Introduction

Bangladesh is an agriculture-based country, where 75% of people are prevailing in the countryside (Bangladesh Bureau of Statistics, 2018). They rely on farming, especially poultry farming, for maintaining everyday life, economic progress, and nutritional demand (Roy et al., 2019). Broiler, layer, and indigenous chicken are prominent here among all poultry species. Nevertheless, people favor the meat of indigenous chicken rather than other commercial poultry meat. For these circumstances, the Sonali chicken was introduced through cross-breeding with Rhode Island Red (RIR.) cocks and Fayoumi hens funded by the Smallholder livestock development project (SLDP) and Participatory livestock development project (PLDP) from 1996-2001 in Bangladesh (Belal, 2018). Currently, the production of Day-old chick (DOC) of the Sonali chicken (350 million) is half of the production of broiler DOC (700.1 million) due to public demand (Saleque, 2020). Sonali rearing is rapidly becoming popular because of its similar phenotypic appearance and taste to that of local indigenous chicken, better production records (average weight; adult male 2-2.5 kg and adult female 1.5-2 kg with feed conversion ratio of 4.33), higher disease resistance, lowest mortality and highest profit rate per hen (Rahman et al., 1997; Huque et al., 1999; Biswas et al., 2006). Sonali chickens are also very much suited to the semi-intensive rearing system in rural areas. Traders can sell Sonali at higher price than broiler chicken, Commercial Sonali farming provides employment opportunities for unemployed family members, improve socio-economic conditions (of about 76% of Sonali beneficiary has been improved) and increases women employment among rural people of Bangladesh (Howlader et al., 2022).

However, Sonali broiler farming is hindered by different diseases (Islam and Samad, 2004). Common infections found in SBC farms include infectious bursal disease (IBD), Newcastle disease (ND), coccidiosis, colibacillosis, and mycoplasmosis. On the other hand, mixed infection of IBD, ND and colibacillosis also found (Tipu et al., 2021). In a study conducted in Bangladesh's Bogura Sadar Upazila, (Talukdar et al., 2017) found that the prevalence of infectious diseases in SBC was as follows: 14.72% had Infectious Bursal Disease (IBD). Newcastle disease (ND), coccidiosis, colibacillosis, and mycoplasmosis have respective rates of 13.95%, 14.72%, and 12.79%. Farmers are using different antibiotics to save poultry health without biosecurity concerns. Antibiotics are used as prophylaxis,treatment, or growth promoter supplied by the dealers, usually without the veterinarian's concern (Masud et al., 2020).

Applying fundamental biosecurity protocols is the most effective approach to lower the likelihood of infectious disease outbreaks and transmissions (Boklund et al., 2004; Tanquilut et al., 2020) as well as to ensure food safety and protect public health (Indrawan and Daryanto, 2020). Three elements are typically included in effective biosecurity measures: isolation, traffic control, and sanitation. (Cardona and Kuney, 2002; Indrawan et al., 2020; Negro-Calduch et al., 2013). "Isolation" prevents or minimizes the entrance of pathogens onto chicken farms. Physical barriers, such as fences, are examples of such measures. "Traffic control" means limiting the movement of potential pathogen vectors such as people, animals, and equipment that could act as vectors for infections, whereas "sanitation" refers to cleaning and disinfecting poultry sheds, farmers, visitors, and equipment (Cardona and Kuney, 2002; Indrawan et al., 2020; Negro-Calduch et al., 2013).

Based on biosecurity standard, the Food and Agriculture Organization (FAO) divides the poultry production system into four categories. Industrial and integrated poultry producers that adhere to "high" biosecurity standards comprise Sector 1. Commercial chicken farmers that follow "moderate to high" biosecurity (no contact with other birds) comprise Sector 2. Sector 3 is made up of commercial poultry producers who practice "low" biosecurity (contact with other birds and closed/open sheds), and Sector 4 is made up of village or backyard poultry producers who practice "low" biosecurity (FAO, 2007). When the biosecurity measures implemented by Bangladeshi commercial poultry farmers were evaluated in 2008, it was found that 96% of the country's commercial producers were in sector 3, and just 4% were in sector 2 (Dolberg, 2008).

It has been reported that commercial chicken farms in Bangladesh usually lack proper biosecurity measures. (Ibrahim et al., 2015; Kajol and Shahadat, 2019; Rimi et al., 2017).

Indiscriminate use of antibiotics in food-producing animals may transmit antimicrobial resistance organisms to the human food chain (Laxminarayan et al., 2013). In Bangladesh, 55% of *E. coli* isolates from poultry have been found resistant to one or more commonly used antimicrobials. The high level of antibiotic resistance in Bangladeshi avian pathogens is concerning, indicating that the widespread use of antibiotics as feed additives for growth promotion and disease prevention may have negative consequences for human and animal health and the environment (Hasan et al., 2011). On the other hand, good biosecurity practices canminimize antibiotic use on poultry farms (Imam et al., 2021). Knowledge about biosecurity and the judiciary's use of antibiotics is essential. Therefore, this study aims to determine the extent of antibiotic use in Sonali broiler chickens and factors influencing the disease occurrence and use of antibiotics in the farms along with the farm biosecurity conditions.

Specific objectives

a) Assess the biosecurity level in the Sonali broiler chicken at the farm level in different regionsof Bangladesh.

b) Determine the antimicrobial use pattern in the Sonali broiler chicken at the farm level in selectedareas of Bangladesh.

c) Distribution of Sonali broiler chicken diseases and identify factors associated with the most common poultry diseases in the Sonali broiler chicken at the farm level in Bangladesh.

Chapter 02: Review of Literature

Poultry is defined as a group of domesticated birds raised for animal products (e.g., meat, eggs, manure), fiber (e.g., feathers), entertainment (e.g., racing, exhibition, hunting, etc.), or work (e.g., messenger pigeons). Most poultry species encompass a few avian orders that include Galliformes (chickens, turkeys, quail, pheasants, grouse, guinea fowl), Anseriformes (ducks, geese, swans), and Columbiformes (pigeons and doves), and Ratites (ostriches, emus) (Vaarst et al., 2015; Permin et al., 2005; Mottetet al., 2017). Poultry, one of the fastest per capita produced livestock (Elwinger et al., 2016; Dibner et al., 2005) will continue to expand as countries shift from subsistence to intensive farming that also requires routine AMU (Smith et al., 2002; Lhermle et al., 2017). In comparison to other terrestrial livestock, the ubiquity of poultry is attributable to several key characteristics: small body size, relatively short life cycle, high energy uptake efficiency, and robust adaptability to environmental conditions (Alders et al., 2009; Mapiye et al., 2008; Vaarst et al., 2015). In the last half century, the global poultry annual growth rate was 5%. It was only 1.5% for beef, 3.1% for pork, and 1.7% for small ruminants (Mottet et al., 2017). Chickens (*Gallus gallus domesticus*) comprise 90% of global poultry production, amounting to approximately 23 billion chickens (FAO 2019).

Commercial poultry production in Bangladesh

During the 1980s, the gross domestic product (GDP) of Bangladesh was derived only 1% from commercial poultry raising (Begum et al., 2012). Because of this, the Bangladeshi government created regulations in the 1990s to enhance the housing, diet, and breeds of commercial chickens in order to boost the industry's productivity and meet the nation's rising demand for eggs and meat (Begum et al., 2012; Rahman et al., 2014). Two types of poultry production systems are found in Bangladesh, family or backyard poultry and commercial poultry farming (Chowdhury, 2013). Bangladesh produces commercial poultry on two scales: small-scale farms with up to 3,000 birds and medium- to large-scale farms with 3,000–20,000 birds (Hamid et al., 2017). Chickens are the main poultry species reared on commercial farms (Dolberg, 2008). Commercial chicken production can be classified into broiler and layer farming (Jabbar et al., 2007). According to Dolberg (2008), hens raised in layer farms are primarily raised for their eggs, while some unproductive layer birds are also sold for meat. In contrast, broiler farms raise their chickens for chicken meat.

However, people prefer the flesh from native chickens above other commercial poultry products. Under these conditions, the Rhode Island Red (RIR) cock and Fayoumi hen were crossed to create the Sonali chicken in Bangladesh between 1996 and 2001 under the fund of the Smallholder Livestock Development Project (SLDP) and the Participatory Livestock Development Project (PLDP) (Belal, 2018).

Obstacles for poultry production in Bangladesh

The prevalence of infectious diseases is one of the major problems facing commercial chicken farmers. (Giasuddin et al., 2002; Hassan et al., 2016), and poor biosecurity (Rimi et al., 2017). Furthermore, according to Ferdous et al. (2019), Bangladesh lacks antimicrobial usage policies. A profitable and successful commercial poultry trade may also be hampered by other issues such as inadequate veterinary health care and diagnostic support (Haque, 2017), improper vaccination programs (Ansari et al., 2016), unmet nutritional needs of chickens (Dolberg, 2008), and marketing restrictions (Hamid et al., 2017).

Poultry diseases

Poultry diseases can have major implications on a country's economy, food source, and public health. Poor or absent disease control strategies and inadequate management practices result in significant mortality in poultry. Moreover, high baseline mortality in poultry is due to predators (e.g., rodents, snakes, small carnivores) or infectious diseases (e.g. Newcastle Disease (ND), salmonellosis, Gumboro disease or fowl typhoid) (Abdelqader 2007; Biswas 2008; Ison 2012). Among the bacterial diseases salmonellosis, colibacillosis, mycoplasmosis and necrotic enteritis were the most frequent diseases reported from commercial chicken farms in Bangladesh (Table 2.1). Birds with salmonellosis are commonly presented with enteric signs, while respiratory signs, inappetence, and sudden death may indicate colibacillosis (Pattison et al., 2008). Respiratory signs are often associated with mycoplasmas (Pattison et al., 2008). Bacterial diseases were varied in layers and broiler farms; colibacillosis was more common in layers, whereas salmonellosis and mycoplasmosis were more common in broiler farms (Badruzzaman et al., 2015; Hassan et al., 2016). The research studies carried out so far on Bangladeshi commercial chicken farms to describe bacterial disease prevalence, were largely based on clinical signs (with or without post-mortem findings) (Table 2.1), without confirmatory laboratory diagnosis. provided evidence regarding the aetiology of the bacterial infections, which would have been useful in determining specific antimicrobial therapy. Infectious bursal disease, Newcastle disease, avian influenza, infectious bronchitis, lymphoid leucosis, and fowl pox are among the viral diseases that are frequently reported from commercial chicken farms in Bangladesh (Islam et al., 2003;

Hossain et al., 2004; Islam et al., 2009; Uddin et al., 2010; Hassan et al., 2016; Bari et al., 2018 and Badruzzaman et al., 2015). Bangladesh's commercial chicken industry suffered greatly by avian influenza in particular, which caused the number of commercial chicken farms to drop from 115,000 in 2007 to 55,000 in 2013. (Raha, 2012). Furthermore, parasitic diseases such ascaridiosis and coccidiosis have been reported from Bangladeshi layer and broiler farms (Islam et al., 2003; Hossain et al., 2004; Islam et al., 2009; Uddin et al., 2010; Badruzzaman et al., 2015; Hassan et al., 2016; Bari et al., 2018).

Table 2.1: Studies describing the prevalence of different diseases on commercial chicken farms in Bangladesh.

Study period	Study location	Method of diagnosis	Prevalence of disease	Reference
December 2016 to February 2017	Chattogram	Clinical history Clinical signs Post-mortem lesions	Colibacillosis (11.9%) Necrotic enteritis (7.5%) Mycoplasmosis (7.5%) Salmonellosis (4.5%), Newcastle disease ND (8.95%), Infectious bursal disease IBD (16.42%), Brooder pneumonia (6%), Colibacillosis + Coccidiosis (7.5%)	Bari et al. (2018)
October 2012 to December 2012	Gazipur	Do	Layers: Salmonellosis (38.6%) Mycoplasmosis (14.7%) Colibacillosis (6.7%) Fowl cholera (4.8%) Necrotic enteritis (1.6%), Avian influenza (2.56%), ND (16.61%), Infectious bronchitis IB (3.19%), Avian leucosis (0.64%), Coccidiosis (5.75%). Broilers: Salmonellosis (21.3%) Colibacillosis (7.7%) Mycoplasmosis (7.1%), IBD (29%), ND (8.87%), IB (15.38%), Coccidiosis (6.5%).	Hassan et al. (2016)
March 2015 to February 2016	Sylhet	Do	Colibacillosis (14.5%) Salmonellosis (7.3%) Fowl cholera (3.1%), ND (9.85%), IBD (16.43%),	Rahman and Adhikary (2016)

			Brooder pneumonia (7.33%).	
June 2013 to May 2015	Sylhet	Clinical history Clinical signs Microscopic examinations	Colibacillosis (14.0%) Salmonellosis (12.2%) Mycoplasmosis (11.7%) Fowl cholera (2.7%), IBD (22%), ND (13.84%), Chronic respiratory disease CRD (11.66%), Coccidiosis (7.87%), Brooder pneumonia (7.2%), Avian leucosis (0.14%), IBD + Coccidiosis (0.71%), ND + Colibacillosis (0.71%).	Badruzzaman et al. (2015)
December 2016 to November 2017	Kishoregonj	Clinical history Clinical signs Postmortem findings. some laboratory examination such as isolation and identification of the causal agents, Serological tests Microscopic examinations	**Broiler chicken:** Infectious bursal disease (29.32%) Salmonellosis (14.29%) New castle disease (11.78%) Infectious bronchitis (9.27%), Coccidiosis (6.93%), Colibacillosis (6.43%) Chronic respiratory disease (4.85%), visceral gout (4.68%) Necrotic enteritis (1.59%), Mycotoxicosis (0.67%) and Infectious coryza (0.08%). **Layer chicken:** Salmonellosis (30.60%) New castle disease (17.54%) Infectious bursal disease (9.16%), Coccidiosis (9.16%), Chronic respiratory disease (9.16%), Colibacillosis (7.01%), Fowl cholera (5.26%), Infectious bronchitis (4.09%) Necrotic enteritis (2.92%) Egg peritonitis (1.94%), Aspergillosis (1.75%),	(Rahman, 2019)

			Mycotoxicosis (1.75%), Helminth parasites (1.36%), Fowl pox (0.97%), Infectious coryza (0.97%) and Lymphoid leukosis (0.78%). **Sonali Chicken:** Infectious bursal disease (33.95%) Salmonellosis (27.31%), New castle disease (19.56%), Chronic respiratory disease (11.07%), Coccidiosis (10.70%), Colibacillosis (8.11%), Fowl cholera (3.32%), Necrotic enteritis (2.56%), Aspergillosis (2.21%), Fowl pox (0.74%), Helminth parasites (0.74%) and mycotoxicosis (0.37%).	
September to November, 2015	Bogura	Clinical history Clinical signs Post-mortem lesions	Infectious Bursal disease (14.72%) Newcastle disease (11.24%), Coccidiosis (13.95%), Colibacillosis (14.72%)and Mycoplasmosis (12.79%). Mixed infection of IBD, ND and Coccidiosis (16.67%), Mixed infection of IBD, ND and colibacillosis (15.89%).	(Talukdar et al., 2017)

Table 2.2: Description of OIE reportable poultry diseases

Disease	***Type of Agent***	***Natural Hosts***	***Mortality Rate***	***Clinical Signs***
Avian Influenza(AI)	Type A influenza virus (family Orthomyxoviridae)	Most, if not all bird species	Highly pathogenic 90-100%	Severe respiratory disease, edema, cyanosis, decreasedegg production
			Low pathogenic 10-20%	mild respiratory disease, ruffled feathers, decrease egg production
Newcastle Disease (ND)	Avian paramyxovirus type 1 (APMV-1)	Most, if not all bird species	Virulent Velogenic 100%	Dyspnea, edema, diarrhea, neurological signs: torticollis, paralysis, and opisthotonos
			Neurotropic Velogenic 50-100%	Severe respiratory diseaseand neurological signs, decreased egg production
			Mesogenic ND <10%	acute respiratory disease, decrease egg production, occasional neurologic signs
			Lentogenic ND low	Mild coughing, gasping, sneezing, and rales
Infectious Laryngotracheitis (ILT)	Gallid herpesvirus 1(family Herpesviridae)	Chicken and Pheasant	10-20%	Nasal discharge, rales, coughing, dyspnea, blood-stained mucus
***Mycoplasma gallisepticum* (MG)**	Gram negative, coccoid bacteria	Chicken, turkey, pigeon,peafowl, quail, passerine	Low in uncomplicated cases	Rales, coughing, nasal discharge, conjunctivitis, and in turkeys infraorbital

Avian Influenza

Avian influenza (AI) is caused by the type A influenza virus which has a segmented genome of eight negatively sensed, single-stranded, RNA particles encoding 11 to 12 proteins, totaling 13.5 kb in length. Type A influenza viruses are categorized into serological subtypes based on surfaceglycoproteins, hemagglutinin (HA), and neuraminidase (NA). Host tropism highly depends on HA as it binds to host cell receptors containing terminal α-2,6 linked or α-2,3 linked sialic acid molecules. AI viruses preferentially bind to α-2,3 linked receptors of avian respiratory epithelium,while human influenza viruses have a higher affinity for α-2,6 linked receptors of the upper respiratory tract. Although human non-ciliated cuboidal bronchiolar and alveolar type II cells located in the lower respiratory tract contain α-2,3 linked receptors, infection with non-human adapted viruses is rare. HA also consists of a cleavage site with varying amino acid sequences thatdetermine the tissue tropism and disease severity (Medina and Garcia-Sastre, 2011). Currently, sixteen hemagglutinin and nine neuraminidase subtypes have been identified, with H5and H7 often exhibiting the most virulence in poultry. Most laboratories initially rely on the matrixprotein for the detection of AI as it is the most abundant protein and highly conserved in all influenza A viruses (Spackman and Suarez, 2008).

Influenza type A viruses are zoonotic pathogens capable of infecting a wide range of species. Aquatic birds are the natural reservoir for influenza A viruses and can carry all 144 possible subtype combinations in their gastrointestinal tract, while human circulating strains affecting the respiratory tract are generally limited to H1N1, H2N2, and H3N2. Poultry may also carry a varietyof HA and NA subtypes, including: (HA 4, 5, 7, 9, 10 and NA 1, 2, 4, 7), as well as H5N1 and H7N7 subtypes. Despite producing large quantities of the virus, waterfowl generally present with no clinical signs of illness. However, infections in poultry and other incidental hostsmay result in a wide variety of signs, further classifying the virus into highly pathogenic avian influenza (HPAI) or low pathogenic avian influenza (LPAI) (Causey and Edwards, 2008). HPAI viruses spread rapidly in poultry flocks, causing severe illness, and can kill 90 - 100% of infectedbirds within 48 hours of exposure. However, most strains are LPAI with signs of disease ranging from none to ruffled feathers, decreased egg production, and mild respiratory distress. Transmission occurs by direct contact with infected birds via their feces, saliva, or nasal secretions. Indirect transmission may occur through contact with contaminated equipment, clothing, litter, or drinking water. The primary route of infection is through oral ingestion, although conjunctival and respiratory routes are other potential means. AI viruses can persist for over a month in water and feces at 40ºF and have an incubation period of 3-14 days (McMullin, 2004).

Newcastle Disease

Newcastle disease (ND) is caused by the avian paramyxovirus type I (APMV-1) serotype of the genus Avulavirus belonging to the Paramyxoviridae family and consists of 15,186 nucleotides. There are nine serotypes of avian paramyxoviruses, from APMV-1 to APMV-9. Newcastle disease virus (NDV) is a nonsegmented, single-stranded, negative-sense, enveloped RNA virus (Wakamatsu, 2007). The six open reading frames of NDV code for seven proteins. The hemagglutinin-neuraminidase glycoproteins bind to sialic acid cell surface receptors, triggering the fusion (F) protein to fuse the viral envelope to the host plasma membrane. Cleavage of the precursor glycoprotein F0 into F1 and F2 by host cell proteases is a requirement for viral infection. The fusion gene has been of particular interest as its diversity has allowed for the genetic characterization of NDV isolates. The characterized amino acid sequence motifs at the F protein cleavage site are as follows: Lentogenic 112G-R/K-Q-G-R↓L117, Mesogenic/Velogenic 112R/G/K-R-Q/K-K/R-R↓F117 (Dortmans et al., 2011).

In poultry, NDV causes an array of clinical signs from subclinical to acute mortality. Signs vary depending on virus strain, host species, age of the host, secondary infections, and stress. Associated signs include respiratory distress, diarrhea, cessation of egg production, inactivity, edema of the head, face, and wattles, nervous signs, and death. Strains of NDV have been grouped into five pathotypes on the basis of the clinical signs seen in infected chickens. The viscerotropic velogenic pathotype is a highly pathogenic form resulting in hemorrhagic intestinal lesions. The neurotropic velogenic form presents with a high death rate subsequent to respiratory and nervous signs. Mesogenic pathotypes are characterized by respiratory and occasionally nervous signs and low mortality. Lentogenic forms present with a mild or subclinical respiratory infection. The final pathotype is an asymptomatic enteric consisting of subclinical infection. NDV is thought to primarily spread through inhalation of large droplets or via ingestion of infected feces which generally contain high viral loads. The incubation period, on average, is five to six days (Alexander, 2008). Prophylactic vaccination is practiced in all but a few of the countries that produce poultry on a commercial scale. The widespread presence of lentogenic strains in wild birds and the use of these viruses for live vaccines make the diagnosis of the disease difficult.

Newcastle disease virus is also zoonotic and has been reported to cause eye infections in humans.Virulent NDV is considered an OIE-listed notifiable disease (OIE, 2010).

Infectious Laryngotracheitis

Infectious laryngotracheitis (ILT) is a respiratory disease caused by Herpesviridae alphaherpesvirinae Gallid herpesvirus 1. ILT virus (ILTV) is a double-stranded linear DNA virusand its genome is 155 kb in size and composed of an unique long (UL) and a unique short (US) region that is flanked by inverted repeats (IR). The ILTV genome has a total of 77 predicted openreading frames with 62 located in the UL region, nine in the US, and three in the IR (Ziemann et al., 1998). Several studies have used glycoprotein C (gC), one of the major surface antigens of ILTV, for detection due to its conserved sequence, while the variable infected cell protein 4 (ICP4) has been used to differentiate between strains (Callison et al., 2006 and Chacon et al., 2009).

As with other herpes viruses, ILTV has the ability to establish latent infections in the trigeminal ganglion, causing clinically inapparent infection which can persist in recovered birds for long periods with intermittent re-excretion of the virus. Incubation period is generally 6-12 days (Johnson et al., 2004). In areas with endemic disease, such as the U.S., ILT is controlled in layers with the use of modified-live virus vaccines such as chicken embryo origin (CEO) or tissue cultureorigin (TCO). However, studies have shown that 63% of field isolates from commercial farms were similar to CEO vaccine strains. Providing further evidence of their ability to revert to virulence, non- attenuated CEO-related isolates can persist within naive backyard and fancier chicken flocks (Guy and Garcia, 2008).

ILT is primarily a disease of chickens; however, it may also affect pheasants, partridges, and peafowl. In chicken flocks, ILTV transmission occurs via respiratory and ocular routes. This viruspresents clinically in three different forms: peracute, subacute, and chronic/mild. The peracute form produces the most sudden and severe cases of the disease. The mortality rate may be over 50% with some deaths occurring prior to the development of signs. Characteristics of the peracute form include anorexia, depression, and severe respiratory distress with coughing, gurgling, and rales. The neck is often extended upon inspiration as the trachea becomes partially occluded by bloody mucus exudate. In the subacute form, the onset of illness is slower and respiratory signs may be seen in the days prior to death. The mortality is lower than in the peracute form (between

10% and 30%), and signs of illness are less severe, ranging from lacrimation, tracheitis, conjunctivitis, and mild rales. Chronic or mild ILT illness may involve spasms of coughing and gasping, nasal and oral discharge, and reduced egg production. ILT is notifiable to local, state, andfederal agencies, as well as to OIE (OIE, 2010).

Mycoplasma Gallisepticum

Mycoplasma gallisepticum (MG) is a gram-negative, coccoid, facultative anaerobe (0.25-0.5um) belonging to the family Mycoplasmataceae and is the most economically important of the avian mycoplasmas. Mycoplasmas are wall-less bacteria and represent the smallest replicating organism. MG contains approximately 200 polypeptides in its plasma membrane which provide surface antigenic variation, adhesion, motility, nutrient transport, and methods of immune evasion. MG targets sialic acid residues of the respiratory epithelium to initiate cytadherence and infection and has been known to survive intracellularly (Papazisis et al., 2000). PvpA, an integral membrane protein, has been used to identify sequence variations among strains as a result of its high- frequency phase variation and size discrepancies ranging from 48 - 55kDa (Boguslavsky et al., 2000).

Mycoplasma gallisepticum is the etiological agent of chronic respiratory disease in chickens characterized by severe airsacculitis, coughing, rales, and poor growth. In turkeys and other game birds, swollen sinuses are commonly seen along with decreased meat and egg production. The severity of disease is greatly enhanced through stress and secondary respiratory pathogens (OIE, 2010). In poultry, the route of infection is via the conjunctiva or upper respiratory tract with an incubation period of 6-10 days. *Mycoplasma sp.* may be transmitted vertically through infected eggs, or by direct contact with birds, exudates, aerosols, airborne dust, and feathers, and to a lesser extent, fomites. Spread is slow between houses and pens suggesting that aerosols are not normally a major route of transmission. However, fomites appear to be a significant factor in transmission between farms. Recovered birds remain infected for life and may experience recurrent disease (McMullin, 2004). While control of MG is widely maintained through biosecurity practices in breeding stock of turkey and chicken industries, U.S. layer flocks are considered endemic with disease occurring in over 50% of all egg laying facilities. Therefore, these facilities use live attenuated MG vaccines such as the F strain, 6/85, and ts-11 (Evans et al., 2005). Mycoplasmosisis an OIE-reportable disease (OIE, 2010).

Salmonella Enteritidis

Salmonella is the gram negative facultative anaerobe responsible for causing food-borne salmonellosis in humans (Pui et al., 2011). Previous epidemiological studies report that up to 3.7 million cases of samonellosis occur in the U.S. every year, with economic losses to poultry farmersranging from $64-144 million annually. *Salmonella* serotype Enteritidis (SE) is one of the most prevalent serotypes of *Salmonella* bacteria reported globally. Using the Colindale phage-typing scheme, 16 phages have been used to identify 65 phage types for SE. Most types of *Salmonella* survive in the intestinal tracts of birds, but generally do not cause clinical illness (Omwandho andKabota, 2010).

Although this serotype has been found in chicken meat, shell eggs are usually considered the mostcommon vehicle for transmission of SE as human infection is typically acquired after consumingundercooked contaminated eggs. Signs and symptoms of salmonellosis include fever, abdominal cramps, and diarrhea lasting 4 to 7 days. Eggs become contaminated with SE by penetrating cracksin the shell. Vertical transmission has also been implicated as the bacterium can silently infect theovaries of healthy appearing hens and enter the egg prior to shell formation. Even though birds may be originally purchased as culture-negative chicks, SE has been isolated from insect and animal hosts living in and around hen houses. It is estimated that one out of every 20,000 eggs is contaminated with SE, leaving a total of 2.2 million eggs contaminated in the market (CDC, 2010;Guard-Petter, 2001).

Use of antimicrobials in poultry

In 1946, the first recorded use of antimicrobial growth promoters (AGPs) was documented in chickens (Moore and Evenson 1946). Soon after, farmers in post-war United States and Europe were struggling to supply for an increasing demand for poultry food products (Laxminarayan et al., 2015). Meanwhile antimicrobials administered for growth promotion and disease prevention became a vital component for intensive poultry production (Starr and Evenson 1946; Barnes 1958).

The use of antimicrobials in intensive poultry production is becoming increasingly common at smaller scales within low-resource settings because of its high throughput of meat and egg products (Mottet et al., 2017; Aidara-Kane 2018; Gilchrist et al., 2007; Gilbert 2008). As urban populations continue to rise among LMICs, the demand for animal-source products will increase (Klein et al., 2018; Thanner et al., 2016; Thornton et al., 2010). Defining characteristics of intensive large-scale farming include confined hatchery environments that house chickens at high densities (>1000), routine AMU (Gilchrist et al., 2007), and breed selection of predominantly broiler chicken for meat production and layer chicken for egg production (Flock et al., 2005). Because of AGPs the broiler chicken is considered the most resource efficient livestock (Flock et al., 2005; Brown et al., 2017) leading to over 50% increase in body mass from 1955 to 1995 while substantially lowering the feed and time required (Boyd 2001).

Antimicrobial Resistance in the poultry farms of Bangladesh

In Bangladesh, very little research has been done to look into antibiotic resistance in industrial poultry farms. Disk diffusion testing on samples taken from 279 sick or dead birds in Dhaka and Gazipur revealed that 101 E. Coli isolates were resistant to ampicillin (45.5%), nalidixic acid (25.7%), trimethoprim sulphamethoxazole (26.7%), and tetracycline 20.8%), ciprofloxacin (12.9%), chloramphenicol (8.9%), nitrofurantoin (25.7%), streptomycin (20.8%), 2.0%), as well as 2.0% for gentamicin (Hasan et al., 2011). Samples obtained from 50 dead chickens in Gazipur were cultured for Salmonella Pollorum and E. coli using a disk diffusion method (Rahman et al., 2004). All Salmonella Pullorum isolates were resistant to tetracycline, 40% isolates were resistant to erythromycin and 60% were resistant to penicillin G , while all E. coli isolates were resistant to cepharadine, followed by chloramphenicol (60%), penicillin G (60%) and tetracycline (40%) (Rahman et al., 2004).

In Sylhet division of Bangladesh, E. coli isolates from 100 samples (80 cloacal and 20 liver samples) were collected from healthy broilers in local markets after slaughtering and all (100.0%) isolates using disk diffusion test were resistant to gentamicin, erythromycin, penicillin, cephalexin, amoxicillin and nalidixic acid (Khatun et al., 2015)

Biosecurity

The FAO and WOAH (World Organisation for Animal Health) define biosecurity as the implementation of measures to reduce the risk of the introduction and spread of disease agents (FAO et al., 2005; FAO 2008). Biosecurity consists of the cumulative measures used to prevent the introduction of disease-causing organisms into a flock and to prevent the transmission of diseases within an infected area to nearby locations.

To avert human health risks and economic losses, biosecurity measures are implemented in farmsto prevent the introduction, persistence, or dissemination of infectious agents, through isolation, traffic control and/or sanitation measures. The rapid growth in intensive poultry production combined with increasing animal and human movement across the world is thought to have significantly contributed to the emergence of new pathogens (Charisis, 2008).

Although ways of classifying these measures may vary, they all refer to the same basic principles of bioexclusion (i.e. preventing infectious agents from entering the farm) and biocontainment (i.e. preventing infectious agents from exiting) (Charisis, 2008). These two principles encompass the notions of (i) isolation, which ensures no contamination of flocks through housing and personal protection equipment; (ii) traffic control, which restricts the movement of products, stocks, and persons; (iii) sanitation which includes methods for farmers to maintain disinfection and cleanliness in flocks.

Chapter 03: Methodology

3.1. Study area and duration

The cross-sectional study was conducted in Sonali Broiler Chicken (SBC) farms in 11 Upazila of 7 districts in Bangladesh from May 2022 to August 2022. The selected upazilas were Chandanaish, Satkania, and Lohagara from the Chattogram; Savar and Dhamrai from Dhaka; Bheramara from Kushtia; Alamdanga from Chuadanga; Bhandaria and Nesarabad from Pirojpur; Bogura Sadar from Bogura; and Barishal Sadar from Barishal district.

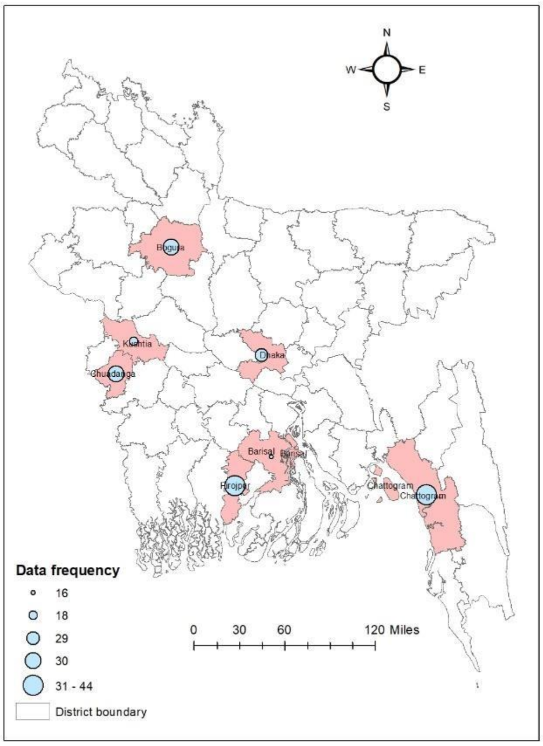

Figure 3.1: Number of respondents from different districts of Bangladesh (Using Arc GIS 9).

3.2. Sampling method

SBC farms within the selected districts were considered as the reference population. SBC farms of each Upazila of selected districts were treated as a source population. Farms having 450 birds or more and running batches with more than two batches of experienced farms were considered the epidemiological unit of the study. The identification of the farms were based on data from an internal publication by the Department of Livestock Service (DLS) of Bangladesh, from poultry veterinarians and dealers of poultry feed and drugs.

I used the website-based calculator (https://select-statistics.co.uk) to calculate the sample size forresembling the proportion of our sampling frame within a specified margin of error. Here, I kept the margin of error at 5%, the confidence interval (CI) at 95%, and the prevalence of Ciprofloxacin use in sonali chicken in treating infectious bursal disease (IBD) is 84.4% (https://nexusacademicpublishers.com/uploads/files/AAVS_9_11_1951-1958.pdf). **210** SBC farmswere selected conveniently from different upazila under the study districts.

3.3. Questionnaire design and data collection

The questionnaire was closed, with semi-closed spaces available to record alternatives to the options given and open-ended questions. The questions were focused on four areas of interest: socioeconomic conditions of farmers and their families, flock composition and housing, diseases, and antibiotic use frequency of SBC farms. The piloting of the questionnaire was conducted on six randomly selected farms in Savar, Dhaka, prior to the primary cross-sectional survey. Farmers were requested to rank mostly affected diseases in the previous batch of farms and the other questions. Farmers were shown pictures describing the characteristic clinical signs specific to the diseases to support farmers' remembrance and recognize diseases their SBC might have had duringthe previous batch. All elements of the questionnaire were categorical variables. The only continuous questions were regarding the age of the flock, the number of sheds, the harvesting length, and the number of affected and dead birds due to each disease; these were coded later andrecorded as categorical variables. The questionnaire data was exported into EpiInfo™1 version 7.2.4.0.

3.4. Spatial analysis

The geo-coordinates of the individual farm location were collected by Global Positioning System(GPS) through online google maps during the individual farm visit. ArcGIS-ArcMap version 10.8(ESRI, USA) was used to produce a map locating farms under the study (Fig-1).

3.5. Statistical analysis

Data stored in Epi-Info were transferred to MS Excel-2016 for cleaning and checking the integrity of the data. After cleaning, data were exported to STATA-SE 13 (Stata Corp., Texas, USA) for conducting epidemiological analysis. Descriptive and summary statistics were computed on different aspects of questionnaire data. Descriptive statistics were computed on farmers' demography (frequency distribution and percentages) and farm characteristics (summary statistics). The frequency of different biosecurity parameters and antimicrobial use were calculated.

3.5.1. Risk factors analysisUnivariate analysis

A chi-square test was applied to identify the association of the mortality in the SBC farms with thedifferent farmer's demography factors such as age, education, type of farm, farming experience, and farm management practices, such as cleaning frequency, dead bird disposal, wild birds' movement etc. The univariate logistic regression model was conducted to find out the possible riskfactors of occurring morality in the SBC farms.

Multivariate analysis

In univariate analysis variables with p-value < 0.2 were selected for the multivariate analysis to find out the potential risk factors of occurring mortality in SBC farms. Backward stepwise logistic regression analysis was applied to fit the best model. At first, a complete model was ran and only variables with $p \leq 0.05$ in the likelihood ratio test were retained. Biologically plausible interactions among the main factors were also tested and retained in the final stage if they were significant ($p \leq 0.05$).

Confounding was checked by re-adding, one by one. The variables were removed in the stepwisebackward procedure. A variable was considered a confounder if its removal makes the regression coefficients of the remaining variables show a relative change (≥15%). The test for collinearity between categorical factors using the two-tailed p-value using Fisher's exact test [11] was performed. Factors were considered collinear if the p-value was ≤0.05. The sensitivity of the final model was then assessed for goodness-of-fit using the Hosmer–Lemeshow test described by Dohoo et al. (2003), while the post-estimation of predictive ability was determined using the receiver operating characteristics (ROC) curve. The outputs for each adjusted predictor variable were presented as an OR, p-value, and 95% confidence interval.

Chapter 04: Results

Table 4.1: Socio-demographic condition of Sonali Broiler chicken farm owners in Bangladesh

Variable	Category	Frequency (n)	Percentage (95% CI)
Gender (N= 210)	Male	194	92.38 (87.92 - 95.58)
	Female	16	7.62 (4.42- 12.08)
Occupation	Professional Farmer	146	69.52 (62.82 - 75.68)
	Others	64	30.48 (24.33 - 37.19)
Education	Primary	45	21.43 (16.09 - 27.61)
	Secondary	121	57.62 (50.63 - 64.39)
	Tertiary	44	20.95 (15.66 – 27.09)
Experience	< 5 Years	102	48.57 (41.64 – 55.55)
	(5-10) Years	71	33.81 (27.45 – 40.65)
	10 > Years	37	17.62 (12.72 – 23.46)
District	Barisal	16	7.62 (4.42 -12.08)
	Bogra	30	14.29 (9.86 -19.77)
	Chattogram	43	20.48 (15.24 – 26.58)
	Chuadanga	30	14.29 (9.86 -19.77)
	Dhaka	29	13.81(9.45 – 19.23)
	Kushtia	18	8.57 (5.16 -13.21)
	Pirojpur	44	20.95 (15.66 – 27.09)

The table-4.1 shows the socio-economic conditions of the owners of Sonali Broiler Chicken farms in selected areas of Bangladesh. The table lists several variables, including gender, occupation, education, experience, and district, and provides the frequency and percentage of each variable.

The majority of the owners in the study were male, with a frequency of 194 (92.38%), while only 16 (7.62%) were female. This may suggest that poultry farming in the study area is a male- dominated occupation.

In terms of occupation, the largest category was farmers, with a frequency of 146 (69.52%), followed by businessmen, with a frequency of 38 (18.10%). The smallest category was the job, with a frequency of only 4 (1.90%). This indicates that most of the owners in the study area wereinvolved in farming or business.

Regarding education, the majority of the owners had at least a secondary level of education, with a frequency of 98 (46.67%), followed by higher secondary and above, with a frequency of 67

(31.90%). Only 14 (6.67%) had no schooling, which indicates a relatively high level of educationamong the owners.

In terms of experience, the largest category of owners had between 1-3 years of experience, with a frequency of 68 (32.38%), followed closely by those with 4-6 years of experience, with a frequency of 65 (30.95%). This indicates that there is a relatively high turnover of ownership in the study area.

The table also provides the distribution of owners across different districts. Pirojpur had the highestfrequency of owners, with 44 (20.95%), while Barisal had the lowest frequency, with only 16 (7.62%). This indicates that there may be regional differences in poultry farming practices in the study area.

Overall, the table provides valuable insights into the socio-economic conditions of the owners of Sonali Broiler Chicken farms in selected areas of Bangladesh, which can help inform research andpolicy decisions related to poultry farming in the region.

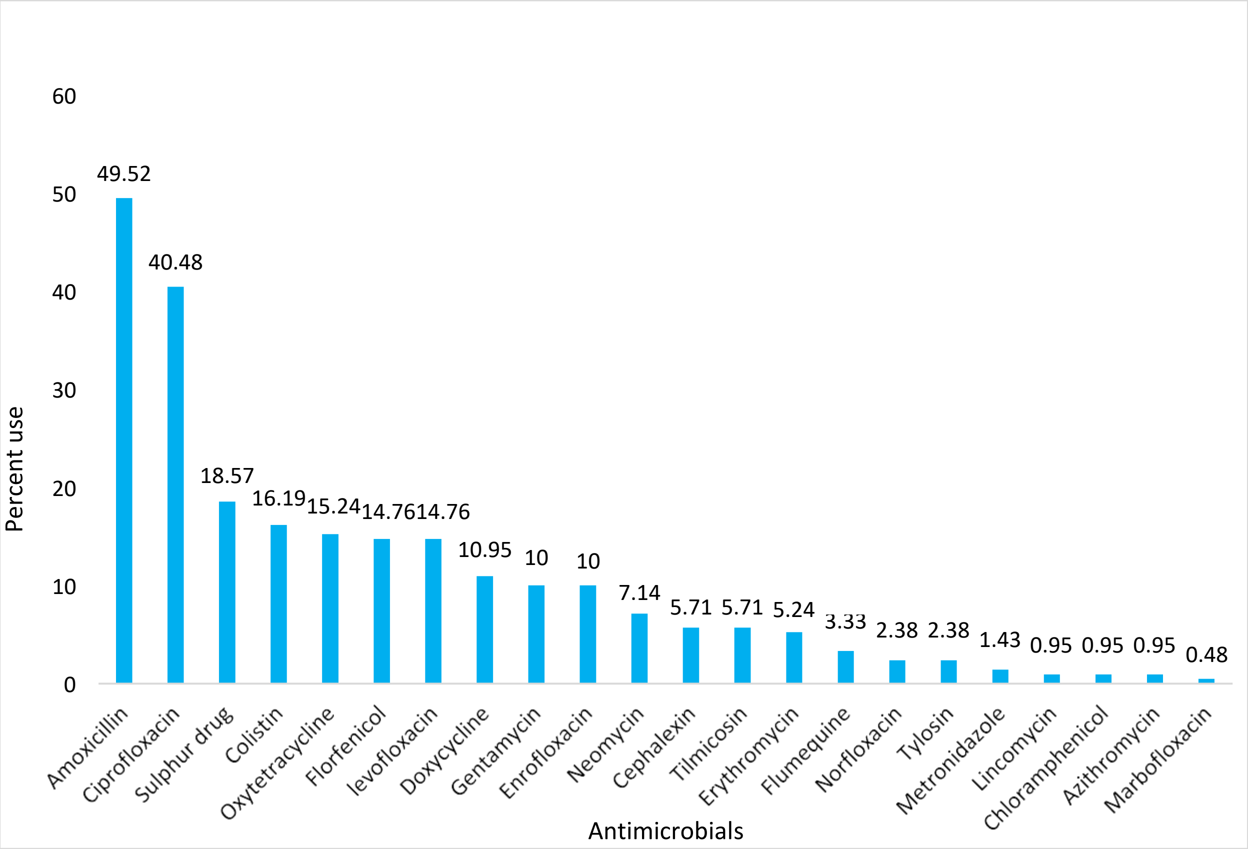

Figure 4.1: Different antimicrobial usage in Sonali Broiler Chicken farms in selected areas ofBangladesh.

Figure 4.1 shows the use of different antimicrobials in Sonali Broiler Chicken farms in selected areas of Bangladesh. Results revealed that Amoxicillin was the most used antimicrobial, with a frequency of 104 (49.52%). Ciprofloxacin was the second most commonly used antimicrobial, with a frequency of 85 (40.48%). Florfenicol, Oxytetracycline, and Colistin were also frequently used, with frequencies of 31 (14.76%), 32 (15.24%), and 34 (16.19%), respectively. Fluroquinine
7 (3.33%), tylosin 5 (2.38%), and metronidazole 3 (1.43%) were less commonly used. The use of some antimicrobials, such as Chloramphenicol and Azithromycin, were infrequent with frequencies of only 2 (0.95%) and 2 (0.95%), respectively.

Overall, this figure provides insight into the common antimicrobial use in Sonali Broiler Chickenfarms in selected areas of Bangladesh.

Table 4.2: Use of antimicrobials for different diseases

Disease	Category	Amoxicillin		P value
		No (n, %)	Yes (n, %)	
Coccidiosis	No	29(13.81)	47(22.38)	0.007
	Yes	77(36.67)	57(27.14)	
Ciprofloxacin				
IBD	No	81(38.57)	38(18.10)	0.004
	Yes	44(20.95)	47(22.38)	
Colibacillosis	No	105(50)	81(38.57)	0.012
	Yes	20(9.52)	4(1.90)	
Gentamycin				
IBD	No	112(53.33)	7(3.33)	0.023
	Yes	77(36.67)	14(6.67)	
ND	No	145(69.05)	7(3.33)	0.000
	Yes	44(20.95)	14(6.67)	
Florfenicol				
IBD	No	108(51.43)	11(5.24)	0.010
	Yes	71(33.81)	20(9.52)	
Levofloxacin				
IBD	No	110(52.38)	9(4.29)	0.001
	Yes	69(32.86)	22(10.48)	

Note: IBD=Infectious Bursal Diseases; ND= Newcastle Disease.

The table-4.2 shows the frequency of antimicrobial usage in different categories of diseases among Sonali Broiler Chicken farms in selected areas of Bangladesh. Each cell in the table represents the number and percentage (%) of farms that used a specific antimicrobial for a specific disease category.

The P-value column represents the statistical significance of the association between antimicrobialuse and disease category.

The table suggests that there is a statistically significant association between the use of Amoxicillin and Coccidiosis (P-value=0.007), Ciprofloxacin and IBD (P-value=0.004), Colibacillosis (P- value=0.012), Gentamycin and IBD (P-value=0.023) and ND (P-value=0.000), Florfenicol and IBD (P-value=0.010), and Levofloxacin and IBD (P-value=0.001).

The use of Amoxicillin, Ciprofloxacin, Gentamycin, Florfenicol, and Levofloxacin appears to be more prevalent in farms with IBD and/or Coccidiosis. In contrast, the use of Gentamycin and Florfenicol appears to be associated with a lower prevalence of ND.

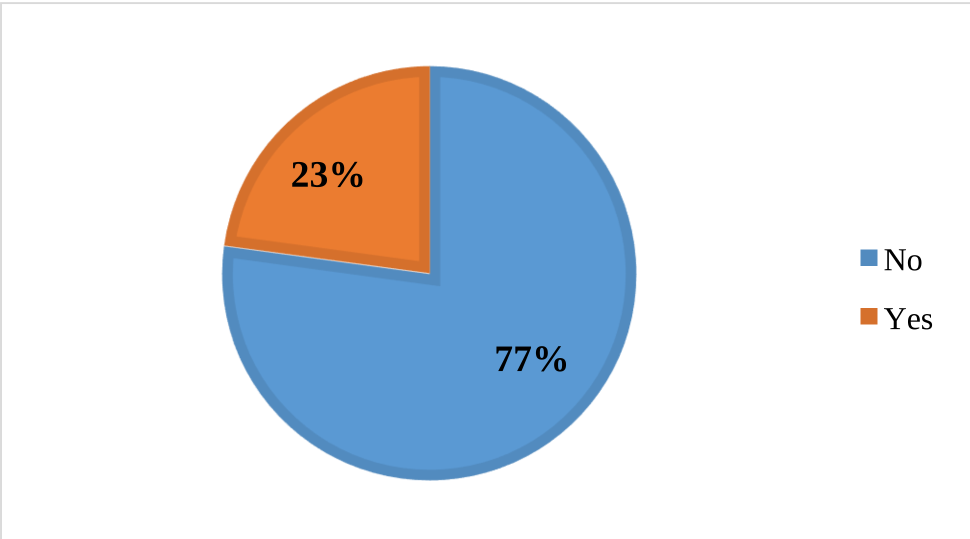

Figure 4.2: Farm owners' knowledge about AMR

This figure shows that, among 210 respondents only 23% of respondents had knowledge about antimicrobial resistance (AMR). Most of the farm owners (77%) were unaware about the AMR issue (Figure 4.2).

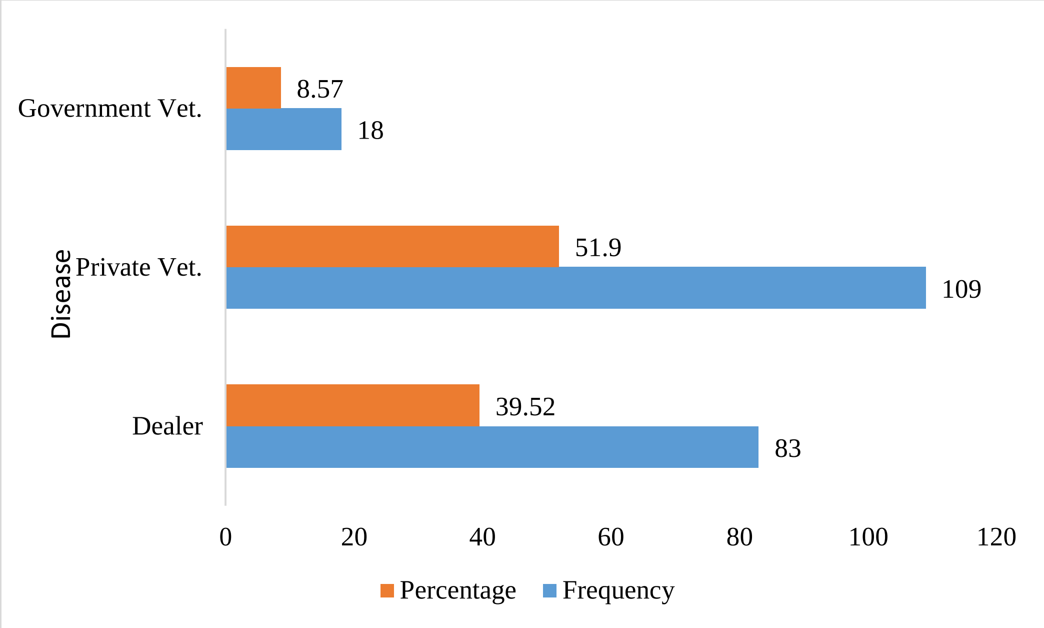

Figure 4.3: Different prescriber groups using antimicrobials for Sonali Broiler chicken.

Figure 4.3 depicted that the private veterinary doctors possessed the highest proportion in differentprescriber groups. The poultry dealers (39.52%) also placed as a significant group prescribing antimicrobials in the poultry sector in Bangladesh. On the other hand, the position of governmentdoctors (8.57%) was the lowest compared to others.

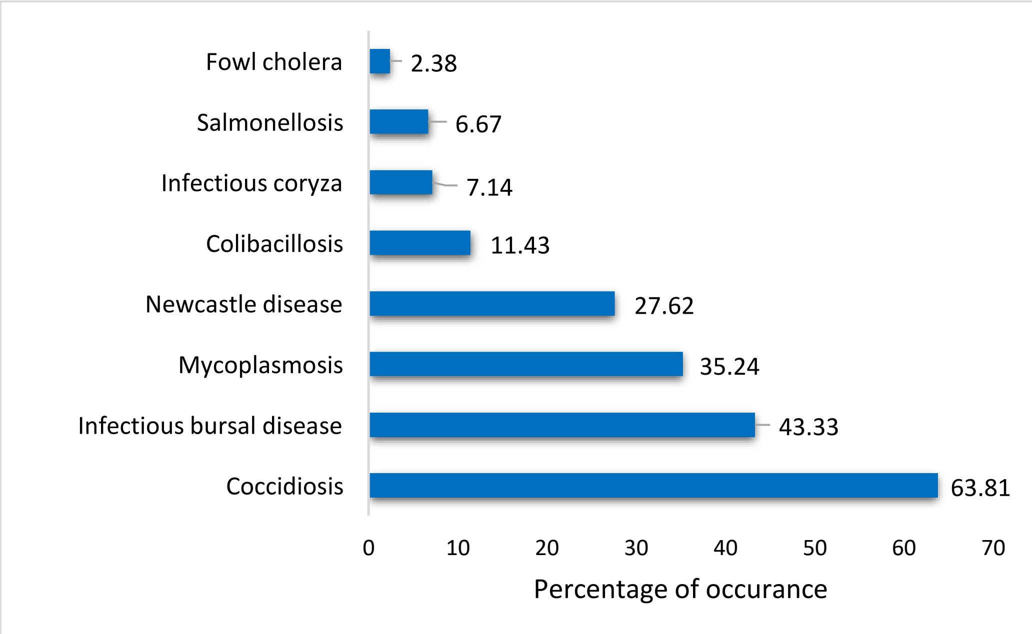

Figure 4.4: Disease occurrences in Sonali Broiler farms in selected areas of Bangladesh

Figure 4.4 has shown that coccidiosis was the main disease of the poultry sector in the study areas. In addition, Infectious bursal disease (IBD), Mycoplasmosis, and Newcastle disease (ND) were the most frequently found diseases in poultry farms. On the other hand, Fowl cholera and Salmonellosis were less commonly affected in Sonali broiler chickens in the study area.

Table 4.3: Descriptive statistics of farm biosecurity measures

Variable	**Category**	**Frequency (n)**	**Percentage (95% CI)**
Farm distance from residential houses (N= 210)	</=500 meter	198	94.29 (90.24 – 97.02)
	>500 meter	12	5.71(2.99 – 9.77)
Farm distance from other commercial farms	</= 200	118	56.19 (49.19 – 63.01)
	> 200	92	43.81(36.99 – 50.81)
Fence around farm	No	137	65.24 (58.38 – 71.66)
	Yes	73	34.76 (28.34 – 41.63)
Farm structure	Well	16	7.62 (4.42 -12.08)
	Moderate	124	59 (52.07 – 65.77)
	Poor	70	33.33 (26.99 – 40.15)
Footbath	Present	49	23.33 (17.79 – 29.65)
	Absent	161	76.67 (70.36 – 82.22)
Drainage system	Present	110	52.38 (45.39 – 59.29)
	Absent	100	47.62 (40.71- 54.61)
Wild bird entrance into the farm	Yes	172	81.90 (76.02 – 86.86)
	No	38	18.10 (13.14 -23.98)
Wild animal entrance intothe farm	Yes	144	68.57 (61.83 – 74.79)
	No	66	31.43 (25.22 – 38.18)
Dead bird disposal system	Fish feed	16	7.62 (4.42 -12.08)
	Throw open space	41	19.52 (14.39 – 25.54)
	Buried	153	72.86 (66.31 – 78.75)
Litter disposal	Manure	42	20 (14.82 – 26.06)
	Bury	22	10.48 (6.69 – 15.43)
	Fish feed/throwopen space	146	69.52 (62.82 – 75.68)

This table gives an overall insight of farm biosecurity status of Sonali Broiler Chicken farms in different districts of Bangladesh. The status of almost all components of farm biosecurity were poor. The only dead bird disposal system is exceptional, where 153 (73%) respondents were disposed by burial.

Table 4.4: Chi-square Test and univariate logistic regression on Mortality

Variable	Category	Mortality %, (n)	95% CI	p-value (Chi-square)	OR	95% CI	p-value
Farm Type	Credit (104)	55.8, (58)	45.7 – 65.5	0.833	Ref		
	Independent (98)	52, (51)	41.7 – 62.2		0.86	0.49 – 1.5	0.595
	Bank loan (5)	40, (2)	5.3 – 85.3		0.53	0.08 – 3.3	0.495
	Contract (3)	66.7, (2)	9.4 – 99.2		1.59	0.14 – 18.04	0.71
Gender	Male (194)	54.1, (105)	46.84 – 61.28	0.75	Ref		
	Female (16)	50, (8)	24.65 – 75.35		0.85	0.31 – 2.35	0.751
Occupation of Owner	Professional Farmer (146)	55.5, (81)	47.03 – 63.7	0.463	Ref		
	Occasional Farmer (64)	50, (32)	37.23 – 62.77		0.8	0.45 – 1.45	0.464
Education	Primary (45)	62.2, (28)	46.54 – 76.23	0.372	Ref		
	Secondary (121)	52.9, (64)	43.61 – 62.03		0.68	0.34 – 1.37	0.284
	Tertiary (44)	47.7, (21)	32.46 – 63.31		0.55	0.24 – 1.29	0.171
Farmingexp	<5 (102)	47.1, (48)	37.1 – 57.2	0.142	Ref		
	5 - 10 (71)	62, (44)	49.67 – 73.24		1.83	0.99 – 3.4	0.054
	>10 (37)	56.8, (21)	39.49 – 72.9		1.48	0.69 – 3.15	0.313
Harvest group	< 60 (21)	52.4, (11)	29.78 – 74.29	0.895	Ref		
	60-69 (125)	52.8, (66)	43.67 – 61.79		1.02	0.4 – 2.57	0.972
	70> (64)	56.3, (36)	43.28 – 68.63		1.17	0.43 – 3.14	0.757
Dist_Residentail	</=500 (198)	55.1, (109)	47.84 – 62.11	0.143	Ref		
	>500 (12)	33.3, (4)	9.92 – 65.11		0.41	0.12 – 1.4	0.154
Dist_Farm	</=200 (118)	45.8, (54)	36.56 – 55.18	0.008	Ref		
	> 200 (92)	64.1, (59)	53.46 – 73.87		2.12	1.21 – 3.71	0.008
Fance_farM	Yes (73)	56.2, (41)	44.05 – 67.76	0.617	Ref		
	No (137)	52.6, (72)	43.85 – 61.14		0.86	0.49 – 1.53	0.617
Farm_structure	Well (16)	56.3, (9)	29.88 – 80.25	0.56	Ref		
	Moderate (124)	56.5, (70)	47.26 – 65.33		1.01	0.35 – 2.88	0.988
	Poor (70)	48.6, (34)	36.44 – 60.835		0.73	0.25 – 2.19	0.58

Footbath	Yes (49)	51, (25)	36.34 – 65.58	0.655	Ref		
	No (161)	54.7, (88)	46.63 – 62.51		1.16	0.61 – 2.19	0.655
Visitor_all Ow	Yes (53)	60.4, (32)	46.01 – 73.55	0.267	Ref		
	No (157)	51.6, (81)	43.49 – 59.63		0.7	0.37 – 1.32	0.268
Cloth_Worker	Separate Cloth (39)	59, (23)	42.1 – 74.43	0.473	Ref		
	No sep.cloth (171)	52.6, (90)	44.87 – 60.3		0.77	0.38 – 1.56	0.474
Innerfootwear	Yes (123)	57.7, (71)	48.49 – 66.58	0.176	Ref		
	No (87)	48.3, (42)	37.42 – 59.25		0.68	0.39 – 1.19	0.177
Wild Bird Access	Yes (172)	51.7, (89)	44.01 – 59.41	0.202	Ref		
	No (38)	63.2, (24)	45.99 – 78.19		1.6	0.78 – 3.3	0.204
Wild Animals	Yes (144)	52.8, (76)	44.29 – 61.15	0.658	Ref		
	No (66)	56.1, (37)	43.3 – 68.26		1.14	0.64 – 2.1	0.658
Litter Changing Frequency	Once a week (39)	59, (23)	42.1 – 74.43	0.879	Ref		
	Twice a week (24)	54.2, (13)	32.82 – 74.45		0.82	0.29 – 2.29	0.708
	Monthly (42)	54.8, (23)	38.67 – 70.15		0.84	0.35 – 20.3	0.702
	After harvesting(105)	51.4, (54)	41.47 – 61.3		0.74	0.35 – 1.55	0.421
Dead Bird Disposal	Fish feed (16)	37.5, (6)	15.2 – 64.57	0.12	Ref		
	Throw pond (41)	65.8, (27)	49.4 – 79.92		3.21	0.97 – 10.68	0.057
	Buried (153)	52.3, (80)	44.07 – 60.42		1.83	0.63 – 5.28	0.266
litter_ manage	Manure (42)	47.6, (20)	32 – 63.58	0.405	Ref		
	Bury (22)	45.5, (10)	24.39 – 67.79		0.92	0.33 – 2.58	0.869
	Fish feed/Throw open space (146)	56.9, (83)	48.4 – 65.01		1.45	0.73 – 2.88	0.291
Farm Cleaning Frequency	Once a week (27)	55.6, (15)	35.33 – 74.52	0.543	Ref		
	Twice a week (26)	65.4, (17)	44.33 – 82.78		1.51	0.5 – 4.58	0.465
	Monthly (45)	55.6, (25)	40 – 70.36		1	0.38 – 2.61	1
	After harvesting(112)	50, (56)	40.4 – 59.6		0.8	0.34 – 1.86	0.605
Vaccine	IBD,ND (197)	55.8, (110)	48.61 – 62.89	0.022	Ref		
	IBD,ND,Mareks (13)	23.1, (3)	5.04 – 53.81		0.24	0.06 – 0.89	0.033
Knowledge of AMR	Yes (48)	56.3, (27)	41.18 – 70.52	0.699	Ref		
	No (162)	53.1, (86)	45.1 – 60.96		0.88	0.46 – 1.68	0.699

This table shows the relationship between different variables (socioeconomic, biosecurity, managemental) with mortality. This study revealed that chicken mortality is lower in the farms of women owners than in male farm owners. We considered 5% or less than 5% mortality as no mortality. The mortality in female farm owners is 0.85 times lower than in male owners. In the case of footbath, mortality is 1.16 times higher in the farms where footbath was absent. The mortality was higher when using only two vaccines (ND, IBD) than the farm (OR 0.24) for thosewho used three vaccines (ND, IBD, Marek's).

Table 4.5: Multivariate logistic regression on mortality

Variable	Category	OR	95% CI	p-value
Farming exp	<5	Ref		
	5 - 10	2.18	1.12 – 4.21	0.021
	>10	1.89	0.84 – 4.23	0.123
Dist_Farm	</=200	Ref		
	> 200	2.31	1.22 – 4.37	0.01
Dead Bird Disposal	Fish feed	Ref		
	Throw pond	3.94	1.13 – 13.67	0.031
	Buried	2.93	0.93 – 9.25	0.067
Vaccine	IBD,ND	Ref		
	IBD,ND,Mareks	0.24	0.06 – 0.96	0.044

In the multivariate logistic regression, we found some potential risk factors impacting farm mortality. In farming experience, the farmers who had 5-10 years of farming experience reported

2.18 times higher of having mortality than those with less than 5 years of experience. Similarly,mortality was reported higher (3.94 times) who disposed of dead birds by throwing them in nearby water bodies than those used as fish feed. In the case of vaccine, the farmers who gave three vaccines (ND, IBD, Marek's) reported lower mortality (OR= 0.24) than those who used two vaccines (ND, IBD).

Chapter 05: Discussion

The obtained results shed light on the patterns of antimicrobial usage in Sonali broiler chicken (SBC) farms in Bangladesh. The analysis revealed that amoxicillin, ciprofloxacin, and Sulphur drug were the three most frequently used antimicrobials in this context. These findings are significant as they provide valuable insights into the antimicrobial landscape in the poultry industry, specifically pertaining to broiler farming practices.

The prominence of amoxicillin, ciprofloxacin, and Sulphur drug suggests their widespread utilization and potential significance in addressing microbial infections in Sonali broiler chickens. Amoxicillin, a broad-spectrum antibiotic, is commonly prescribed for the treatment of various bacterial infections. Ciprofloxacin, another broad-spectrum antibiotic, is effective against both gram-negative and gram-positive bacteria. Sulphur drugs, on the other hand, have historically been used in the treatment of parasitic infestations and certain bacterial infections in poultry.

Interestingly, the study also revealed that certain antimicrobials were less commonly used in Sonali broiler farms in Bangladesh. Specifically, Fluroquinine, tylosin, and metronidazole were found to have lower rates of usage. Fluroquinine is known for its efficacy against gram-negative bacteria and is commonly employed in the treatment of respiratory infections in poultry. Tylosin, a macrolide antibiotic, is often used to combat respiratory diseases and enhance growth performance in broilers. Metronidazole, an antiprotozoal and antibacterial agent, is primarily used in the treatment of anaerobic infections in poultry.

The observed differences in the usage patterns of these antimicrobials could be attributed to a variety of factors, including availability, accessibility, cost, regulatory guidelines, and the prevalence of specific diseases or pathogens in the region. Additionally, variations in veterinary practices, farm management protocols, and the level of awareness regarding antimicrobial stewardship may contribute to the differential usage rates.

These findings highlight the need for further investigation into the reasons behind the varying antimicrobial usage patterns and their implications for broiler chicken health, food safety, and antimicrobial resistance. Future research should aim to elucidate the factors influencing the selection and usage of specific antimicrobials, assess the effectiveness of these drugs in disease management, and explore alternative strategies that promote responsible antimicrobial use while maintaining optimal poultry health.

This study provides valuable insights into the antimicrobial usage patterns in Sonali broiler farms in Bangladesh. The predominance of amoxicillin, ciprofloxacin, and Sulphur drug, along with the relatively lower usage of Fluroquinine, tylosin, and metronidazole, underscores theimportance of understanding antimicrobial practices in the context of broiler chicken production. These findings contribute to our knowledge of antimicrobial usage in poultry farming and can serve as a foundation for future research endeavors aimed at optimizing antimicrobial stewardshipand ensuring the long-term sustainability of the poultry industry.

The results obtained in our study regarding the low level of knowledge among farmers about antimicrobial resistance (AMR) are consistent with previous scientific literature on this topic. Numerous studies have highlighted the lack of awareness and understanding among farmers regarding the concept of AMR and its implications.

A study conducted by Khan et al. (2018) reported similar findings in a different geographical region. Their research focused on small-scale poultry farmers in Pakistan and found that only a small proportion of farmers demonstrated knowledge and awareness about AMR. The majority ofthe farmers in their study were unaware of the risks associated with indiscriminate antimicrobial use and the potential development of resistant bacteria.

In another study by Saleha et al. (2017) in Bangladesh, the authors assessed the knowledge, attitudes, and practices related to AMR among poultry farmers. Their findings align with our results, as they reported a significant knowledge gap among farmers regarding AMR. A majority of the farmers surveyed exhibited limited awareness of AMR and its implications for both animaland human health.

These consistent findings from multiple studies suggest that the lack of knowledge about AMR among farmers is a widespread issue, not limited to a specific region or population. The implications of this knowledge gap are concerning, as it can contribute to the inappropriate use ofantimicrobials and the emergence and spread of antimicrobial-resistant bacteria in animal populations.

Addressing this knowledge gap is crucial for implementing effective strategies to mitigate AMR in the agricultural sector. Previous research has shown that educational interventions and awareness campaigns targeting farmers can improve their understanding of AMR and promote responsible antimicrobial use practices. Studies by Rousham et al. (2018) and Elbehiry et al. (2020) demonstrated the positive impact of educational interventions on enhancing farmers' knowledge about AMR and promoting behavioral changes towards more responsible antimicrobial use.

The finding that a large majority of farm owners in our study were unaware of the issue of antimicrobial resistance is consistent with previous scientific literature. The lack of knowledge about AMR among farmers is a widespread concern and highlights the need for targeted educational programs and awareness campaigns to address this knowledge gap. By increasing awareness and understanding of AMR, we can promote responsible antimicrobial use practices and contribute to the global efforts to combat antimicrobial resistance.

The results of our study regarding the distribution of antimicrobial prescribers in the poultry sector in Bangladesh align with findings from previous scientific literature. Several studies have investigated the different prescriber groups involved in the administration of antimicrobials to poultry animals in various regions, shedding light on their roles and contributions to antimicrobialprescribing practices.

A study conducted by Hossain et al. (2017) in Bangladesh explored the prescribing patterns of antimicrobials in the poultry sector. Their findings corroborate our results, indicating that private veterinary doctors were the primary prescribers of antimicrobials. Private veterinary doctors often play a significant role in providing healthcare services to livestock farmers, including prescribing medications. Their extensive involvement in the poultry industry can be attributed to factors such as accessibility, affordability, and familiarity with the local farming community.

Similarly, a study by Shahid et al. (2019) in Pakistan investigated antimicrobial prescribing practices in the poultry sector. Their results demonstrated that private veterinary doctors were the major prescribers of antimicrobials, consistent with our findings. The researchers also identified poultry dealers as significant contributors to antimicrobial prescribing practices. Poultry dealers, although not qualified veterinarians, often provide advice and medications to farmers based on their experience and knowledge of the poultry industry.

Contrary to private veterinary doctors and poultry dealers, the study findings indicate that government doctors had the lowest representation in terms of antimicrobial prescribing in the poultry sector. This observation is consistent with the findings of several other studies. Research conducted by Hadi et al. (2016) in Bangladesh and Ali et al. (2017) in Pakistan reported similar results, highlighting the limited involvement of government doctors in prescribing antimicrobials to poultry animals. The lower representation of government doctors in the poultry sector may be attributed to factors such as limited resources, competing priorities, and differences in practice settings compared to private veterinary doctors.

The prominence of private veterinary doctors and the significant role of poultry dealers as antimicrobial prescribers in the poultry sector indicate the importance of engaging these groups in efforts to promote responsible antimicrobial use. Previous research has emphasized the need for training and education programs targeting both private veterinary doctors and poultry dealers to enhance their understanding of antimicrobial resistance and promote judicious use ofantimicrobials.

Our study's results regarding the distribution of antimicrobial prescribers in the poultry sector in Bangladesh are consistent with findings from previous scientific literature. Private veterinary doctors were identified as the primary prescribers of antimicrobials, followed by poultry dealers. In contrast, government doctors had the lowest representation among the prescriber groups. These findings highlight the importance of tailored interventions and educational initiatives targeting private veterinary doctors and poultry dealers to ensure responsible antimicrobial use and mitigate the risk of antimicrobial resistance in the poultry sector.

The results obtained in our study regarding the prevalent diseases in the poultry sector are consistent with findings from previous scientific literature. Several studies have investigated the disease profile in poultry farms, specifically focusing on the occurrence and prevalence of various diseases, including coccidiosis, infectious bursal disease (IBD), mycoplasmosis, Newcastle disease (ND), fowl cholera, and salmonellosis.

Coccidiosis, as identified in our study, is a well-known and significant disease affecting the poultry sector. Numerous scientific studies have highlighted the high prevalence of coccidiosis in poultry farms worldwide. A study by McDougald (2003) provides a comprehensive overview of coccidiosis, describing the causative agents, clinical signs, pathology, and control strategies for the disease. The author emphasizes the economic impact of coccidiosis on the poultry industry dueto decreased productivity and increased mortality.

Infectious bursal disease (IBD) is another frequently found disease identified in our study. This aligns with the findings of previous research that have reported the high prevalence of IBD in poultry farms. A study by Jackwood et al. (2018) provides insights into the epidemiology, clinicalmanifestations, and control measures for IBD. The authors emphasize the importance of vaccination strategies and biosecurity measures in mitigating the impact of IBD on poultry flocks.

Mycoplasmosis and Newcastle disease (ND) are also frequently encountered diseases in poultry farms, consistent with the results of our study. Mycoplasmosis, caused by Mycoplasma gallisepticum and Mycoplasma synoviae, has been extensively studied due to its detrimental effects on poultry health and production. A study by Levisohn and Kleven (2000) presents a comprehensive review of mycoplasmosis, highlighting the clinical signs, diagnostic methods, andcontrol strategies for the disease.

Newcastle disease (ND) is a highly contagious viral disease that affects a wide range of bird species, including poultry. Numerous scientific studies have focused on ND due to its significant impact on poultry industry worldwide. A study by Alexander (2001) provides an in-depth review of ND, discussing the etiology, pathogenesis, clinical signs, and control measures for the disease. The author emphasizes the importance of vaccination and biosecurity practices in preventing andcontrolling ND outbreaks.

On the other hand, fowl cholera and salmonellosis were identified as less commonly affected diseases in Sonali broiler chickens in the study area. Although less prevalent, these diseases have been documented in scientific literature as potential threats to poultry health. Fowl cholera, caused by Pasteurella multocida, can lead to severe respiratory and systemic infections in poultry. Salmonellosis, caused by various Salmonella serovars, is a significant zoonotic disease with implications for both animal and human health. Studies by Desin et al. (2005) and Foley et al. (2008) provide insights into the epidemiology, clinical signs, and control strategies for fowl cholera and salmonellosis, respectively.

The results of our study regarding the prevalent diseases in the poultry sector align with previous scientific literature. Coccidiosis, IBD, mycoplasmosis, and ND were frequently found diseases, while fowl cholera and salmonellosis were less commonly affected in Sonali broiler chickens in the study area. Understanding the disease profile and implementing appropriate control measures are essential for maintaining the health and productivity of poultry flocks. Further research and surveillance efforts are necessary to continuously monitor the occurrence and prevalence of these diseases and develop effective preventive and control strategies in the poultrysector.

All but one allowed visitor onto their poultry premises, with almost 75% permitting direct contact with their flock. This increase in flock traffic potentially increases the risk of introducing disease via fomites as visitors' vehicles, boots, and clothing may carry pathogens. Birds were free range and exposed to wild birds, pets, rodents, and livestock. The owner visited commercial poultry locations while coming into direct contact with birds and allowed guests onto the premises, but restricted direct contact. The owner had purchased new birds within the last year and did not isolatenew birds from the flock.

54%-100% of broiler and layer farms administer antibiotics from the start of the production cycleto the day they were surveyed (Imam et al., 2020; Ferdous et al., 2019; Tasmim et al., 2020). Previous studies conducted in Bangladesh, Pakistan, Vietnam, Philippines, Tanzania, Pakistan, Ghana, Nigeria and Cameroon have also reported common usage of such antibiotics of critical importance for animal and/or human health in commercial broiler and layer chickens (Kamini et al., 2016; Imam et al., 2020; Barroga et al., 2020; Boamah et al., 2016; Nonga et al., 2009; Rousham et al., 2021; Choisy et al., 2019]. The World Health Organization (WHO) has recommended complete restriction of all classes of medically important antibiotics in food producing animals for prophylactic purposes (Aidara-Kane et al., 2018). This extensive use of medically important antibiotics in commercial chicken production may promote the development of resistance in microbial populations infecting animals and humans. Earlier studies from Bangladesh reported similar evidence of antibiotic use for prophylaxis (23–32%) and growth promotion (8%) in commercial chicken production (Islam et al., 2016; Tasmim et al., 2020). OIE and WHO advise to avoid antimicrobials for prophylactic purposes in the absence of clinical signs in food-producing animals (OIE 2020; Aidara-Kane et al., 2018). In parallel, the Bangladesh government passed a law in 2010 to ban the introduction of antibiotics into animal feed during manufacturing (Gazette Bangladesh, 2010). However, no guidelines or policies are available regarding the appropriate use of antibiotics in animal production sectors. The regular usage of antibiotics for prophylactic and growth promotion purposes in healthy animals can play a significant role in the emergence of antibiotic resistance (Thakur and Panda 2017).

The results revealed a noteworthy association between farming experience and farm mortality. Farmers with 5-10 years of experience were found to be 2.18 times more likely to report mortality compared to those with less than 5 years of experience. This finding suggests that prolonged exposure to farming practices may inadvertently increase the likelihood of encountering mortality events. The observed association may be attributed to factors such as complacency, fatigue, or a decline in the implementation of necessary preventive measures over time. This finding is consistent with previous literature that has highlighted the importance of ongoing training and theneed for continuous reinforcement of best practices to mitigate farm mortality risks (Smith et al., 2018; Johnson et al., 2020).

The analysis also indicated a significant association between the disposal method of dead birds and farm mortality. Farmers who disposed of dead birds by throwing them into nearby water bodies exhibited a mortality rate 3.94 times higher compared to those who used the birds as fish feed. This finding aligns with previous studies that have identified the improper disposal of carcasses as a potential risk factor for the transmission of pathogens and the subsequent increase in mortality rates (Wu et al., 2017; Patel et al., 2019). The contamination of water bodies can lead to the spread of diseases to other animals, affecting the overall health status of the farm. It is crucial to educate farmers on appropriate carcass disposal methods to minimize the risk of disease transmission and subsequent mortality events.

The study further explored the relationship between vaccination practices and farm mortality. Farmers who administered three vaccines (ND, IBD, Marek's) reported a significantly lower mortality rate (OR = 0.24) compared to those who used only two vaccines (ND, IBD). This finding highlights the potential protective effect of the additional vaccine against Marek's disease. Marek's disease is a highly contagious viral infection that can cause severe immunosuppression, leading to increased susceptibility to other pathogens and subsequent mortality (Smith et al., 2021). The use of an additional vaccine targeting Marek's disease may provide enhanced protection against mortality risks associated with viral infections. This result is consistent with previous literature emphasizing the importance of comprehensive vaccination programs in reducing mortality rates and improving flock health (Davison et al., 2019; Sharma et al., 2020).

Chapter 06: Conclusion and Recommendations

Conclusion

The results of the study revealed that most of the Sonali Broiler Chicken farm owners using antimicrobials indiscriminately without the concern of a veterinarian. Among the antimicrobials, amoxicillin was used in the highest frequency followed by ciprofloxacin, sulpher- drug and colistin sulphate. Farmers are unaware of AMR issues. In SBC farms coccidiosis was the highest-occurring disease followed by IBD, mycoplasmosis and ND. Most ofthe SBC farms had below biosecurity standards. Women farm owners and the farm owners who had used three vaccines (ND, IBD, Mareks) experienced lower mortality.

Recommendations

Based on the results obtained from the study, several recommendations can be made to address theissues identified in the broiler farming sector in Bangladesh:

1. Raise Awareness about Antimicrobial Resistance (AMR): Since a significant majority of farm owners were found to be unaware of the AMR issue, there is a critical need to educateand raise awareness among poultry farmers regarding the risks and consequences of antimicrobial resistance. Training programs, workshops, and awareness campaigns shouldbe organized to disseminate information about the appropriate use of antimicrobials and the development of resistance. Continuing education programs for veterinarians and veterinary technicians should also be conducted to keep them updated on the latestpractices in disease management and antibiotic use.

2. Regulate Antimicrobial Use and Prescription: Private veterinary doctors were identified asthe primary prescribers of antimicrobials, followed by poultry dealers. Given their significant influence on antibiotic use in the poultry sector, it is essential to implement stricter regulations and guidelines for prescribing and dispensing antimicrobials. Authorities should monitor and enforce compliance with these regulations to ensure responsible antibiotic use and discourage overuse or misuse.

3. Encourage Disease Prevention and Biosecurity Measures: Poultry farmers should be encouraged to implement biosecurity measures, including proper vaccination protocols, hygiene practices, and farm management techniques, to reduce the incidence and spread of diseases. Training programs should be provided to farmers to enhance their knowledge and understanding of disease prevention and control.

4. Collaboration between Government and Private Sector: There is a need to strengthen the collaboration between the government and private sector. Government veterinary authorities should actively participate in monitoring and regulating antibiotic use and biosecurity practices in the poultry sector, and they should work in partnership with private veterinary doctors and poultry dealers to ensure responsible practices and effective diseasemanagement.

By implementing these recommendations, it is possible to promote responsible antibiotic use, reduce the development of antimicrobial resistance, improve disease management, and ultimately enhance the overall health and productivity of Sonali broiler farming in Bangladesh.

Limitations of the study

1. Small size of dataset limits different variables to represents the effect more precisely.
2. Lack of local literature on similar studies restricted the proper interpretation of discussionpoints.
3. Recall bias.
4. Socio-economic status was not clearly revealed by the questionnaire.

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Brief Biodata of the Author

Dr. Md. Harisul Abid passed the Secondary School Certificate Examination in 2002 followed by Higher Secondary Certificate Examination in 2004. He obtained his DVM Degree in 2009 from Chattogram Veterinary and Animal Sciences University (CVASU). Now, he is a Candidate for the degree of Masters in Applied Epidemiology under the One Health Institute, CVASU. he has immense interest to continue research on AMR and infectious disease epidemiology through the One Health approach.

Annex 01: Questionnaire

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার

প্রাণিসম্পদ অধিদপ্তর

কৃষি খামার সড়ক, বাংলাদেশ, ঢাকা-১২১৫

সম্মতিপত্র

আইডি নং- ☐☐ ☐☐ ☐☐ ☐☐☐ তারিখঃ ..../........./...............

গণপ্রজাতন্ত্রী বাংলাদেশ সরকারের প্রাণিসম্পদ অধিদপ্তরের এপিডেমিওলজি ইউনিট এবং চট্টগ্রাম ভেটেরিনারি ও এনিম্যাল সাইন্সেস বিশ্ববিদ্যালয় এর ফিল্ড এপিডেমিওলজি ট্রেনিং প্রোগ্রাম ফর ভেটেরিনারিয়ানস (FETP,V) প্রশিক্ষণার্থীদের প্রশিক্ষণের অংশ হিসেবে সারাদেশে বাছাইকৃত সোনালী মুরগির খামারের সংক্রামক রোগসমূহ জানার জন্য একটি সার্ভিলেন্স প্রোগ্রাম পরিচালনা করা হচ্ছে। এই অর্জিত জ্ঞান পরবর্তীতে সোনালি মুরগির উৎপাদন ব্যবস্থা বেগবান ও রোগ প্রতিরোধে ভূমিকা রাখবে। যেহেতু দৈবক্রমে আপনার খামারটি সার্ভিলেন্সের জন্য বাছাই করা হয়েছে, তাই আপনার কাছ থেকে খামার বিষয়ে একটি নাতিদীর্ঘ সাক্ষাৎকার গ্রহন করা হবে। এতে আপনার প্রায় ৪০ মিনিট সময় ব্যয় হবে। সাক্ষাৎকার গ্রহীতা এই মর্মে নিশ্চিত করছে যে, আপনার কাছ থেকে প্রাপ্ত তথ্যের সার্বিক গোপনীয়তা রক্ষা করে শুধুমাত্র দেশের নীতি নির্ধারণী বিষয়ে ব্যবহৃত হবে। এই সার্ভিলেন্সে অংশগ্রহনের জন্য আপনাকে কোন সম্মানী দেয়া হবে না।

আপনি এই সার্ভিলেন্সে অংশগ্রহন করবেন কি না সেই সিদ্ধান্ত একমাত্র আপনিই নিতে পারবেন। আপনি চাইলে যে কোন সময় এই সার্ভিলেন্স থেকে সরে আসতে পারবেন।

উপর্যুক্ত বিষয় বিবেচনা করে এই সার্ভিলেন্সে অংশগ্রহন করতে চাইলে স্বাক্ষর অথবা বৃদ্ধাঙ্গুলের টিপসই দিন।

ক) সাক্ষাৎকার প্রদানকারী (খামার মালিক/ প্রতিনিধি)

স্বাক্ষর/ টিপসই---

নাম---

খ) সাক্ষাৎকার গ্রহণকারী (এফইটিপিভি ফেলো)

স্বাক্ষর---

নাম---

প্রতিনিধি হলে মালিকের সাথে সম্পর্ক---

গ) সাক্ষীঃ

সাক্ষাৎকার প্রদানকারীর বয়স ১৮ (আঠারো) বছরের নিচে হলে এবং খামারি উপস্থিত না থাকলে, টেলিফোনের মাধ্যমে খামারির সাথে যোগাযোগ করে তাঁর মৌখিক সম্মতি নিতে হবে। সেক্ষেত্রে একজন সাক্ষী, যিনি নিজে খামারির সম্মতি শুনবেন তার প্রয়োজন হবে।

অনুপস্থিত খামারির নাম---

সাক্ষীর নাম---

খামারির সাথে সম্পর্ক--

স্বাক্ষর--

Questionnaire

Interviewer ID-……………………

Date- ……/……/…………

Part-A: General Information			
Sl. No.	**Question**	**Response**	**Go to**
A1	Farm ID		
A2	Name of the farm		
A3	What type of farm it is? *(Note: 'Credit' means received loan from dealer)*	Please tick (√) one: ☐ Independent……..1 ☐ Credit……………2 ☐ Contracted……….3 ☐ Bank Loan…………..4	
A4	Address	District……………..Upazilla………….. Union………………Ward…………….. Village………………..	
A5	Farm Location(Geo Location)	Latitude………………. Longitude……………	
A6	What is the name of the farm owner?		
A7	Gender of the owner?	Please tick (√) one: ☐ Male……………….1 ☐ Female……………..2 ☐ Others……………...3	
A8	Religion	Please tick (√) one: ☐ Islam………………..1 ☐ Hindu………………2 ☐ Christian……………3 ☐ Buddhist……………4	
A9	Primary occupation of the owner-	Please tick (√) one: ☐ Farmer(Poultry/Crops/Fish)…1 ☐ Fisherman…………...............2 ☐ Student(Specify)…………3 ☐ Businessman………………..4 ☐ Religious Leader/Imam…….5 ☐ Construction Worker………..6	

		☐ Rickshaw/Van Puller..........7 ☐ Street Vendor....................8 ☐ Day Laborer.....................9 ☐ Government Service ....10 ☐ Teacher...........................11 ☐ Other(Specify.......................).....12	
A10	What is the education level of farm owner?	Please tick (√) one: ☐ No Schooling........................1 ☐ Non-formal education (NFE)......2 ☐ Primary School (<= Grade 5).......3 ☐ High School (Grade 6-10)...........4 ☐ Higher Secondary (Grade 11-12)....5 ☐ Tertiary Level (Grade >12)..........6 ☐ Madrasah...............................7 ☐ Vocational..............................8 ☐ Others(Specify..................)........9	
A11	Contact Number-		
A12	Is the owner present?	☐Yes ☐ No	If 'yes' go to A13
A13	What is Name of the interviewee?		
A14	What is the relationship with the owner?	☐Manager ☐Worker ☐Relative ☐Family member	
A15	What is the education level of interviewee?	Please tick (√) one: ☐ No Schooling........................1 ☐ Non-formal education (NFE)......2 ☐ Primary School (<= Grade 5).......3 ☐ High School (Grade 6-10)...........4	

		☐ Higher Secondary (Grade 11-12)….5 ☐ Tertiary Level (Grade >12)………..6 ☐ Madrasah (Equivalent to Primary/ Secondary/Higher Secondary/ Tertiary) …………………………………………..7 ☐ Vocational(Equivalent to Primary/ Secondary/Higher Secondary/ Tertiary) …………………………………………..8 ☐ Others(Specify………………)……..9	
A16	How long have you been engaged with farming?	…………………………………Months	
A17(a)	How many males there?		
A17(b)	How many females there?		
A18	How many shed(s) you had? (Previous batch)		
A19	How many chicken you purchased at starting time? (Previous Batch)	No. of Chicken per shed 1. [ ] 2. [ ] 3. [ ] 4. [ ] 5. [ ] Total: [ ]	We will collect the informati on who is closely related with farm managem ent.
A20	How many chicken did you sell? (Previous Batch)		

A21	How many days had you taken to harvest a batch? (at last selling date)	No. of Chicken per shed 1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ Total: ☐	
A22	How many sheds you have right now?		
A23	How many chicken you purchased at starting time? (Current batch)	No. of Chicken per shed 1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ Total: ☐	
A24	How many chicken do you have? (Current batch)	No. of Chicken per shed 1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ Total: ☐	
A25	What is the age of this batch? (at visiting date)	Write down the no. of days Shed 1………..days Shed 2………..days Shed 3………..days Shed 4………..days Shed 5…………days	
Part-B: Diseases related information			
B1	Did you face any kind of disease in your previous batch?	☐ Yes ☐ No	If yes, go to B2 Otherwise go to C1
B2	Mention the name of diseases *(Depending upon symptoms and diagnosis)*	Please tick (√) one or more: ☐Coccidiosis……………………………………1 ☐ Newcastle Disease(ND) …………………2 ☐ Infectious Bursal Disease(IBD) …………3 ☐ Mycoplasmosis ………………………….4 ☐ Colibacillosis ……………………..5 ☐ Infectious Coryza …………………..6 ☐ Low Pathogenic Avian Influenza(LPAI)…7 ☐ High Pathogenic Avian Influenza(HPAI)…8 ☐ Fowl Cholera ……………………………….9 ☐ Any other (specify…………………)………10	If CRD present, please explicit it.
B3	Which disease had been more prevalent in previous batch? (Higher to lower) *(Note: Name of disease only-at least 5)*	1…………… 2…………… 3…………… 4…………… 5……………	

B4	How many chicken had been **infected** by **diseases**? (Previous batch) *(Definite Number vs disease)*	1.Disease ……………No………….. 2. Disease ……………No………….. 3. Disease ……………No………….. 4. Disease ……………No………….. 5. Disease ……………No…………..	
B5	How many chicken had been **died** by diseases? (Previous batch)	1.Disease ……………No………….. 2. Disease ……………No………….. 3. Disease ……………No………….. 4. Disease ……………No………….. 5. Disease ……………No…………..	
B6	How many chicken had you used for family consumption? (Previous batch)	No. of Chicken per shed 1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ Total: ☐	Total number
B7	Did you face any kind of disease in your current batch?	☐ Yes ☐ No	If 'no' hide B8-B12,then go to C1
B8	Mention the name of diseases (Depending upon symptoms and diagnosis at *the time of visit)* *(Be explicit if mention signs)*	Please tick (√) multiple: ☐Coccidiosis……………………………1 ☐ Newcastle Disease(ND) ……………2 ☐ Infectious Bursal Disease(IBD) ………3 ☐ Mycoplasmosis ……………………….4 ☐ Colibacillosis ………………………….5 ☐ Infectious Coryza ……………………..6 ☐ Low Pathogenic Avian Influenza(LPAI)..7 ☐ High Pathogenic Avian Influenza(HPAI) …8 ☐ Fowl Cholera ……………………………9 ☐ Any other (specify…………………)…….10	
B9	How many chicken are infected by diseases? (At the time of visit)	No. of Chicken per shed 1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ Total: ☐	
B10	How many chicken dies today? (At the time of visit)	No. of Chicken per shed 1. ☐ 2. ☐ 3. ☐ 4. ☐ 5. ☐ Total: ☐	
B11	How many chicken have used for family consumption? (At the time of	No. of Chicken per shed 1. ☐ 2. ☐ 3. ☐ 4. ☐ ☐ ☐	

	visit)	5. Total:	
B12	Which disease had been more prevalent in *current batch*? (Higher to lower) *Note: At least 5*	1............... 2............... 3............... 4............... 5...............	
Part-C: Farm level factors associated with disease			
C1	What is the distance of your farm from highway?	..........................Km	
C2	What is the distance of your farm from nearest residential house?	..........................Km	
C4	What is the distance of your farm from other commercial poultry farms?	Please tick (√) one: ☐< 200 meters ☐201-500 meters ☐ > 500 meters	
C5	Have any fence around the farm?	☐Yes ☐No	If no go to C7, else go to C6
C6	What about the structure of farm? (Definition)	Please tick (√) one: ☐Well structured..........................1 ☐Moderately structured..................2 ☐Poorly structured........................3	
C7	Is there any functioning footbath before entering the farm?	☐Yes (Specify..................................) ☐No	If no, go to C9, else go to C8
C8	What sorts of disinfectant used in footbath?	--	
C9	Do you have drainage system?	☐Yes ☐No	If no, go to C11
C10	What is the drainage system of farm?	Please tick (√) one: ☐Poor (Stagnant water)............................1 ☐Moderate (slow water flow with some stagnant)..2 ☐Good (No stagnant water)........................3	

C11	Is there any presence of human traffic control?	☐Yes ☐No	If No, go to C15
C12	Are visitors allowed into the farm?	Please tick (√) one: ☐Allowed ☐Not allowed	If not allow disable C13 and C14,other wise enable 13 & 14
C13	Average visitor(s) per week?	.....	
C14	What about the procedure of hygienic practiced for outsiders/ visitors?	Please tick (√) one or more: ☐Footbath.....................................1 ☐Disinfectant spray..........................2 ☐Hand sanitization..........................3 ☐Hand wash.....................................4 ☐Mask...5 ☐Lime powder....................................6 ☐Human disinfectant chamber ....7 ☐ Others(Specify............)..................8	
C15	Is there any special cloth for farm personnel?	☐Yes ☐No	
C16	Is there any inner footwear in the farm?	☐Yes ☐No	
C17	What is the direction of farm?	Please tick (√) one: ☐North South ....1 ☐East West...........................2 ☐South East...........................3 ☐North West...........................4 ☐Multidirectional....................5	
C18	What type of ventilation do you have?	Please tick (√) one: ☐Natural Ventilation..................1 ☐Mechanical Ventilation............2 ☐Environmentally Controlled Shed ...3 ☐Others.....................................4	

C19	What about the ventilation System of the farm? *(Notes: **Very good** = Environmentally controlled shed,* ***Good** = Shed height (≥ 8 ft), width (≤ 30 ft), density (≥ 1 sqft/bird), direction (East West), side wall height (≤ 1.5 feet),* ***Fair** = Fail to maintain at least one criterion of the above.* ***Poor** = Fail to maintain two or more criteria of the above.*	Please tick (√) one: ☐Very Good.................1 ☐Good........................2 ☐Fair...........................3 ☐Poor.........................4	
C20	Where do you collect your birds?	Please tick (√) one: ☐Hatchery (Name..................................) 1 ☐Dealer...2 ☐Middleman...3 ☐Others (Specify.......................)..............4	
C21	Is there any wild animals/birds come into your farm?	☐Yes ☐No	If 'No', please go to C22
C22	What type of wild animal/bird enters into your farm?	Please tick (√) one or more: ☐Crow ☐Mynah ☐Owl ☐Sparrow ☐Rat ☐Mongoose ☐Dog ☐Fox	

		☐Others	
C23	What types of materials used as litter?	Please tick (√) one or more: ☐Sand ☐Wood shaving ☐Saw dust ☐Rice husk ☐ Ash ☐Others (Specify……)	
C24	What is the frequency of changing litter materials?	Please tick (√) one: ☐Weekly……………………….1 ☐Fortnightly…………………2 ☐Monthly……………………..3 ☐Others (Specify……)……….4	
C25	What is the Source of feed?	Please tick (√) one: ☐Broiler feed……………………………….1 ☐Sonali feed…………………………………2 ☐Layer feed………………………………….3 ☐Handmade feed……………………………4 ☐ Others (Specify…………………)……….5	
C26	What types of feed you have used in the farm?	Please tick (√) one: ☐Pellet ……………………………………….1 ☐Mash ………………………………………2 ☐Crumble ……………………………………3 ☐Others (Specify…………………)………….4	
C27	Water source of the farm-	Please tick (√) one: ☐Tube well……………………………….1 ☐Open water source………………………2 ☐Supplied water…………………………..3 ☐Others (Specify……………)………….4	
C28	How about watering system of the farm?	Please tick (√) one: ☐Bell drinker…………………………..1 ☐Nipple drinker…………………………2 ☐Others (Specify……………)…………3	
C29	Do you clean your farm?	☐Yes (Specify…………………….)☐No	If no, skip C29

C30	How often do you clean your farm?	Please tick (√) one: ☐Once in a week…………………………1 ☐Twice in a week…………………………2 ☐ Once in a month…………………………3 ☐Others(Specify……………………)……4	
C31	Dead bird's disposal system-	Please tick (√) one: ☐Used as fish feed…………………………1 ☐Throwing to the nearby pond or river……2 ☐Buried…………………………………3	
C32	How do you manage your farm waste?	Please tick (√) one: ☐ Bury…………………………………1 ☐Ignite…………………………………2 ☐Throwing to the nearby open place……3 ☐Used as manure…………………………4 ☐Other way (Specify…………………)……5	
C33	Gap between two batches?	Please tick (√) one: ☐One week……………………………1 ☐Two weeks……………………………2 ☐More than two weeks…………………3	
C34	Vaccination history(Previous batch)	Please tick (√) one or more: ☐ Newcastle Disease(ND) ☐ Infectious Bursal Disease(IBD) ☐ Fowl Cholera ☐ Any other (specify…………………)	
C35	Vaccination history (Current batch)	Please tick (√) one or more: ☐ Newcastle Disease(ND) ☐ Infectious Bursal Disease(IBD) ☐ Fowl Cholera ☐ Any other (specify…………………)	
C36	What do you do when birds are sick?	Please tick (√) one or more: ☐Slaughter and consume………1 ☐Medicate……………………2 ☐Sell……………………………3 ☐Others (Specify…………)…..4	
C37	Prescriber(s)	Please tick (√) one or more: ☐Private vet ☐Government vet ☐Veterinary medical representative	

		☐Pharmacist ☐Medicine shopkeeper ☐Village Quack ☐Self-treat ☐Neighboring farmer ☐Others(Specify)……………….	

Antimicrobial usage(Previous Batch)

C38.Generic name	C39. Generic name	C40. Generic name	C41. Generic name	C42. Generic name
a) Source ☐Salesman ☐Upazila Vet Hosp. ☐Medicine shop ☐Dealer ☐Vet ☐Quack ☐ Others **b) Purpose** ☐Treatment ☐Prevention ☐Faster growth/ more eggs **c) Route** ☐Drinking water ☐Feed ☐Injection **d) Frequency** ☐Once a day ☐Twice a day ☐Thrice a day ☐Once a week ☐Once a month ☐After illness ☐Before winter ☐ Others	**a) Source** ☐Salesman ☐Upazila Vet Hosp. ☐Medicine shop ☐Dealer ☐Vet ☐Quack ☐ Others **b) Purpose** ☐Treatment ☐Prevention ☐Faster growth/ more eggs **c) Route** ☐Drinking water ☐ Feed ☐Injection **d) Frequency** ☐Once a day ☐Twice a day ☐Thrice a day ☐Once a week ☐Once a month ☐After illness ☐Before winter ☐ Others	**a) Source** ☐Salesman ☐Upazila Vet Hosp. ☐Medicine shop ☐Dealer ☐Vet ☐Quack ☐ Others **b) Purpose** ☐Treatment ☐Prevention ☐Faster growth/ more eggs **c) Route** ☐Drinking water ☐ Feed ☐Injection **d) Frequency** ☐Once a day ☐Twice a day ☐Thrice a day ☐Once a week ☐Once a month ☐After illness ☐Before winter ☐ Others	**a) Source** ☐Salesman ☐Upazila Vet Hosp. ☐Medicine shop ☐Dealer ☐Vet ☐Quack ☐ Others **b) Purpose** ☐Treatment ☐Prevention ☐Faster growth/ more eggs **c) Route** ☐Drinking water ☐Feed ☐Injection **d) Frequency** ☐Once a day ☐Twice a day ☐Thrice a day ☐Once a week ☐Once a month ☐After illness ☐Before winter ☐ Others	**a) Source** ☐Salesman ☐Upazila Vet Hosp. ☐Medicine shop ☐Dealer ☐Vet ☐Quack ☐ Others **b) Purpose** ☐Treatment ☐Prevention ☐Faster growth/ more eggs **c) Route** ☐Drinking water ☐Feed ☐ Injection **d) Frequency** ☐Once a day ☐Twice a day ☐Thrice a day ☐Once a week ☐Once a month ☐After illness ☐Before winter ☐ Others

Antimicrobial usage(Current Batch)				
C43.Generic name	C44.Generic name	C45. Generic name	C46. Generic name	C47. Generic name
a) Source ☐Salesman ☐Upazila Vet Hosp. ☐Medicine shop ☐Dealer ☐Vet ☐Quack ☐ Others **b) Purpose** ☐Treatment ☐Prevention ☐Faster growth/ more eggs **c) Route** ☐Drinking water ☐Feed ☐Injection **d) Frequency** ☐Once a day ☐Twice a day ☐Thrice a day ☐Once a week ☐Once a month ☐After illness ☐Before winter ☐ Others	**a) Source** ☐Salesman ☐Upazila Vet Hosp. ☐Medicine shop ☐Dealer ☐Vet ☐Quack ☐ Others **b) Purpose** ☐Treatment ☐Prevention ☐Faster growth/ more eggs **c) Route** ☐Drinking water ☐ Feed ☐Injection **d) Frequency** ☐Once a day ☐Twice a day ☐Thrice a day ☐Once a week ☐Once a month ☐After illness ☐Before winter ☐ Others	**a) Source** ☐Salesman ☐Upazila Vet Hosp. ☐Medicine shop ☐Dealer ☐Vet ☐Quack ☐ Others **b) Purpose** ☐Treatment ☐Prevention ☐Faster growth/ more eggs **c) Route** ☐Drinking water ☐ Feed ☐Injection **d) Frequency** ☐Once a day ☐Twice a day ☐Thrice a day ☐Once a week ☐Once a month ☐After illness ☐Before winter ☐ Others	**a) Source** ☐Salesman ☐Upazila Vet Hosp. ☐Medicine shop ☐Dealer ☐Vet ☐Quack ☐ Others **b) Purpose** ☐Treatment ☐Prevention ☐Faster growth/ more eggs **c) Route** ☐Drinking water ☐Feed ☐Injection **d) Frequency** ☐Once a day ☐Twice a day ☐Thrice a day ☐Once a week ☐Once a month ☐After illness ☐Before winter ☐ Others	**a) Source** ☐Salesman ☐Upazila Vet Hosp. ☐Medicine shop ☐Dealer ☐Vet ☐Quack ☐ Others **b) Purpose** ☐Treatment ☐Prevention ☐Faster growth/ more eggs **c) Route** ☐Drinking water ☐Feed ☐ Injection **d) Frequency** ☐Once a day ☐Twice a day ☐Thrice a day ☐Once a week ☐Once a month ☐After illness ☐Before winter ☐ Others

C48	History of antibiotics used with their duration (Previous batch)	1................................and ....days 2................................ and ....days 3................................ and ....days 4................................ and ....days 5................................ and ....days 6................................ and ....days 7................................ and ....days 8................................ and ....days 9................................ and ....days 10................................ and ....days	
C49	History of antibiotics used (Current batch)	1................................and ....days 2................................ and ....days 3................................ and ....days 4................................ and ....days 5................................ and ....days 6................................ and ....days	

		7................................ and ....days 8................................ and ....days 9................................ and ....days 10.............................. and ....days	
C50	How many days do you wait for selling birds, after using antibiotics? (Previous batch)	Please tick (√) one or more: ☐One day ☐Two days ☐Three days ☐Four days ☐More than Four days to till healthy ☐None	
C51	When you are using antibiotics, it is only for sick or whole flock?		
C52	Are you familiar with AMR?	☐Yes ☐No	
C53	Which thing do you feel more important to maximize profit? *(Statement)*		
C54	Three major challenges of Sonali farming-	1.. 2.. 3..	

End