)	41.6 (26.2-57)	-
Cefalexin	-	0 (0-60)	-	60
Cefixime	72	-	72	-
Cefotaxime	-	12.2 (11.1-13.3)	7.1	-
Ceftazidime	-	16.7 (11.2-28.8)	-	-
Ceftriaxone	14	-	11.8 (9.5-14)	-
Cefuroxime	49.1	-	49.1	-
Chlorampheni col	66.7	11.3 (0-16.7)	80.9 (66.6-95.2)	-
Ciprofloxacin	54.4	36 (7.1-72.7)	52.3 (16.7-54.4)	-
Colistin		52.3 (50-54.5)	-	-
Cotrimoxazol e	-	33.4 (28.5-83.4)	-	-
Doxycycline	-	-	55.6	-
Enrofloxacin	-	75.9 (46.2-87.5)	57.9	-
Erythromycin	-	68.5 (63.6-79.7)	81.1	100
Gentamicin	-	-	59.7 (49-70.4)	0
Imipenem	1.7	-	1.7	-
Kanamycin	-	38.9 (16.6-50)	38.1	100
Levofloxacin	0	47.2	23 (0-45.8)	-
Meropenem	-	9.1 (0-16,.7)	-	-
Nalidixic acid	70.2	42.2 (28.5-60)	53 (35.7-70.2)	-
Neomycin	-	30 (0-55.7)	67.9	0
Norfloxacin	-	0	-	0
OTC	-	89.1	58	-
Pefloxacin	-	48.2 (8.9-87.5)	-	-
Penicillin	-	-	-	100
Rifampicin	-	-	-	100
SXT	-	16.7 (0-63.6)	66	-
Streptomycin	-	72.5 (50-100)	95.2	60
Tetracycline	-	-	91.8 (83.6-100)	100

(Note: MR= Median resistance, IQR= Interquartile range.)

Discussion

We assessed the rationale for prescribing antimicrobials to livestock, pet animals, and poultry, as well as their response due to diagnostic methods. Adequate laboratory diagnostic facilities can assist vets and owners in diagnosing actual causes, potentially reducing unnecessary antibiotic use (Haider *et al*., 2017). We noticed that the vast majority of patients were diagnosed and treated with antimicrobials without the assistance of any lab tests or confirmatory diagnosis (Table 4). In Bangladesh, veterinarians seldom follow any strategy for identifying pathogens and their susceptibility to antimicrobials before prescribing those (Bhowmik *et al.*, 2018). Thus, antimicrobials were used excessively, and antimicrobial resistance is rapidly evolving and spreading

Demography of patients in the research area

Data was collected from the following sources in order to perform a study on animal health care to assess the necessity for a confirmatory lab test, or AST, when prescribing antimicrobial drugs to animals in the country: Figure 2 depicts SAQTVH (54%), Chattogram Veterinary and Animal Sciences University (27%), TTPHRC, CVASU (27%), pet clinics in Dhaka (4%), Chattogram (2%), and Mirsarai UVH (13%). Table 1 illustrates the following four species: goat (37.9%), dog (11.3%), cat (27.7%), cow (13%), and poultry (10.1%). Cattle, goats, sheep, and buffaloes account for 28%, 67%, 3%, and 2% of the livestock population of Bangladesh, respectively (Hatab *et al.*, 2019). About 83.9% of all households possess livestock (animals, poultry, or both) in the country (Livestock-Banglapedia, 2021). In rural areas, 57.7% of households possess livestock, which includes large animals, small ruminants, and poultry (Roess *et al.*, 2015). Beside, pet animals are the closest friends, confidants, and family members. The possibility of microbe transfer across these various host species is rather high due to these contacts. As a result, disease and antibiotic resistance gene transfer in both pet animals and humans must be studied (Das *et al.*, 2023). The animal health care system of Bangladesh is fully diverse, incorporating untrained healthcare practitioners and a variety of organizations at various levels (Fortané *et al*., 2020). Government veterinary healthcare practitioners seldom (9.7%) visit the farms (A. Akhter, 2015).

Effects of laboratory diagnosis on antimicrobial treatment responses

According to Table 2, all cases of Mirsarai UVH and pet clinics in Chattogram were diagnosed and treated with antimicrobials based on only clinical signs. In Dhaka pet clinics, 20% (3/15) of cases were diagnosed based on clinical signs with a rapid kit test. Through examination of clinical signs and lab tests, 9.9% (19/192) of patients at SAQTVH-CVASU were diagnosed and prescribed antimicrobials. About 35% of patients at TTPHRC were diagnosed and treated with antimicrobials based on lab diagnosis (blood test, microscopic examination etc.). However, no antimicrobial sensitivity test was conducted in the study area. In Bangladesh, antibiotics were prescribed to the majority of the animals without proper diagnosis of the diseases (Haider *et al*., 2017). Clinical signs and pathognomonic lesions were used to diagnose specific bacterial, viral, and fungal infections in animals (A. T. M. Badruzzaman, 2015). In certain cases, cultural and biochemical characteristics of the causative organisms were used to confirm the diagnosis, as is standard procedure (Niilo, 1969). To confirm hemoprotozoan infestation, blood smears were prepared and examined under a microscope following Giemsa staining (Hendrix & Robinson, 2022). In the study, about 15.5% were diagnosed and treated based on a lab diagnosis, and 94.6% recovered. In contrast, 84.5% of patients were given antimicrobials without a confirmatory diagnosis through a lab test, and the antimicrobial response was 78.6%, as shown Table 4. The p value was 0.019 ($p < 0.05$), which is statistically significant. It is seen; the diagnostic procedure had a substantial influence on patient response. Diagnostics play an important role in preventing the misuse of antibiotics because they permit healthcare providers to choose the most efficient treatment for a specific disease, reducing the risk of antimicrobial resistance (Trevas *et al*., 2021).

Effects of the number of antibiotics used at once on treatment responses

Among all antibiotic, ceftriaxone was the most commonly used antibiotic (15.9%). Penicillin-streptomycin and sulfur drugs accounted for 11.9% and 8.7%, respectively

(Table 3). The rising demand for animal protein in recent years has led to a rapid increase in the production and consumption of animal products. In most developed countries 50–80% of the antibiotics produced are used only for livestock (Hosain *et al.*, 2021). Approximately 94.16% of poultry farmers in Bangladesh use antibiotics on their farms to control diseases and increase egg production (Ferdous *et al.*, 2019). According to hospital-based studies, antimicrobials were prescribed to 56–66% of diseased animals (Bhowmik *et al.*, 2018, Samad *et al*., 2020). The most common uses of penicillin-streptomycin were in goats (21.3%) and cattle (34.7%), as shown in Figure 3. Streptomycin-penicillin (31%) was the most regularly given antibiotic, followed by sulfadimidine (14%), amoxicillin (11%), gentamicin, sulfadiazine-trimethoprim (9%), and tylosin (1%) (Bhowmik *et al.*, 2018). In Figure 4, ceftriaxone was given to pet animals in a significant percentage of cases, including cats (31.9%) and dogs (35.4%). In poultry, sulfa drugs were most frequently given (23.4%), as shown in Figure 5. Enrofloxacin, erythromycin, ciprofloxacin, amoxicillin, and oxy-tetracycline were prescribed in 19.1%, 17%, 10.6% 6.4%, and 6.4% of the antimicrobials used in poultry, respectively (Table 3). The most common usage of antibiotics in poultry (broiler chicken) was for therapeutic purposes (44%), followed by prophylactic (32%), and growth promotion (8%). Colistin (30.14%), ciprofloxacin (19.2%), tylosin (13.7%), neomycin (2.74%), amoxicillin (5.5%), trimethoprim (26%), doxycycline (20.6%), enrofloxacin (19.2%), and erythromycin (4.1%) were found to be common antibiotics (M Saiful Islam *et al.*, 2016). Figure 6 shows that two or more antimicrobial agents were administered concurrently to 22.2% of poultry cases during the research period. Most (80%) of farmers who rear broiler chickens use combination antibiotics, and most of them provide multiple antibiotics (M Saiful Islam *et al.*, 2016). In cats and goats, more than two antibiotics were utilized in 7.5% and 3% of cases, respectively. Prescribing one, two, or more antimicrobials at the same time resulted in a 77%, 90.1%, or 95.2% treatment response rate, respectively. Table 5 shows that the P value was 0.038, which is statistically significant. Using more antibiotics has a positive influence on treatment response since it has demonstrated a high level of response to treatment. But the misuse or overuse of antimicrobials in food-producing animals causes major problem of AMR that hasn't received enough attention. Regulations and specific limits on the use of antimicrobials in veterinary medicine might help to reduce the overuse or abuse of these drugs in food-producing animals (Ionel, 2018).

Comparison of antimicrobial usage and antimicrobial resistance

Penicillin-streptomycin (34.7%) was the most often used antibiotic in cattle. However, extreme resistance to penicillin-streptomycin was seen for *Staphylococcus aureus* (65.9%) and *Streptococcus* spp. (83.4%), but it was lower in *Escherichia coli*, *Klebsiella* spp., and *Salmonella* spp. OTC was used 16.3% of the time; however, it showed strong resistance for *E. coli* (74.9%), *Salmonella* spp. (79%), and *Streptococcus* spp. (84.5%) (Table 7). Antimicrobials are essential components that are used for disease treatment and control as well as growth promoters in animal production. The frequent use of antimicrobials in veterinary medication may result in residuals in animal-derived products, which can carry several risks to human health through AMR (Zahangir Hosain *et al.*, 2021). Ceftriaxone was prescribed in 31.9% of cat cases, and it shown considerable resistance to *E. coli*, S*taphylococcus aureus*, and *Streptococcus* spp. It was prescribed in 35.4% of dog cases and was sensitive to *E. coli*. Table 8 shows that *E. coli* resistance to metronidazole was higher in dogs (60%) than in cats (50%). Sulfa drugs were mostly prescribed to poultry (23.4%). High resistance to sulfa drugs was found in *E. coli* (88.4%), *Campylobacter spp*. (85%), and *Staphylococcus aureus* (66%). Erythromycin was given in 19.1% of cases. Table 9 shows that it was strongly resistant to *Vibrio* spp. (100%), *Enterobacter* spp. (94.4%), *Staphylococcus aureus* (81.1%), *Salmonella* spp. (68.5%), and *E. coli* (67.3%). *E. coli*, *Salmonella* spp., *Enterobacter* spp., *Staphylococcus* spp., and *Campylobacter* spp. are all probable zoonotic pathogens that pose direct human health risks (Heredia & García, 2018). MDR *E. coli*, *Salmonella* spp., and *Enterobacter* spp. isolates from both poultry and dairy have shown resistance to imipenem, azithromycin, and colistin sulfate, all of which are restricted for human use and forbidden for use in animal health (Abdus Sobur *et al.*, 2019). This might be owing to the excessive and inconsiderable usage of these antibiotics in veterinary care or the spread of AMR genes from human to animal diseases.

Limitation

Data was acquired from only a few veterinary hospitals in two areas. Sheep, buffalo, and duck are also important, but they weren't included. Owners were not always cooperative. There were inadequate publications concerning AST in veterinary facilities. So, the study involved a considerable number of cases and publications.

Conclusion

The current study presents an understanding of the rationale for prescribing antimicrobials to livestock, pets, and poultry and their responses. It also shows the use of resistant antimicrobials. AMR is evolving rapidly in Bangladesh. The emergence and zoonotic transmission of AMR bacteria or associated-resistant genes is critical due to their presence in animal products, particularly environments and by-products. Performing AST before prescribing antimicrobials to animals will be an effective strategy to reduce AMR in Bangladesh.

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Biography

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