

**ASSESSMENT OF KNOWLEDGE, ATTITUDES, AND PRACTICES ON
ANTIMICROBIAL USE AND RESISTANCE AMONG COMMERCIAL
POULTRY FARM OWNERS AND WORKERS IN SELECTED CITIES
OF EASTERN ETHIOPIA**

MSc THESIS

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MARCH 2025

HARAMAYA UNIVERSITY, MAYA

**Assessment of Knowledge, Attitude and Practices On Antimicrobial Use
and Resistance among Commercial Poultry Farm Owners and Workers in
Selected Cities of Eastern Ethiopia**

**A Thesis Submitted to the College of Veterinary Medicine, Postgraduate
Program Directorate
HARAMAYA UNIVERSITY**

**In Partial Fulfilment of the Requirements for the Degree of
MASTER OF SCIENCE IN VETERINARY EPIDEMIOLOGY**

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DEDICATION

This work is dedicated to my beloved parents, whose unwavering encouragement, positive dream for my success, and enduring belief in my potential have been a deep source of inspiration and instrumental in my academic journey.

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BIOGRAPHIC SKETCH

The author was born in March 1994 in a kebele called Didibbe Kistana in Horro district; seven kilometers away to the east from Shambu, a capital of Horro Guduru Wallagga Zone. He completed his primary and secondary school education in his birthplace, laying a strong academic base. In September 2012, he embarked on a new journey at Haramaya University, being enrolled in the College of Veterinary Medicine. After six years of study, he successfully graduated in July 2018 with a degree of Doctor of Veterinary Medicine. In July 2019, he started his professional career as a Coordinator of Animal Health Clinic in Horro Guduru Wallagga Zone, at Jimma Rare District Livestock and Fishery Resources Office. Over the next three years, he made significant contributions to the field, serving until August 2022. Eager to advance his insight, he seized the opportunity to join Haramaya University's Postgraduate Program in October 2022. He is currently pursuing a Master's degree in Veterinary Epidemiology, continuing his commitment of advancing his academic endeavors.

ACKNOWLEDGEMENTS

First and foremost, I am profoundly thankful to the Almighty, for His countless blessings and unwavering care all the way through my life.

I owe a debt of gratitude to my research advisors, Dr. Yihenew Getahun, Dr. Dawit Kassaye, and Dr. Dinaol Belina, for their invaluable guidance and scholarly instructions throughout my research journey. The confidence to independently analyze research data was instilled within me through the expertise of Dr. Yihenew Getahun, along with his open-minded and flexible teaching approach. Besides, the intricate and engaging courses of research methodology and analytical epidemiology were made comprehensible to me through the scholarly instruction of Dr. Dawit Kassaye. Equally, a solid foundation in veterinary medicine was provided to me through the mentorship of Dr. Dinaol Belina, bridging my academic angles.

I also extend my heartfelt appreciation to the agricultural and natural resource offices of Dire Dawa, Harar and Jigjiga cities, as well as the assistants who helped me during data collection for their time and support.

Lastly, I extend my wholehearted gratitude to my beloved parents and siblings. Their persistent belief in my destiny and ambitions for my academic success have continually inspired me. Their unwavering support and encouragement have been pivotal in my journey, and I am deeply indebted to them for their enduring positive influence.

ACRONYMS AND ABBREVIATIONS

AMR	Antimicrobial Resistance
AMS	Antimicrobial Stewardship
AMU	Antimicrobial Use
CSA	Central Statistical Agency
EFSA	European Food Safety Authority
ESRI	Environmental Systems Research Institute
EU-ART	European Union Antibiotic Reduction Targets
FAO	Food and Agriculture Organization
FDA	Food and Drug Authority
IACG	Interagency Coordination Group
ICARS	International Center for Antimicrobial Resistance Solution
IPC	International Poultry Council
KAPs	Knowledge, Attitudes and Practices
MRLs	Maximum Residual Limits
NCCID	National Collaborating Centre for Infectious Diseases
NCD	Newcastle Disease
NPDS	National Poultry Development Strategy
OMS	Organização Mundial da Saúde
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
UNEP	United Nations Environmental Program
USAID	United States Agency for International Development
USPEA	United States Poultry and Egg Association
WHO	World Health Organization
WOAH	World Organization for Animal Health

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Assessment of Knowledge, Attitudes and Practices on Antimicrobial Use and Resistance among Commercial Poultry Farm Owners/ Workers in Selected Cities in Eastern Ethiopia

ABSTRACT

Antimicrobials are vital for disease control and productivity; however, their inappropriate use leads to antimicrobial resistance, a global threat to public health. A cross-sectional study was conducted to assess the knowledge, attitudes, and practices of poultry farm owners and workers towards antimicrobial use and resistance in three selected cities in Eastern Ethiopia, through structured interviews with a census of 106 poultry farms. Findings indicated that only 30.2% (95% CI: 22.1%-39.7%) had good knowledge, regarding antimicrobials (36.7%, OR=24.7, $p<0.001$), unawareness of residues (67.9%; OR=0.02, $p<0.001$), disease-specific drug (34.9%; OR=54.2, $p=0.001$), unfamiliarity with residue transmission (64.2%, OR=0.01, $p<0.001$), and difference in efficacy of antimicrobials (64.2%; OR=8.79, $p=0.033$). Attitudes were desirable in 48.1% (95% CI: 38.6%-57.7%), subjected to random antimicrobial use (64.4%, OR=3.94, $p=0.026$), missing doses (7.7%, OR=0.04, $p = 0.013$), using with feed (53.6%, OR=20.91, $p<0.001$), correct dosage (61.5%, OR=11.82, $p=0.010$), controlling access to antimicrobials (57.4%, OR=7.02, $p=0.016$), not obliged to finish before expiration (65.3%, OR=10.01, $p=0.001$), and minimizing antimicrobial use (75.9%, OR=15.37, $p<0.001$). Improved practices were noted only in 38.7% (95% CI: 29.8%-48.4%), with personal drug administration (90.9%, OR=11.8, $p=0.010$), non-professional recommendations (77.8%, OR=28.93, $p=0.016$), uninformed about its use as growth promoter (8.3%, OR=0.05, $p=0.036$), noting withdrawal times (87.5%, OR=30.9, $p<0.001$), adjusting dose when no recovery (95.6%, OR=13, $p=0.002$), not ceasing treatment even if symptoms go (64.5%, OR=30.9, $p=0.007$), and not switching antimicrobials (13.2%, OR=0.004, $p=0.001$). Pertaining to the associated factors for each, knowledge was found to be directly related with attitudes ($r=0.3278$, $p=0.0006$) and practices ($r=0.4300$, $p<0.0001$), and also attitudes with practices ($r=0.2278$, $p=0.0189$). In general, this study identified significant gaps in knowledge, attitudes and practices related to antimicrobial use and resistance among commercial poultry farm owners and workers in eastern Ethiopia, necessitating targeted interventions to enhance understanding and promote responsible antimicrobial use practices. Therefore, comprehensive education, veterinary guidance, mentorship programs, and robust antimicrobial resistance surveillance systems are necessary to address the gaps and curb the spread of resistance in the study areas and beyond.

Keywords: Antimicrobial use, Antimicrobial resistance, Attitudes, Eastern Ethiopia, Knowledge, Commercial poultry farm owners and workers, Practices

1. INTRODUCTION

1.1. Background of the Study

Antimicrobial resistance (AMR) is one of the most critical global public health problems facing countries at every income level in all regions. In 2019, direct deaths in the world, contributed to bacterial AMR, were 1.27 million (WHO *et al.*, 2022). Consequently, this will worsen with poverty and inequality; thus, there is a need to make it an issue for public health. Antimicrobials are essential in maintaining the health and productivity of poultry through their actions against bacteria, viruses, and parasites (Hassan *et al.*, 2021; Van Boeckel *et al.*, 2015). They reduce morbidity and mortality in poultry flocks (Hao *et al.*, 2014), and in other cases be used as growth promoters, improving feed efficiency and the overall performance of the flock (Dhama *et al.*, 2014; Kalia *et al.*, 2022).

However, the misuse and overuse of antimicrobials pose significant risks to public health and the environment. Inappropriate antimicrobial use drives the development of drug-resistant pathogens, reducing their effectiveness and jeopardizing the ability to treat infections (Frost *et al.*, 2018; Kiambi *et al.*, 2021). Poultry farms are considered potential reservoirs for resistant bacteria because of the high frequency of AMU (Hedman *et al.*, 2020). These bacteria can be transmitted to humans through consumption of food and direct contact (Tabler *et al.*, 2021).

In Ethiopia, chicken rearing is one of the key factors in food security and livelihood for people (Yitayih *et al.*, 2021). Nonetheless, AMR impacts poultry farming since resistant infections lead to increased mortality, reduced production, and increased treatment costs. This leads to economic losses on farms due to poor treatment and lower performance of flocks. Also, AMR is a danger to food safety since resistant bacteria can contaminate poultry products and affect consumer health (OMS, 2017; Selaledi *et al.*, 2020). This implies that resistant bacteria can be passed from poultry to humans, mainly affecting poultry workers, consumers, and their families (Agyare *et al.*, 2019). It is compulsory to understand how AMU and AMR be managed in poultry farming to protect public health (NCCID, 2016).

Several challenges are facing the poultry farming subsector in Ethiopia, including poor management practices, disease outbreaks, and a lack of regulatory control, resulting in inadequate use and overuse of antimicrobials (Desta, 2021). Most poultry producers in Ethiopia are smallholder farmers who raise chickens within their homesteads for socio-cultural and economic reasons. Challenges limiting these producers range from limited access to information, markets, veterinary services, and quality feed (Yemane *et al.*, 2016). Conversely, commercial poultry operations situated in urban areas focus on the cultivation of meat, eggs, or both from enhanced breeds, encountering various obstacles such as competition, elevated costs, and outbreaks of diseases (Fekadu *et al.*, 2022). Despite the critical role of poultry farming in Ethiopia, there is a lack of knowledge towards antimicrobial use (AMU) and AMR patterns among poultry farm owners and/or workers (Yitayih *et al.*, 2021). Therefore, further study is needed, particularly in eastern Ethiopia, to assess the knowledge, attitudes, and practices (KAPs) of poultry farmers regarding AMU and AMR.

1.2. Statement of the Problem

Antimicrobial resistance remains a current challenge in Ethiopia, which is mostly due to improper and excessive use of antimicrobials in poultry production. Improper use includes application not based on veterinary advice, with the wrong dose, or against the wrong type of infection. Overuse is understood as excessive or frequent application which is usually prophylactic, rather than based on actual infections. Without proper veterinary oversight, these practices lead to the emergence of resistant bacterial strains, posing significant risks to public health, animal welfare, and food safety (Salam *et al.*, 2023; WHO, 2022).

Poultry is a high-demand product in Ethiopia; however, most small-scale farmers have no access to veterinary services, lack sufficient information on AMU and AMR, and receive poor-quality feed. This leads to undiagnosed or poorly treated diseases, hence the misuse of antimicrobials. The occurrence of frequent outbreaks of diseases and inadequacy of regulatory mechanisms enhance improper AMU by exposing bacteria to suboptimal doses that foster resistance (Desta, 2021).

Despite the critical role of poultry farming in Ethiopia's economy and food security (Abdi *et al.*, 2017; Asfaw *et al.*, 2022; Gemedo *et al.*, 2020), data on AMU and AMR levels among

poultry farm workers is limited. The knowledge, attitudes and practices (KAPs) of poultry farm owners and workers regarding AMU and AMR have not been thoroughly studied, especially in the eastern regions of the country. This lack of data hinders the development of effective strategies to fight AMR. This leads to continued misuse and overuse of antimicrobials. Therefore, this research is performed with the intent of assessing the KAPs of poultry farm owners and workers regarding AMU and AMR in three eastern Ethiopian cities. Identifying factors affecting AMU and AMR is key to develop targeted interventions, promoting responsible practices, and mitigating resistance spread (Assefa, 2019). Ensuring public health and sustainable poultry farming practices is essential, and this research provides critical information to achieve these goals.

1.3. Significance of the Study

The increasing threat of AMR in the Ethiopian poultry sector requires immediate attention. This study focuses on assessing the KAPs of poultry farm owners and workers concerning AMU and AMR, which is required to understand and identify the root causes of antimicrobial misuse. The insights acquired from this study will be used to formulate specific interventions aimed at good AMU practices that will go a long way toward reducing the spread of resistant microbes and, hence, protecting animal, public, and environmental health. These will be contributory to sustainability and productivity within the poultry industry protecting the environment from contamination by resistant microorganism. This in turn contributes to informed data for policymakers and regulatory authorities to develop effective guidelines that control AMU and reduce AMR. Besides, it will indicate gaps in education to help design specific training programs for poultry farm owners and workers. This research will contribute significantly to public health, economic development, policy formulation, environmental sustainability, and scientific knowledge and will be one of the milestone efforts to combat AMR in Ethiopia.

1.4. Objectives of the Study

1.4.1. General Objective

The general objective of the study was to assess the level of KAPs related to AMU and AMR among commercial poultry farm owners and workers, focusing on factors that contribute to the emergence of AMR in target areas.

1.4.2. Specific Objectives

- i) To assess the level of knowledge among commercial poultry farm owners and workers regarding AMU and AMR.
- ii) To assess the attitudes of poultry farm owners and workers towards AMU and AMR.
- iii) To identify the current practices of poultry farm owners and workers related to AMU and AMR.
- iv) To determine the contributing factors affecting AMU behavior of poultry farm owners and workers and the resulting AMR in three cities in eastern Ethiopia.

2. LITERATURE REVIEW

2.1. Antimicrobial Use and Resistance Theories

Theoretical frameworks provide a structured lens through which complex phenomena can be understood. In the context of AMU and AMR, existing frameworks help us analyze factors influencing behavior, decision making, and outcomes (Ruckert *et al.*, 2024). The Health Belief Model (HBM) suggests that health-related behaviors are influenced by perceived susceptibility, severity, benefits and barriers (Jacobson *et al.*, 2011). This helps us understand why farmers choose certain practices based on their beliefs about risks and benefits. On the other hand, Theory of Planned Behavior (TPB) focuses on attitudes, subjective norms, and perceived behavioral control (Siqueira *et al.*, 2022), to explore how farmers' attitudes toward antimicrobials, social influences, and perceived control impact their decisions. So far, Socio-Ecological Model considers multiple levels of influence like from individual, interpersonal, and community (Golden and Earp, 2012) to examine factors and their combined effects.

Moreover, Conceptual Models illustrate relationships between variables (Field *et al.*, 2014), depicting how knowledge and attitudes affect actual practices in poultry farming. The components of the model include Knowledge, Attitudes, and Actual Practices. Knowledge, represented as a foundational block, encompassing awareness of AMR, understanding of proper AMU, and awareness of associated risks (Mudenda *et al.*, 2022). Attitudes, as an intermediate step, indicate that positive attitudes toward responsible AMU lead to better practices (Al-Mustapha *et al.*, 2020). Actual practice, the ultimate outcome, involves dosage adherence, compliance with the withdrawal period, and overall responsible AMU. The model illustrates both direct pathways (knowledge → practices) and indirect pathways (knowledge → attitudes → practices) (Chilawa *et al.*, 2023). Additionally, mediators such as social norms and perceived behavioral control could enhance or hinder these pathways (Caudell *et al.*, 2020).

2.2. Historical Perspectives on Antimicrobial Use and Resistance in Poultry

2.2.1. Evolution of Antimicrobial Use

The use of antimicrobials in animal production can be traced back to the 1910s, a period marked by meat shortages that led to widespread protests and riots across the United States (Warren, 2014). During that period, researchers sought methods to increase meat production at lower costs, leading to the adoption of antibiotics and other antimicrobial agents (Agyare *et al.*, 2019). Mid-twentieth century researchers discovered that subtherapeutic doses of antibiotics enhanced poultry growth rates, leading to their routine incorporation into feed and water to promote growth and prevent diseases. Subsequently, the rise in poultry production increased AMU, with large-scale commercial farms relying heavily on antibiotics (Castanon, 2007; Warren, 2014). Regulatory changes in the poultry industry have included the introduction of withdrawal periods by regulatory agencies, the banning of certain antibiotics such as chloramphenicol and fluoroquinolones due to concerns about AMR and residues (Murphy *et al.*, 2017), and the implementation of mandatory labelling requirements that provide clear guidelines on AMU, dosages, and withdrawal periods (Sarkar and Okafor, 2022).

2.2.2. Antimicrobial Resistance Milestones

The Swann Report (1969) was a pivotal document that established a connection between AMU in agriculture and AMR in humans, advocating for more wise use of antimicrobials (Wellcome, 2024). Furthermore, the review by O'Neill (2016) underscored the global threat posed by AMR, calling for immediate and coordinated action across various sectors to mitigate this growing crisis. In response, the World Health Organization Global Action Plan on AMR was launched in 2015, with the aim of combating AMR through enhanced surveillance, stewardship, and research efforts (Minimol *et al.*, 2023). Similarly, the European Union Antibiotic Reduction Targets (EU-ART) were established to decrease AMU in livestock, including poultry, as part of a broader strategy to curb AMR (Murphy *et al.*, 2017). Furthermore, World Antibiotic Awareness Week is an annual initiative designed to increase awareness of the responsible AMU and the dangers of AMR (Choy and Hsu, 2017). The One-Health Approach also emphasizes a cohesion of human, animal, and environmental health in the fight against AMR (Collignon and McEwen, 2019).

2.3. Antimicrobial Use Patterns and Practices

2.3.1. Sources of Antimicrobials

According to Eguale (2018) in Ethiopia, poultry farmers access antimicrobials from different and often unregulated sources, such as veterinarians, drug sellers, fellow farmers, and informal markets. For more than 80% of farmers, agrovets are the main suppliers of antimicrobials and the sole providers of animal health information, in addition to their social contacts (Samuel *et al.*, 2023). Farmers often turn to drug vendors for their poultry needs, especially in the absence or unaffordability of agrovets although they are informal traders who sell veterinary drugs without proper regulation or quality control (McKernan *et al.*, 2021). However, six out of ten farmers consult veterinarians for advice on AMU, but many of them disregard their professional advice. Moreover, farmers also learn from and imitate their fellow farmers, who are often their family members or friends, in using antimicrobials for their poultry (Samuel *et al.*, 2023).

2.3.2. Types of Antimicrobials Used

Depending on their purpose, poultry farmers use different kinds of antimicrobials for their birds. Some of these objectives include curing diseases, preventing infections, improving growth, and increasing productivity (Koirala *et al.*, 2021). For example, poultry farmers frequently use various antimicrobials, such as tylosin, colistin, neomycin, doxycycline, and combinations of two or three drugs. Specifically, they apply tylosin for respiratory diseases and colistin for digestive disorders (Agyare *et al.*, 2019). In addition, farmers use neomycin and doxycycline to protect their poultry from coccidiosis and other bacterial infections, respectively (Herago *et al.*, 2021). Dual or triple antimicrobial therapies are used for growth promotion and productivity improvement, as well as for the treatment of mixed infections (Calik *et al.*, 2019).

The most commonly used antimicrobials in poultry farming in Ethiopia are antibacterial such as tetracyclines, sulfonamides, aminoglycosides and penicillins (Dagnev *et al.*, 2020); antiprotozoals like amprolium and sulfa drugs; antihelminthics such as albendazole, tetramisole, and plant compounds (Beyene *et al.*, 2015). Probiotics as live microorganisms are added to the feed and/or water of chickens to improve their intestinal balance and health. Additionally, they also enhance the digestion and absorption, stimulate the immune system, and

prevent or treat diarrhea (Selaledi *et al.*, 2020). Phytochemicals (natural compounds derived from plants) have various beneficial effects on poultry health and performance. They can modulate the gut microbiota, improve the immune system, reduce oxidative stress, and inhibit pathogenic microorganisms. Some examples of phytochemicals used in Ethiopia for poultry are ethno-veterinary medicine as indicated by Wodegebriel *et al.* (2018).

2.4. Factors Affecting Knowledge of Poultry Farm Owners and Workers

2.4.1. Socio-demographic Factors

Several socio-demographic characteristics, including age, education, experience, income, and farm size, affect poultry farmers' knowledge, attitudes, and practices regarding the AMU and AMR (Chilawa *et al.*, 2023). According to Caudell *et al.* (2022), farmer attitudes and understanding about antimicrobials improved with experience, education and age. Similarly, greater antimicrobial knowledge and practices are correlated with higher income and larger farm size (Sindato *et al.*, 2020). In contrast, a study by Mounzer *et al.* (2021) has provided variable results, suggesting that age, income, or education may not entirely explain variations in the knowledge, attitudes, and practices of chicken farmers about AMU and AMR.

According to Geta and Kibret (2021), socio-demographic variables such as education level, farm size, type of chicken production, and source of antimicrobial advice influence the KAPs of poultry farmers towards AMU and AMR in Ethiopia, which are often low and inappropriate. In three districts in central and western Ethiopia, livestock farmers' knowledge, attitudes, and behaviors related to AMU and AMR were evaluated by Tufa *et al.* (2023). According to Tufa and colleagues, most farmers had positive practice scores in relation to AMU but little knowledge and attitudes regarding AMU and AMR. Based on this, it is discovered that improving antimicrobial stewardship (AMS) in the livestock industry requires an understanding of farmers' perspectives.

2.4.2. Economic and Behavioral Factors

Knowledge, attitudes, and practices of poultry farmers about AMU and AMR are also affected by economic and behavioral factors, including cost, benefit, risk, perception, motivation, and habit (Chilawa *et al.*, 2023). Therefore, antimicrobials are used in poultry farms to both prevent

illness losses, decreased marketability, and higher veterinary costs, and gain financial advantages such as to raise productivity, profitability, and food security (Agyare *et al.*, 2019).

The quality and viability of AMU, as well as poultry production are threatened by economic and environmental issues faced by poultry producers (Islam *et al.*, 2022). Regarding AMU and AMR, poultry farmers have varying beliefs, motives, and practices, which can affect their decision-making, compliance, and change in behavior (Hibbard *et al.*, 2023). They are typically driven more by financial incentives, social norms, or personal opinions than by empirical evidence, professional advice, or public health concerns, and they view the advantages of using antimicrobials as outweighing the risks (Gemeda *et al.*, 2020). Furthermore, it is challenging to alter the habit of poultry farmers with AMU and AMR, particularly in the lack of sufficient information, awareness and support (Hassan *et al.*, 2021).

2.4.3. Information Sources

The sources, channels and frequency of information are among the information and communication components that influence the knowledge and attitudes regarding AMU and AMR (Rayner *et al.*, 2019). For example, veterinarians, agrovets, drug vendors, fellow farmers, the media and the internet are some of the sources where one can find information and guidance regarding AMU and AMR (Higuita-Gutiérrez *et al.*, 2020), yet veterinarians play a crucial role as primary sources of information for poultry farmers, offering personalized advice, conducting farm visits, and addressing specific concerns. In addition, they guide farmers on disease management, treatment protocols and responsible AMU (Al Sattar *et al.*, 2023). Furthermore, extension officers act as intermediaries between research and practice, organizing workshops, distributing educational materials, and facilitating knowledge transfer to ensure that evidence-based information reaches farmers at the grassroots level (Bradstock *et al.*, 2007). The precision, consistency and comprehensiveness of the information and guidance farmers receive, then again, may be subject to broad changes in the quality, reliability, and accessibility of different sources (Matabi, 2017; Omondi, 2022). Furthermore, digital platforms, websites, and mobile apps provide accessible information, allowing farmers to access guidelines, research articles, and videos related to AMU and AMR, thus complementing face-to-face interactions and offering continuous learning opportunities (Mohsin *et al.*, 2023).

2.4.4. Educational Programs and Awareness Creation

Educational initiatives are vital to enhance knowledge on responsible AMU and AMR among poultry farmers (Al Sattar *et al.*, 2023; Hassan *et al.*, 2021). Specifically, the programs directly target farmers, enhancing their understanding of best practices. For example, workshops typically cover essential topics on proper dosage, withdrawal periods, and risks associated with AMR, while extension services offer on-farm guidance with evidence-based recommendations (Nkansa *et al.*, 2020). As a result, those who participate in educational programs generally exhibit better knowledge about AMU and AMR, leading to more informed decision making and improved practices (Subedi *et al.*, 2023).

2.5. Attitudes Toward Responsible Antimicrobial Usage

2.5.1. Risk Perception

Poultry farmers' risk perception influences their AMU decisions. On the subject of AMU and AMR, poultry farmers have varying beliefs, motives, and practices, which can affect their decision-making, compliance, and change in behavior (Hibbard *et al.*, 2023). They are typically driven more by financial incentives, social norms, or personal opinions than by empirical evidence, professional advice, or public health concerns, and they view the advantages of using antimicrobials as outweighing the risks (Gemeda *et al.*, 2020). Still, they may perceive the development of AMR as a distant risk, especially if they lack information. In view of that, responsiveness to the link between AMU and AMR helps farmers recognize the direct impact of their practices. For example, while considering the risk of treatment failure due to resistant infections, poultry farmers (particularly) who prioritize food safety are likely to stand aware of the risk of antimicrobial residues in poultry products. Since these residues can enter the food chain and affect consumers, responsible AMU has to be implemented so as to minimize this risk (Geta and Kibret, 2021; Hassan *et al.*, 2021; Mohsin *et al.*, 2023).

2.5.2. Moral Circumstances

Ethical dilemmas arise when farmers need to choose between animal welfare and economic viability. For instance, using antimicrobials to promote growth may improve profits but could compromise animal health. Therefore, responsible AMU must be established to consider both

economic factors and animal well-being (Diarra and Malouin, 2014). Farmers weigh the benefits of AMU (for example, faster growth) against potential harm to their chicken. This obliges someone to be ethical with the intention of prioritizing less suffering with caring actions. In addition, withdrawal periods are crucial to prevent residues in meat and eggs (Mulchandani *et al.*, 2023; Van Boeckel *et al.*, 2015). Ethical decisions must be extended beyond the farm environment, since farmers may fail to recognize their role in preventing AMR spread to humans, yet responsible AMU contributes to public health by preserving effective antibiotics (Landers *et al.*, 2012).

2.6. Best Practices and Guidelines for Responsible Antimicrobial Use

2.6.1. Dosage and Administration

Existing guidelines on drug administration strictly emphasize the importance of administering antimicrobials in the correct dosage, as underdosing may lead to treatment failure, while overdosing can contribute to AMR (Habte *et al.*, 2017). Veterinarians provide specific dosage recommendations based on the type of antimicrobial and the weight of the animals, poultry in our case. Antimicrobials can be administered orally, with water or by injection, with the chosen route depending on the properties of the drug, the severity of the condition, and practical considerations (Gray *et al.*, 2021). Proper administration ensures effective drug delivery, and guidelines specify the duration of treatment, highlighting that completing the full course is essential to prevent suboptimal dosing and resistance. Stopping treatment before the full course may allow the surviving bacteria to develop resistance behavior in the next exposure to that same drug (Garedew *et al.*, 2015; Kakooza *et al.*, 2023).

2.6.2. Alternatives to Antimicrobial Use

Probiotics are beneficial bacteria that promote gut health by competing with harmful bacteria, thereby reducing the need for antimicrobials. Previous studies have shown that probiotic supplements can enhance immunity and overall flock health, leading to reduced antimicrobial use (Maina *et al.*, 2019). Additionally, vaccination prevents infections and reduces the reliance on antimicrobials. Proper vaccination schedules protect against common poultry diseases prevalent in Ethiopia, such as Newcastle disease and infectious bursal disease. Furthermore,

consulting with veterinarians to design an effective vaccination program is crucial for Ethiopian poultry farmers (Asfaw *et al.*, 2021; Guteta, 2021; Habte *et al.*, 2017). Furthermore, biosecurity practices such as isolating new birds, controlling visitor access, and maintaining hygiene too are critical to preventing the introduction and spread (Mudenda *et al.*, 2023; Selaledi *et al.*, 2020). A robust biosecurity plan tailored to Ethiopian poultry farms (Ismael *et al.*, 2021; Melkamu *et al.*, 2016; Tsegaye *et al.*, 2023; Waktole *et al.*, 2023) can significantly reduce the incidence of diseases, minimizing the need for antimicrobials. Responsible use involves following dosage guidelines, administration routes, and exploring non-antibiotic alternatives. Ethiopian poultry sectors can maintain flock health by implementing best practices and minimizing the risks associated with AMR (Fekadu *et al.*, 2022; Habte *et al.*, 2017).

2.6.3. Challenges in Implementing Responsible Practices

Poultry farming in Ethiopia operates within tight profit margins and purchasing newer and more effective antimicrobials which can strain limited budgets. Consequently, farmers may go for cheaper alternatives or suboptimal dosages to save money. However, responsible AMU often requires higher-quality antimicrobials, which come with a price. Therefore, farmers must weigh the short-term cost of treatment against long-term benefits, such as reduced AMR and improved flock health (Abadula *et al.*, 2022; Yemane *et al.*, 2016). Animal producers often follow established routines based on tradition or convenience, and breaking habits is challenging, especially when it comes to changing AMU practices. Even if farmers are aware of best practices, they can default to familiar routines (Kakooza *et al.*, 2023). Thus, introducing new practices requires behavior change, and farmers may resist adopting responsible AMU due to inertia or fear of disturbing their existing adaptations (IACG, 2018; Speksnijder *et al.*, 2015).

Farmers' behaviors towards AMU are influenced by their social networks, and if peers continue old practices, it reinforces the status quo (current status). Therefore, it is essential to encourage collective change within farming communities (Kiambi *et al.*, 2021). Overcoming resistance involves education, motivation, and support. Addressing economic constraints and overcoming behavioral barriers are critical to promoting responsible AMU. As concluded by Habiba *et al.* (2023), customized interventions, economic incentives, and community engagement can help poultry farm owners/workers transition to more sustainable practices.

2.7. Impact of Knowledge and Attitudes on Actual Practices

2.7.1. Knowledge-Practice Gaps

Antimicrobials are widely used in the poultry industry worldwide, including in Ethiopia. However, many Ethiopian farmers do not know how to use them properly and safely (Sambo *et al.*, 2015). They often ignore the risks associated with antimicrobial residues in poultry products and the emergence of resistance within poultry pathogens (Gebeyehu *et al.*, 2021). It has also been indicated in the book section by Agyare *et al.* (2019) that only a few farmers are aware of these issues, and even fewer follow the advised withdrawal and antimicrobial use practices. Farmers have different levels of knowledge and concern about the pros and cons of AMU. Their KAPs depend on factors such as education level, farming experience, information sources, and veterinary support (Oloso *et al.*, 2022). Many farmers believe that antimicrobials are more beneficial than harmful and use them based on personal or peer recommendations rather than veterinary advice (Kiambi *et al.*, 2021).

As emphasized in worldviews on evidence-based nursing by Westerlund *et al.* (2019), the knowledge-practice gap refers to the disparity between what individuals know (knowledge) and what they actually do (practices). In the context of poultry farming, this gap manifests itself when farmers possess information about responsible AMU but fail to implement it consistently. Farmers may be aware of best practices, but face challenges in translating that knowledge into daily routines (Alhaji *et al.*, 2018; Siddiky *et al.*, 2022). Habitual practices often override newly acquired knowledge, and limited resources such as time, finances, and labor further affect the adoption of recommended practices (Esha, 2023; Mudenda *et al.*, 2023).

Attitudes play a crucial role in bridging the gap, where positive attitudes toward responsible AMU enhance the likelihood of implementing best practices, while negative attitudes, such as skepticism about AMR risks, hinder behavior change. As a result, antimicrobial use patterns and practices in poultry farming are often irrational and inappropriate (Odey *et al.*, 2024), as many farmers lack knowledge and awareness of how to use antimicrobials correctly, in terms of dose, timing, or frequency so that farmers who raise animals must understand and abide by the principles of AMR, withdrawal times, and residues (Ragassa and Berhanu, 2023). Moreover, many poultry farmers are indifferent to the environmental impact of antimicrobial

use and do not know how to use them wisely. They also lack the skills or motivation to adopt alternative methods that can reduce their reliance on antimicrobials (Mudenda *et al.*, 2023).

2.7.2. Behavioral Concepts

The Theory of Reasoned Action (TRA) postulates that behavioral intentions are influenced by attitudes and subjective norms (Al-Suqri and Al-Kharusi, 2015). In the context of AMU, this means that the positive or negative evaluations of the responsible AMU practices, along with their perceptions of social pressure (for example, peer expectations, veterinarian advice), shape their intentions and drive their actual practices (Kiambi *et al.*, 2021; Shahi *et al.*, 2023; Speksnijder *et al.*, 2015). The Theory of Planned Behavior (TPB) extends TRA by adding the concept of perceived behavioral control (Siqueira *et al.*, 2022). This theory highlights that farmers' beliefs about their ability to perform responsible AMU significantly impact their practices. High perceived control leads to better adherence to responsible AMU practices (Shahi and Jamsripong, 2024; Ssajjakambwe *et al.*, 2023).

These theories guide interventions such as educational campaigns, skills training, and peer influence. Educational campaigns aim to improve knowledge-attitude component and emphasizing social (subjective) norms. Skills training improves perceived behavioral control with practical routines, while peer influence uses social networks to reinforce positive attitudes and encourage behavior change (Frost *et al.*, 2018; Kallu *et al.*, 2024; McKernan *et al.*, 2021).

2.8. Exemplary Approaches on Antimicrobial Use and Resistance

2.8.1. Optimizing Antimicrobial Use and Combating Resistance

It is critical to monitor and control AMU in poultry production, ensuring that the levels of residues in chicken products within the maximum residual limits (MRLs) set by food safety authorities (Anwar *et al.*, 2023). The One Health concept calls for collaboration among various agricultural system components (Mudenda *et al.*, 2023), when the relationship between animal, human, and environmental health is recognized. In addition, implementing prevention and control strategies such as biosecurity, sanitation, hygiene, immunization, and disease surveillance helps reduce the need for antimicrobials (Iredell, 2019). Apart from that, what is notably needed is AMS improvement, which includes creating and implementing rules,

guidelines, and policies for prudent AMU, as well as educating and training farmers, veterinarians, and other pertinent individuals (Chilawa *et al.*, 2023).

Furthermore, according to Tartari *et al.* (2017), it is critical to track and document AMU and AMR data (the types, amounts, and patterns of antimicrobials used, as well as the frequency and patterns of resistant bacteria) in poultry industry. This intervention encourages research and innovation to find and support new methods to prevent and treat poultry infections, such as vaccines, probiotics, phages, and low-resistance antimicrobials (Scarafilo, 2016). Ethiopia has developed its first National Poultry Development Strategy (NPDS), which aims to enhance the sustainable development of the poultry subsector and contribute to the country's food and nutrition security, income generation and poverty reduction (Shapiro *et al.*, 2020).

As a result, prophylactic and metaphylactic use of antibiotics should be limited and controlled according to NPDS recommendations. To prevent and control poultry illnesses, alternative interventions to AMU should be implemented, such as improved biosecurity, hygiene, immunization, and nutritional supplements (Gebeyehu *et al.*, 2021). Additionally, to minimize side effects and slow the spread of AMR, the strategy promotes integrated interventions that support the optimal selection, dosage, and duration of antimicrobial therapy. Collaboration among all stakeholders, including veterinarians, farmers, feed manufacturers, pharmaceutical firms, regulators, and consumers, is crucial. The approach should be grounded in evidence-based guidelines, surveillance and education, as suggested by Fekadu *et al.* (2022).

Educating consumers, policymakers, and the media about the dangers and repercussions of AMR, as well as the advantages of cautious AMU and ethical poultry farming practices, is the ultimate but certainly not least line of attack (Orubu *et al.*, 2020). Ethiopia has just released its third One Health strategy plan for 2021–2025, which aims to prevent and contain AMR and draws on the successes and difficulties of previous plans (Muhie, 2019). The International Centre for Antimicrobial Resistance Solutions (ICARS), which works with the Ethiopian Ministry of Agriculture and the Food and Agriculture Organization of the United Nations, is one example of an ongoing initiative and project that aims to optimize AMU and combat AMR in poultry farms in Ethiopia (Sammataro and Yoder, 2023).

2.8.2. Case Studies and Success Stories

A notable case study involves a large broiler farm in the United States that faced high mortality rates due to bacterial infections. The farm implemented a comprehensive vaccination program targeting common poultry pathogens, resulting in a significant decrease in mortality and a reduced reliance on antibiotics for disease treatment. This case underscores the importance of vaccination in preventing infections and reducing the need for drugs. Regular monitoring and adjustment of vaccination schedule are crucial for persistent success (Agyare *et al.*, 2019).

Another effective intervention was conducted on small-scale layer farms in Belgium, where veterinarians provided farm-to-farm training sessions and introduced decision support tools, such as mobile apps, which offered dosage recommendations and withdrawal periods. This intervention led to improved farmer knowledge related to AMU guidelines and increased compliance on withdrawal periods. Tailored training sessions and user-friendly tools were found to improve responsible practices effectively (Mulchandani *et al.*, 2023).

A successful behavioral change campaign, ‘Antibiotics are not always the answer’, was initiated in the United Kingdom by a regional health department in collaboration with poultry associations. The campaign included educational workshops for farmers, veterinarians, and extension officers, public awareness events that emphasize responsible AMU, and the distribution of leaflets and posters. Main points from this campaign include community engagement and clear messaging to drive behavior change, as well as the reinforcement of positive attitudes through consistent campaigns (Emes *et al.*, 2023).

2.9. Conceptual Framework

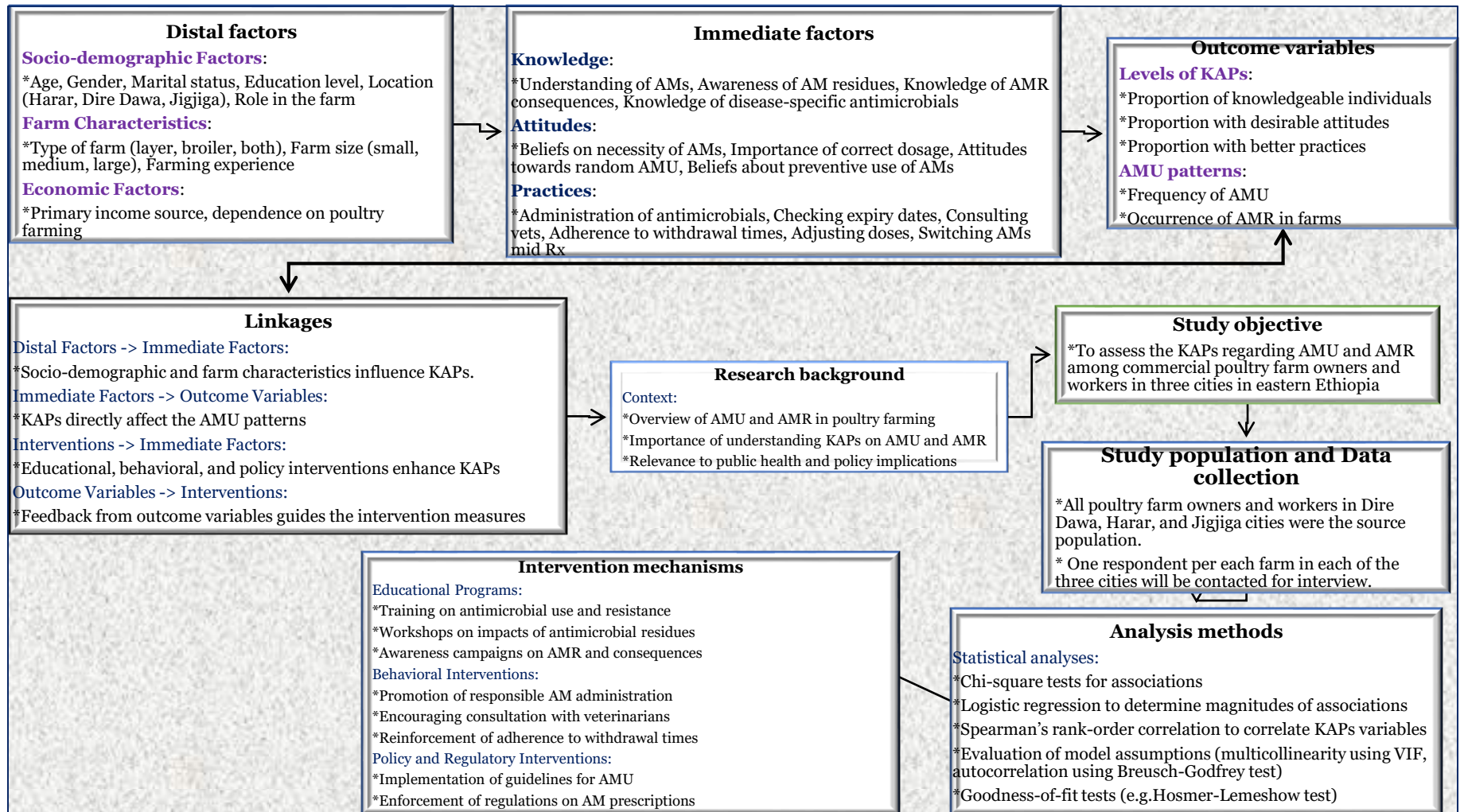


Figure 1. Schematic flow diagram demonstrating a conceptual framework

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted in three cities located in eastern Ethiopia: Harar, Dire Dawa, and Jijjiga. Dire Dawa is one of the largest urban centers in the country, positioned near the border with Somalia. As of 2023, its population is approximately 551,000, making it the second-largest chartered city in Ethiopia after Addis Ababa (CSA, 2023). Situated at an elevation of 1,276 meters above sea level on the Dechatu River, Dire Dawa is encircled by a ring of cliffs. As represented in figure 2 below, it is situated between the coordinates of 9°27'30" and 9°45'00" N latitude, and 41°43'30" and 42°15'00" E longitude (USAID/Ethiopia, 2020). Dire Dawa experiences a semi-arid climate, with an annual average rainfall of 629 mm and an average temperature of 23.9°C. Dire Dawa stands as an industrial and commercial hub, featuring several markets and the Dire Dawa Airport. The city is also renowned for its significant poultry farming industry, comprising both large and small-scale farms producing eggs and meat for local and national markets (Keffale and Mume, 2015). As of 2022, the Dire Dawa Administration Council estimated the total number of chickens to be 98,858 (CSA, 2022).

Harar, the capital city of both Harari Region and the East Hararghe Zone, had an estimated population of 283,000 as of 2023 (CSA, 2023). Perched on a hilltop at an elevation of 1,885 meters above sea level, Harar is encircled by a historic wall with five gates. The city enjoys a subtropical highland climate, with an average annual rainfall of 782 mm and an average temperature of 19.3°C. Harar is geographically located between 9°15'00" and 9°18'50"N latitude, and 42°02'30" and 42°18'40"E longitude as in figure below (USAID/Ethiopia, 2020). Renowned for its rich history and culture, Harar is regarded as the fourth holiest city in Islam, home to 82 mosques and 102 shrines. The city is also celebrated for its traditions and distinctive coffee. Predominantly inhabited by Harari people, who possess their own language and culture, Harar also accommodates various other ethnic groups, including Oromo, Amhara, Somali, and Gurage. In 2022, the poultry population in Harar was estimated to be 85,180 (CSA, 2022).

Jigjiga, the capital city of the Somali Regional State, has an estimated population of 428,759 as of 2023 (CSA, 2023). It is situated at coordinates $9^{\circ}21'00''\text{N}$ and $42^{\circ}48'00''\text{E}$ (USAID/Ethiopia, 2020). The region is predominantly inhabited by pastoral and agro-pastoral communities who rely on livestock production for their livelihoods. With a high population density, Jigjiga is a significant source of livestock for both domestic and export markets. Human-animal interactions and consumption habits are notably high in the area. Frequent cross-border movements of pastoral communities and their livestock to neighboring countries, such as Djibouti and Somalia, are common. Located in the Jigjiga Zone, the city is approximately 106 km east of Harar and 628 km from Addis Ababa. Jigjiga sits at an elevation of 1,609 meters above sea level and experiences a subtropical mid-highland climate influenced by nearby mountains. This climate results in hot and dry summers with cold winters. The city's average temperature ranges between 25 to 31°C , and its annual rainfall varies from 11 to 712 mm. Humidity levels range between 45% and 70%. As of 2022, the total poultry population in the Somali region was estimated to be 383,756 (CSA, 2022).

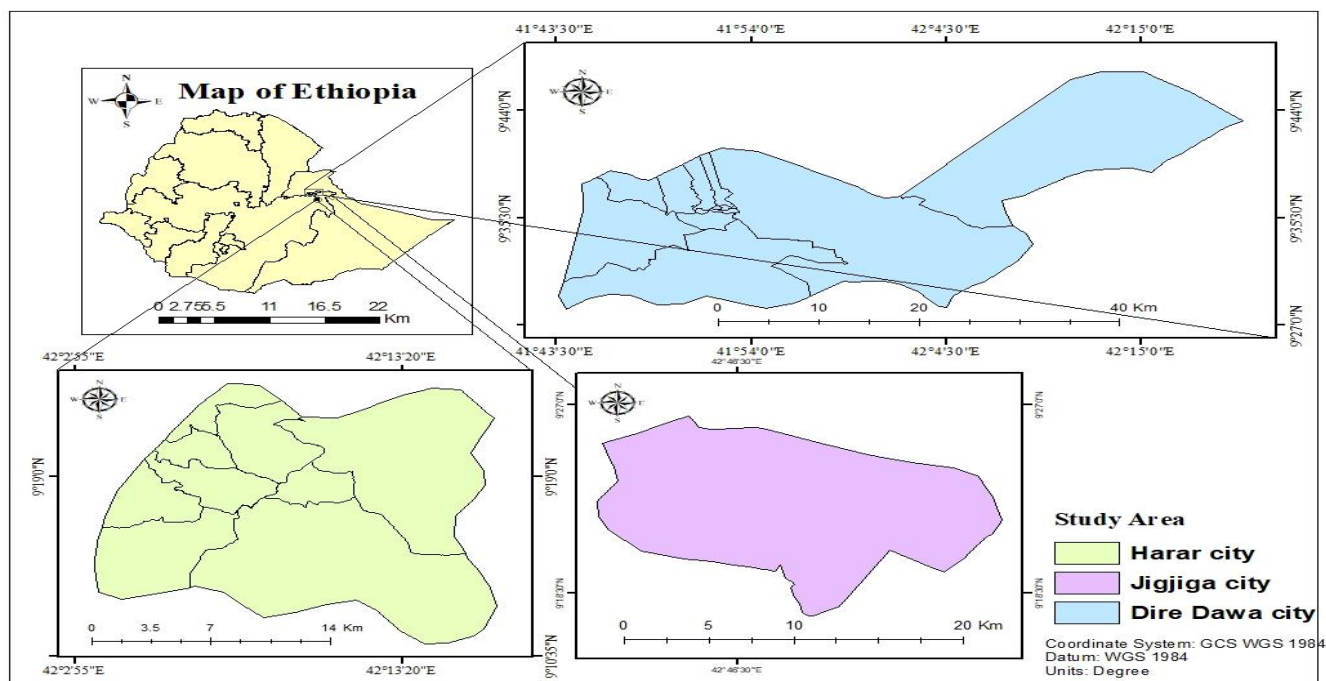


Figure 2. Map of Dire Dawa, Harar and Jigjiga cities, Eastern Ethiopia (Source: ESRI, 2024).

3.2. Study Population

Our source population were all owners and workers of poultry farms with (small-scale (100 up to 1,000), medium (1,001 up to 10,000), and large-scale (above 10,000 chickens)) in these cities. The farm scale was adapted from Wondmeneh *et al.* (2017). All registered poultry farms in the study areas were recruited into the study so that poultry farm owners/workers in each city were considered as our target and study population.

3.3. Study Design

A cross-sectional study was conducted to assess level of KAPs among commercial poultry farm owners and/or workers regarding antimicrobial use and resistance in Dire Dawa, Harar and Jigjiga cities from March to December of 2024.

3.4. Sample Size and Sampling Technique

Checklists of registered poultry farms from the agricultural offices of the three cities were obtained and enrolled for the survey. Based on this, a total of 106 commercial poultry farms, 48, 36, and 22 from Dire Dawa, Harar, and Jigjiga cities, respectively, were engaged for the study. From each farm, we contacted one person (either a farm owner, manager, or poultry health expert). Because, those individuals were the ones most commonly involved in practices related to AMU and AMR in the poultry farms.

3.5. Data Collection Methods and Quality Assurance

3.5.1. Data collection procedures

Structured questionnaire (Appendix 2) with six sections including: demographic information, characteristics within the farm, AMU on the farm, Knowledge, Attitudes, and Practices of poultry farm owners/workers supported by face-to-face interviews which were designed based on the Theory of Planned Behavior and the literature report (IACG, 2018), and was developed after performing a thorough literature review on comparable studies (Speksnijder *et al.*, 2015). The questionnaire contained 52 questions, of which seven open-ended and forty-five closed-ended about the socio-demographics (eight questions), farm characteristics (seven questions),

antimicrobial use on the farm (six questions), knowledge about AMU and AMR (eleven questions), their attitudes (nine questions), and eleven questions about their self-reported practices. Antimicrobial resistance was not taken as a separate section; rather, it was included in questions under knowledge, attitudes, and practices. The questionnaire was prepared in English and translated into local languages (Afan Oromo and Amharic) for easy communication with respondents who are not elite. The questionnaire was reviewed and assessed for its content, design, relevance, and plausibility.

3.5.2. Data Quality Control and Validation

A pilot study as a feasibility study was conducted in Maya city to check reliability of the survey tool on 12 participants from 12 farms, that was fortunately around 10% of the study population. Cronbach's alpha test statistic was used to measure internal consistency and reliability by assessing how closely a set of items (questions) was related within the scale. The alpha test output gave us scale reliability coefficients of 0.9018, 0.8529, and 0.8970 for knowledge, attitudes, and practices, respectively. Generally, a Cronbach's alpha value of greater than a lower threshold of 0.7 revealed good internal consistency for the measurement instrument as indicated by Nunnally (1994). Consequently, the results in our pilot study demonstrated that the reliability of the survey tool which was found to be worthy and feasible to conduct the study consistently. Being from separate city, the data from pilot survey was not included in the final survey for the sake of independence of each information. Lastly, data collection was employed by the investigator and assistants from each study area.

3.6. Scoring Methods

Knowledge was measured by assessing the understanding of AMU and AMR, where yes/no questions used to evaluate that knowledge. A score of 1, and 2 was assigned for the dichotomous response alternatives, 1 for unintended and 2 for intended response which was answered by either 'Yes' or 'No'. A mean score of all individual responses to each knowledge-based question was computed and compared with a grand mean (average of all mean knowledge scores) as it was adapted from previous guidelines (Merica *et al.*, 2018; WHO, 2008). The grand mean for knowledge level in the current study was found to be 1.56, where participants with a mean knowledge score ≤ 1.56 were categorized as poor knowledge, while those with > 1.56 as

good knowledge. Ultimately, knowledge variable was appended as a final column in Excel Spreadsheet, being outcome variable for the knowledge section of data.

Subsequently, attitude was measured by assessing beliefs and opinions towards AMU and AMR. Responses to attitude-related questions were graded on a three-point Likert scale as agree, uncertain, and disagree (Likert, 2017), and assigned their respective points (larger score for the most expected response). Finally, mean scores across each attitude-related questions were obtained from a sum totals for all respondents. The grand mean for three-point Likert scale was found to be 2.15. Individual attitude-scores were categorized into two as ‘undesirable’ and ‘desirable’ with values ≤ 2.15 and > 2.15 , respectively.

Finally, practices were measured by evaluating the actual behaviors related to AMU, where “yes/no/do not know or not sure” answers were used to evaluate the practices. A mean practice score was computed in the way as above (Knowledge- and Attitudes-sections) and then assigned values of three, two, and one, respectively for each, along with the degree of their expectedness in the descending order. The mean was used as a cut-off point to categorize each respondent’s practice score into two, those with a mean practice scores of ‘less or equal to the grand mean (suboptimal practices)’ and ‘above the grand mean (better practices)’, assigning to that values of 0 and 1, respectively. Then, a general practice was put into the variable section as the response variable. Better or positive practices are exemplified by activities like proper AMU and adherence to guidelines, while suboptimal practices by irrational/misuse, underuse, overuse and the like. In general, scores above the mean indicate better knowledge, appropriate practices, and desirable/positive attitudes, whereas scores below or equal to the mean represent a lack of knowledge, suboptimal practices, and undesirable/negative attitudes.

3.7. Data Management and Analysis

The data entered into MS Excel Spreadsheet (2016) were cleaned and edited to ensure its accuracy and consistency. Securely stored and encoded data was analyzed using Stata/SE version 14. The Chi-square test was used to assess the association between socio-demographic information and the KAPs level of commercial poultry farm owners and workers, while binary logistic regression analysis was used to assess the magnitude of association by using odds ratio

between AMU and AMR knowledge, attitudes, and practices with their respective explanatory variables.

The assumptions of the constructed models were rigorously evaluated to ensure their robustness and reliability. Before the regression analysis, data were screened for missing values and multicollinearity using Variance Inflation Factor (VIF). Variance Inflation Factor values between 1 and 5 indicated acceptable levels of multicollinearity as per Liao and Valliant (2012). This ensured that the explanatory variables were sufficiently independent from each other. For any instances of high multicollinearity, variables were either removed or combined.

Autocorrelation was likely assessed using tests such as the Breusch-Godfrey test and robust standard errors, ensuring that residuals from the regression models did not exhibit autocorrelation, which could bias the results. Additionally, model fitness was diagnosed using goodness-of-fit tests (Hosmer-Lemeshow test) to ensure that the final constructed models were robust and reliable. Moreover, Spearman's rank-order correlation was used to determine the relationship and direction of association between the mean scores of the outcome variables (KAPs), where correlation coefficients set as weak ($0 < |r| < 0.3$), moderate ($0.3 \leq |r| < 0.5$), or strong ($0.5 \leq |r| < 1$) positive/negative association (Schober and Schwarte, 2018). Finally, the data were interpreted, organized and presented using tables, graphs, and narratives, as appropriate.

3.8. Operational Definitions

Poultry farmers in this context indicate individuals or groups who raise chickens for commercial purposes in the Dire Dawa, Harar, and Jigjiga cities. We have identified and selected poultry farm owners/workers (either the farm owner, manager, focal person, or poultry health expert) for the study by using a sampling technique that ensures the representativeness and generalizability of our results.

Knowledge is the capacity to acquire, retain and use information; a mixture of comprehension, experience, discernment, and skill (Lee *et al.*, 2021). Knowledge of poultry farmers on AMU and AMR was measured by using a questionnaire run by a face-to-face interview that asks about the principles, risks, and consequences of AMU and AMR in poultry production, human health, and the environment.

Attitude is the degree of acceptance or willingness to adopt a certain behavior or practice (Lee *et al.*, 2021). The attitude of poultry farm owners/workers towards prudent AMU and AMR practices was measured by using a Likert scale asking them to rate their level of agreement or disagreement with a set of statements about rational and prudent use of antimicrobials, emergence and spread of AMR, and preventive measures to reduce the need for antimicrobials in poultry farming.

Practice is the actual application of knowledge and attitude in real life situations (Lee *et al.*, 2021). The practice of poultry farm owners/workers regarding AMU and AMR was measured by observation and/or questioning.

Behavior is the observable actions or responses of individuals or groups (Caudell *et al.*, 2020). In our case, the behavior of poultry farm owners/workers related to AMU and AMR was observed by assessing the compliance or adherence of respondents to the recommended AMU and AMR guidelines.

Awareness is the degree of knowledge or understanding of a certain topic or issue (knowledge or understanding of AMU and AMR in our case) according to Hassan *et al.* (2021).

Antimicrobial use refers to the use of antimicrobials for therapeutic, preventive, or growth-promoting purposes in poultry production systems (Geta and Kibret, 2021; Hassan *et al.*, 2021).

Patterns are the regularities or trends observed in the data or behavior (Oluwasile *et al.*, 2014). It refers to the way antimicrobial drugs (such as antibiotics) are used within a specific context, including information on quantification of antimicrobial use, the timing of treatment (e.g., animal age and weight), and the types of antimicrobials used. Understanding the AMU pattern is crucial to address AMR and promote responsible use of these drugs (Kasabova *et al.*, 2021).

Chemoprophylaxis refers to the administration of veterinary medicinal products to healthy animals with the goal of preventing infection based on a recognized risk or potential consequences. It is typically used to prevent the occurrence of infectious diseases in individual animals, unlike metaphylaxis (which targets a group of animals, a mass-medication).

The decision to use chemoprophylaxis should be made by a veterinarian, considering epidemiological and clinical knowledge, and documented appropriately (Baptiste and Pokludová, 2020).

3.9. Ethical Considerations

After informing about the purpose, methods, risks, and benefits of the investigation to the respondents and any other concerned bodies, their willingness was obtained by written informed consent prior to collecting data (Appendix-1). The confidentiality of all participants was carefully reserved.

4. RESULTS

4.1. Socio-Demographic Information of the Study Participants

The study included participants from three eastern Ethiopian cities: Harar (33.9%), Dire Dawa (45.3%), and Jigjiga (20.8%). The majority of participants were male (83.02%), with the largest group being 36-45 years of age (42.4%). A higher proportion of participants were married (54.7%), and either diploma or degree holders (33.9%). Most participants operated layer farms (58.5%), followed by farms with both layers and broilers (24.5%). Participants primarily operated small-scale (54.7%) and medium-scale farms (41.5%), higher percentage with less than three years farming experience (48.11%). The poultry farms were categorized into small-scale (100 to 1,000 chickens), medium-scale (1,001 to 10,000 chickens), and large-scale (above 10,000 chickens), following the classification by Wondmeneh *et al.* (2017). Majority of the respondents were farm owners (54.7%), and those who did not depend on poultry farming as their primary source of income constituted comparably higher (53.8%) proportion (Table 1).

4.2. Socio-Demographics Versus Knowledge, Attitudes and Practices

The chi-square analysis revealed several socio-demographic factors that significantly influenced knowledge levels towards AMU and AMR. Conversely, location did not have a significant impact ($p=0.905$), suggesting uniform awareness across Harar, Dire Dawa, and Jigjiga. Gender also did not significantly affect knowledge levels ($p=0.658$), with only 22.2% of females and 27.3% of males with good knowledge. Education level was highly significant ($p<0.001$), where those with higher education levels (diploma/degree or above) had significantly good knowledge (61.1%). Furthermore, farm size ($p=0.048$) and farming experience ($p<0.001$) were also significant, with larger farms (75.0%) and those with more than five years of experience (77.8%) having higher knowledge levels. The role in the farm was critical, with health experts being predominantly of good knowledge (68.4%, $p<0.001$).

The attitudes of commercial poultry farm owners and workers towards AMU and AMR were influenced by several socio-demographic factors, although not all showed statistical significance. Some socio-demographic characteristics did not significantly impact attitudes,

with approximately similar levels of desirable attitudes across regions, age categories, marital statuses, and primary income source. However, the type of farm showed a significant association ($p=0.044$), with those managing both layers and broilers displaying more desirable attitudes (69.2%). Farm size showed a marginally non-significant association ($p=0.075$), with larger farms having better attitudes (75.0%). Farming experience was significantly associated with attitudes ($p<0.001$), with those having more than five years of experience showing the highest percentage of desirable attitudes (100.0%). Educational level also had a significant impact on attitudes ($p<0.001$), with higher education correlating with more desirable attitudes (86.1%). Gender of study participants showed a marginally non-significant association ($p=0.058$), with male respondents having more desirable attitudes (52.3%). The role within the farm was significant ($p=0.001$), with health experts showing better attitudes (57.9%).

The practices of study participants towards AMU and AMR were significantly influenced by various socio-demographic factors. To describe, location, gender, type of farm, farm size, and primary income source did not significantly affect practices. However, age showed a highly significant association with practices ($p=0.001$), with the 36-45 age group exhibiting better practices (62.2%). Marital status also significantly influenced practices ($p=0.001$), with married individuals showing higher percentages of better practices (51.7%). In the same way, education level had a significant impact on practices ($p<0.001$), with those holding a diploma or degree displaying better practices (97.2%). Farming experience was another critical factor ($p<0.001$), with individuals having more than five years of experience demonstrating better practices (70.4%). The role in the farm showed significant associations with practices ($p<0.001$), with health experts exhibiting better practices (43.6%). These findings emphasized the importance of targeted interventions to improve practices based on significant socio-demographic factors (Table 1).

Table 1. Socio-demographic information versus KAPs level of respondents on AMU and AMR

Variables		Knowledge		Attitudes		Practices		
		No.(%)	No.(%) good knowledge	X ² (P-value)	No. (%) desirable attitude	X ² (P-value)	No. (%) better practice	X ² (P-value)
Location	Harar	36 (33.9)	8 (22.2)	3.5(0.170)	15 (41.7)	1.7(0.436)	13 (36.1)	0.2(0.922)
	Dire Dawa	48 (45.3)	14 (29.2)		23 (47.9)		19 (39.6)	
	Jigjiga	22 (20.8)	10 (45.4)		13 (59.1)		9 (40.9)	
Gender	Female	18(16.98)	4(22.2)	0.65(0.419)	5(27.8)	3.6(0.058)	6(33.3)	0.3(0.609)
	Male	88(83.02)	28(31.8)		46(52.3)		35(39.8)	
Age category (years)	17-25	18(16.9)	3(16.7)	2.3(0.678)	8(44.4)	4.1(0.398)	4(22.2)	18.9(0.001)
	26-35	25(23.6)	7(28.0)		11(44.0)		4(16.0)	
	36-45	45(42.4)	16(35.6)		25(55.6)		28(62.2)	
	46-55	15(14.2)	5(33.3)		7(46.7)		4(26.7)	
	56-65	3(2.8)	1(33.3)		0(0.0)		1(33.3)	
Marital status	Unmarried	48(45.3)	10(20.8)	3.6(0.056)	22(45.8)	0.2(0.667)	10(18.8)	11.8(0.001)
	Married	58(54.7)	22(37.9)		29(50.0)		31(51.7)	
Level of education	No education	10(9.4)	2(20.0)	24.9(<0.001)	3(30.0)	22.3(<0.001)	2(20.0)	79.4(<0.001)
	Primary school	30(28.3)	4(13.3)		13(43.3)		2(6.7)	
	High school	30(28.3)	4(13.3)		13(43.3)		2(6.7)	
	Diploma/degree	36(33.9)	22(61.1)		22(61.1)		35(97.2)	
Type of farm	Layer	62(58.5)	17 (2.4)	1.9 (0.593)	31 (50.0)	8.1(0.044)	23 (37.1)	3.7(0.294)
	Broiler	4(3.8)	0 (0.0)		0 (0.0)		0 (0.0)	
	Both	26(24.5)	8 (30.8)		18 (69.2)		12 (46.2)	
	Neither	14(13.2)	3 (21.4)		9 (64.3)		4 (28.6)	
Farm size	Small-scale	58(54.7)	12 (20.7)	6.1(0.048)	26 (44.8)	5.2(0.075)	20 (34.5)	0.5(0.780)
	Medium-scale	44(41.5)	13 (29.5)		29 (65.9)		17 (38.6)	
	Large-scale	4(3.8)	3 (75.0)		3 (75.0)		2 (50.0)	
Farming experience (in years)	<3	51(48.11)	3 (5.9)	49.8(<0.001)	17 (33.3)	32(<0.001)	11 (21.6)	18.4(<0.001)
	3-5	28(26.42)	4 (14.3)		14 (50.0)		9 (32.1)	
	>5	27(25.4)	21 (77.8)		27 (100.0)		19 (70.4)	
Role in the farm	Farm owner	58(54.7)	10(17.2)	17.8(<0.001)	28(48.3)	13.6(0.001)	13(22.4)	27.1(<0.001)
	Manager	29(27.4)	9(31.0)		12(41.4)		11(37.9)	
	Health expert	19(17.9)	13(68.4)		11(57.9)		17(43.6)	
1 ^o income source	No	57(53.77)	17(29.8)	0.01(0.930)	26(45.6)	0.3(0.579)	19(33.3)	1.5(0.223)
	Yes	49(46.23)	15(30.6)		25(51.02)		22(44.9)	
			32(30.2%)		51(48.1%)		41(38.7%)	

Note that: X² = Chi-square, No. = number, % = percentage, 1^o = primary

4.3. Characteristic Features within the Farms

The distinctive characteristics within commercial poultry farms in the study areas indicated important viewpoints into the poultry farming scene with highest proportion (45.3% (95% CI: 35.9-54.9%)) of farms found in Dire Dawa, followed by Harar with 34.0% (95% CI: 25.5-43.6%) and Jigjiga with 20.8% (95% CI: 13.9-29.7%). The majority of farms (93.4%, 95% CI: 86.6-96.8%) raised exotic breeds, while only a small fraction (6.6%, 95% CI: 3.1-13.4%) reared mixed breeds. Most of the farms (96.2%, 95% CI: 90.2-98.6%) were intensive, with only 3.8% (95% CI: 1.4-9.8%) semi-intensive systems. The source of feed also varied, with 57.6% (95% CI: 47.8-66.7%) of farms purchasing feed from market, 12.3% (95% CI: 7.2-20.1%) homemade feed, and 30.2% (95% CI: 22.1-39.7%) relying on both (homemade and market) sources.

Prevalent diseases within the farms revealed multiple health challenges, with Coccidiosis affecting 21.7% (95% CI: 14.8-30.7%) of farms, Newcastle Disease (NCD) 11.3% (95% CI: 6.5-19.0%), and Fowl typhoid 4.7% (95% CI: 1.9-11.0%). Co-infections were also common, with 16.0% (95% CI: 10.1-24.4%) of farms experiencing both Fowl typhoid and Coccidiosis, 22.6% (95% CI: 15.6-31.7%) suffering from NCD and Coccidiosis, and 18.9% (95% CI: 12.4-27.6%) facing the triple threat of NCD, Fowl typhoid, and Coccidiosis (Table 2).

Table 2. Distinctive characteristics within poultry farms under study

Variables		No. (%)	95% CI
Study location	Harar	36(34.0)	25.5-43.6
	Dire Dawa	48(45.3)	35.9-54.9
	Jigjiga	22(20.8)	13.9-29.7
Breed	Exotic	99(93.4)	86.6-96.8
	Mixed	7(6.6)	3.1-13.4
Housing system	Semi-intensive	4(3.8)	1.4-9.8
	Intensive	102(96.2)	90.2-98.6
Source of feed	From market	61(57.6)	47.8-66.7
	Homemade	13(12.3)	7.2-20.1
	Both	32(30.2)	22.1-39.7
Prevalent diseases	Coccidiosis	23(21.7)	14.8-30.7
	NCD	12(11.3)	6.5-19.0
	Fowl typhoid	5(4.7)	1.9-11.0
	Fowl typhoid, Coccidiosis	17(16.0)	10.1-24.4
	NCD, and Coccidiosis	24(22.6)	15.6-31.7
	NCD, and Fowl typhoid	5(4.7)	1.9-11.0
	NCD, Fowl typhoid, Coccidiosis	20(18.9)	12.4-27.6

Note that: N_0 = Number, CI = Confidence interval, NCD = Newcastle Disease

In order to keep track of disease occurrences and patterns within the poultry farms, the current study also considered enquiring about disease outbreak history within the last six months of the survey period. It helps for early detection and intervention. In view of that, 48 (45.3%) of the survey respondents (18 (37.5%) Harar, 23 (47.9%) Dire Dawa, and 7 (14.6%) from Jigjiga) reported that their poultry farms experienced no diseases within the last six months. Newcastle disease was reported by 19 (17.9%) of the participants (of which, 5(26.3%) Harar, 8 (42.1%) Dire Dawa, and 6 (31.6%) from Jigjiga), making it the most common disease encountered. Correspondingly, coccidiosis was reported by 17 (16.0%) of the respondents (3 (17.6%) Harar, 8 (47.1%) Dire Dawa, and 6 (35.3%) from Jigjiga), where fowl typhoid was relatively rare and affected only 6 (5.7%) of the farms (2 (33.3%) from Harar, and 4 (66.7%) from Dire Dawa). Anemia and cannibalism were each reported by 1 (0.9%) of the study participants from Harar, making them the least reported issues (Table 3).

Table 3. Diseases encountered on farms within last six months of the study period per study areas

Diseases occurred within the last six months of the study period	Number (%) Harar	Number (%) Dire Dawa	Number (%) Jigjiga	Number (%) subtotal (%)
No disease encountered	18 (37.5)	23 (47.9)	7 (14.6)	48 (45.3)
Coccidiosis	3 (17.6)	8 (47.1)	6 (35.3)	17 (16.0)
Newcastle disease	5 (26.3)	8 (42.1)	6 (31.6)	19 (17.9)
Fowl typhoid	2 (33.3)	4 (66.7)	0 (0.0)	6 (5.7)
Anemia	1 (100)	0 (0.0)	0 (0.0)	1 (0.9)
Coccidiosis and Newcastle disease	5 (38.5)	5 (38.5)	3 (23.1)	13 (12.3)
Anemia and Coccidiosis	1 (100)	0 (0.0)	0 (0.0)	1 (0.9)
Anemia, Coccidiosis and Cannibalism	1 (100)	0 (0.0)	0 (0.0)	1 (0.9)
			Grand total	106 (100%)

4.4. Antimicrobial Use within the Poultry Farms

The study on AMU among commercial poultry farm owners and workers in the three eastern Ethiopian cities presented several key points. To begin with, more than half (53.8%, 95% CI: 44.1-63.1) of respondents had used antimicrobials for dual purposes, both therapeutic and non-therapeutic uses. Non-therapeutic use alone accounted for 29.2% (95% CI: 21.3-38.7), while

purely therapeutic use was relatively low at 16.9% (95% CI: 10.9-25.5), indicating a preference for preventive measures over treatment (Table 4).

Regarding information sources for AMU, a significant proportion of respondents (40.6%, 95% CI: 31.5-50.3) rely on a combination of veterinarians and neighbors/colleagues. The reliance on multiple sources, including online platforms and social media, pointed out the diverse channels through which farmers seek information, reflecting both the accessibility of digital resources and the influence of community networks. The predominant use of biosecurity measures combined with vaccines (69.8%, 95% CI: 60.3-77.9) surpassed vaccines alone (30.2%, 95% CI: 22.1-39.7).

Commonly used antimicrobials contained combinations such as tetracyclines and amprolium (19.8%, 95% CI: 13.2-28.6), and enrofloxacin with other drugs (18.8%, 95% CI: 12.4-27.6), indicating a trend of multi-drug regimens to cover a broad spectrum of pathogens. The frequency of AMU varies, fortunately by similar proportion, 29.25% (95% CI: 21.3-38.7) administering antimicrobials only once every 2-6 months, and another 29.25% (95% CI: 21.3-38.7) using them 2-5 times per month. Barriers to changing AMU practices included limited availability of alternatives (42.45%, 95% CI: 33.3-52.2) and insufficient information on proper use (23.58%, 95% CI: 16.4-32.7), suggesting that improving access to resources and education could significantly affect AMU practices (Table 4).

Table 4. Proportion of antimicrobial use characteristics among respondents in the poultry farms

Variables with categories		No.(%)	95% C.I.
Purpose of AMU	Therapeutic	18(16.9)	10.9-25.5
	Non-therapeutic	31(29.2)	21.3-38.8
	Dual-purpose	57(53.8)	44.1-63.1
Information sources for AMU	Veterinarians	21(19.8)	13.2-28.6
	Neighbor/Colleagues	2(1.9)	0.5-7.4
	Veterinarians, Online platforms	9(8.5)	4.4-15.7
	Veterinarians, Neighbor/Colleagues	43(40.6)	31.5-50.3
	Veterinarians, Online platforms, Neighbor/Colleagues	16(15.09)	9.4-23.4
	Veterinarians, Social media, Neighbor/Colleagues	7(6.6)	3.1-13.4
	Online, Government agencies, Colleagues	1(0.9)	0.1-6.6
	Veterinarians, Government agencies, Colleagues	6(5.7)	2.5-12.2
Prevention methods	Biosecurity plus vaccine	74(69.8)	60.3-77.9
	Only vaccine	32(30.2)	22.1-39.7
Commonly used antimicrobials	Enrofloxacin	11(10.4)	5.8-17.9
	Tetracyclines	7(6.6)	3.1-13.4
	Tetracyclines, Amprolium	21(19.8)	13.2-28.6
	Enrofloxacin, Amprolium	10(9.4)	5.1-16.8
	Enrofloxacin, Amprolium, Sulfa	2(1.9)	0.5-7.4
	Tetracyclines, Amprolium, Sulfa	21(19.8)	13.2-28.6
	Enrofloxacin, Tetracyclines, Amprolium	20(18.8)	12.4-27.6
	Enrofloxacin, Tetracyclines, Doxycycline, Amprolium	1(0.9)	0.1-6.6
Frequency of AMU	Enrofloxacin, Tetracyclines, Amprolium, Sulfa	13(12.3)	7.2-20.1
	Only when chickens are ill	18(16.98)	10.9-25.5
	Once every 2-6 months	31(29.25)	21.3-38.7
	Once per month	26(24.53)	17.2-33.8
	2-5 times per month	31(29.25)	21.3-38.7
Barriers to change AMU	None	4(3.77)	1.4-9.8
	Low awareness about AMR	1(0.94)	0.1-6.6
	Insufficient info on proper AMU	25(23.58)	16.4-32.7
	Limited availability	9(8.49)	4.4-15.7
	Limited availability, Insufficient info on proper use	45(42.45)	33.3-52.2
	Limited availability, No alternatives to reduce AMU,	14(13.21)	7.9-21.2
	Low awareness		
	No alternatives to reduce use, Low awareness on AMR, Insufficient info	8(7.55)	3.8-14.5

Note that: AMU = Antimicrobial use, AMR = Antimicrobial resistance, No = Number, CI = Confidence interval

i4.5. Respondents' Level of Knowledge, Attitudes and Practices

The survey results indicated that only few 32(30.2%) respondents were of good knowledge about AMU and AMR, whereas less than half 51(48.1%) of them were with desirable attitudes, and about one third 41(38.7%) demonstrated better practices (Figure 3).

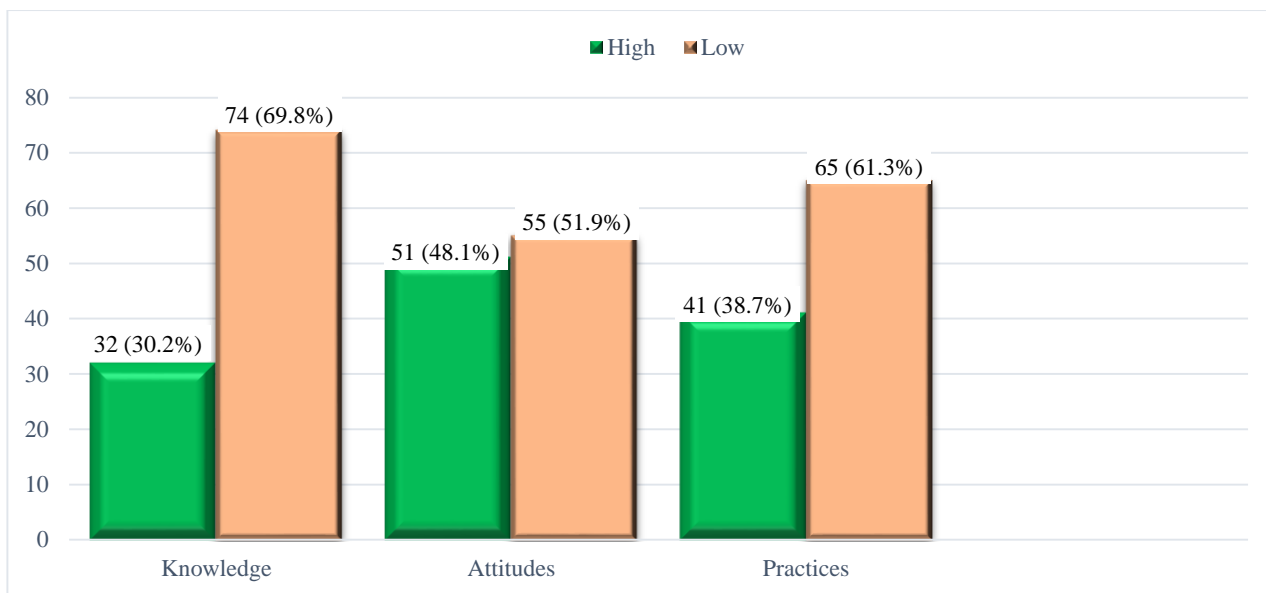


Figure 3. Overall percentage of KAPs level of respondents on Antimicrobial Use and Resistance

4.5.1. Knowledge about Antimicrobial Use and Resistance

The knowledge-based questionnaire responses from the study participants were categorized into two as intended for expected answers and unintended responses in case the answer is not what an investigator really expect from each respondent. The current survey result revealed that most commercial poultry owners and workers lack understanding of critical aspects of AMU and AMR. Although 91.5% know the correct body to prescribe antimicrobials, only 36.7% understand their purposes, and 32.1% recognized the effects of antimicrobial residues. Moreover, while 68.9% were aware of AMR consequences, only 34.9% can identify effective antimicrobials for specific diseases. In general, there is a significant knowledge gap that must be addressed to utilize antimicrobials better and mitigate resistance risks (Table 5).

Table 5. Questionnaire section regarding Knowledge of respondents on AMU and AMR

Knowledge-based questions	Responses	
	Intended (%)	Unintended (%)
Do you understand what antimicrobials are and their purposes?	39 (36.7)	67 (63.2)
Do you know a legally permitted body to prescribe antimicrobials?	97 (91.5)	9 (8.5)
Do you understand what antimicrobial residues are and their effects?	34 (32.1)	72 (67.9)
Do you know a concept of antimicrobial resistance (its consequences)?	73 (68.9)	33 (31.1)
Can you identify specific antimicrobials effective against particular diseases?	37 (34.9)	69 (65.1)
Do humans get affected by antimicrobials from eating poultry products?	38 (35.8)	68 (64.2)
Is it necessary to treat entire flock when a few birds show signs of illness to prevent an outbreak, even if it might lead to antimicrobial resistance?	73 (68.9)	33 (31.1)
Can antimicrobials be used to treat any type of disease in poultry?	85 (80.2)	21 (19.8)
Do all antimicrobials have the same healing effect on poultry diseases?	91 (85.8)	15 (14.2)
Do you suggest that it is better to use herbal remedies as substitutes for AMs?	21 (19.8)	85 (80.2)
Do you consider antimicrobials to be effective for treating all kinds of diseases?	68 (64.2)	38 (35.8)
	59.6 (56.2)	46.4 (43.8)

The mean of the expected responses in the survey questions alone may not be satisfactory to determine the knowledgeable of the study participants. Rather, mean scores were considered after which we found out the grand mean (mean of all the mean scores) and used it as a cut-off point. The study participants with mean scores above the grand mean were considered as with good knowledge while those with less or equal to the grand mean as of poor knowledge.

The logistic regression analysis results on the knowledge of respondents towards AMU and AMR revealed a number of significant findings. In the univariable analysis, location did not significantly affect knowledge levels, as indicated by almost analogous percentages of good knowledge individuals in Harar (22.2%), Dire Dawa (29.2%), and Jigjiga (45.4%), suggesting that regional differences in knowledge dissemination might be minimal. Overall, 30.2% (95% CI: 22.1-39.7) of respondents with good knowledge on AMU and AMR, while 69.8% (95% CI: 60.3-77.9) were not. Notably, respondents who understood antimicrobials were 25 times more likely (OR=24.7, 95% CI: 4.3-143.4, $p < 0.001$) to be knowledgeable about AMU and AMR. On the contrary, those unaware of antimicrobial residues were 99% less likely to be knowledgeable (OR = 0.01, 95% CI: 0.003-0.048, $p < 0.001$). Conversely, respondents informed about AMR were approximately twenty-four times more likely to be knowledgeable (OR = 23.6, 95% CI: 3.1-182.3, $p = 0.002$). Additionally, those familiar with disease-specific antimicrobials were

about thirty-five times more likely to be knowledgeable compared to those who were not (OR = 34.6, 95% CI: 10.8-110.7, $p < 0.001$).

On the other hand, respondents who were unaware about the transmission of antimicrobial residues to humans were significantly less likely to be knowledgeable about AMU and AMR, with the odds being 97.6% lower compared to those who understood (OR = 0.024, 95% CI: 0.01-0.08, $p < 0.001$). Likewise, respondents who were uninformed about the consistency of antimicrobials effectiveness were 69% less likely to be knowledgeable (OR=0.31, 95% CI: 0.1-1.0, $P = 0.042$). Conversely, participants who understood that antimicrobials as not equally effective against all diseases were about four times more likely to be knowledgeable (OR=4.3, 95% CI: 1.5-12.5, $P = 0.007$).

After adjusting for other variables, respondents who understood AMs were significantly more likely to be knowledgeable about AMU and AMR, with the odds being approximately 25-fold higher (OR=24.7, 95% CI: 4.3-143.4, $p < 0.001$) as compared to who did not. On the contrary, those who were unaware of antimicrobial residues were 98% less likely to be knowledgeable (OR=0.02, 95% CI: 0.004-0.116, $p < 0.001$). Moreover, respondents who knew disease-specific antimicrobials were fifty-four times more likely to be knowledgeable (OR=54.3, 95% CI: 5.7-514.8, $p = 0.001$). Again, respondents who were unaware about transmission ability of antimicrobial residues to humans was 99% less likely to be knowledgeable (OR=0.01, 95% CI: 0.001-0.083, $p < 0.001$). What is more, those who did not assume the general efficacy of antimicrobials (64.2%) were approximately nine times more likely to be knowledgeable about AMU and AMR (OR = 8.79, 95% CI: 1.2-64.9, $p = 0.033$) (Table 6).

Table 6. Respondents' knowledge about AMU and AMR analyzed by binary logistic regression

Variable	Univariable logistic regression analysis				Multivariable logistic regression analysis		
	Category	No. (%) of respondents	No. (%) of Knowledgeable	OR (95% CI)	P-value	OR (95% CI)	P-value
Location	Harar	36 (33.9)	8 (22.2)	Ref*	*	---	
	Dire Dawa	48 (45.3)	14 (29.2)	1.4 [.3668, 2.5426]	0.475	---	---
	Jigjiga	22 (20.8)	10 (45.4)	2.9 [.2223, 2.6303]	0.068	---	---
Understanding Antimicrobials	No	67 (63.2)	4 (5.9)	.02 [.0073, .0852]	<0.001	Ref*	<0.001
	Yes	39 (36.7)	28 (71.8)	Ref*			
Know prescription authority	No	9 (8.5)	3 (33.3)	Ref*	0.830	---	---
	Yes	97 (91.5)	29 (29.9)	.85 [.1996, 3.6452]			
Know Antimicrobial residues	No	72 (67.9)	4 (5.6)	.01 [.0033, .0481]	<0.001	.02 [.0037, .1161]	<0.001
	Yes	34 (32.1)	28 (82.4)	Ref*			
Information on AMR	No	33 (31.1)	1 (3.03)	Ref*	0.002	Ref*	0.399
	Yes	73 (68.9)	31 (42.5)	23.6 [3.059, 182.326]			
Know disease specific Antimicrobials	No	69 (65.1)	5 (7.2)	Ref*	<0.001	Ref*	0.001
	Yes	37 (34.9)	27 (72.9)	34.6 [10.7916, 110.6784]			
AM residues to humans	No	68 (64.2)	4 (5.9)	.024 [.0064, .0772]	<0.001	.01 [.0007, .0826]	<0.001
	Yes	38 (35.8)	28 (73.7)	Ref*			
Follow Rx protocols	No	33 (31.1)	8 (24.2)	Ref*	0.372	---	---
	Yes	73 (68.9)	24 (32.9)	1.53 [.6015, 3.8948]			
Applicability of AMs	Yes	21 (19.8)	8 (38.1)	Ref*	0.380	---	---
	No	85 (80.2)	24 (28.2)	.64 [.2354, 1.7368]			
Consistency of AMs effectiveness	Yes	15 (14.2)	8 (53.3)	Ref*	0.042	Ref*	0.799
	No	91 (85.8)	24 (26.4)	.31 [.1026, .9572]			
Herbal drug alternatives	No	85 (80.2)	22 (25.9)	Ref*	0.057	---	---
	Yes	21 (19.8)	10 (47.6)	2.6 [.9728, 6.9667]			
General efficacy of AMs	Yes	38 (35.8)	5 (13.2)	Ref*	0.007	Ref*	0.033
	No	68 (64.2)	27 (39.7)	4.3 [1.5079, 12.5278]			

Ref*=reference category, OR=Odds ratio, CI=confidence interval, Rx=treatment, AM(s)=antimicrobial(s), ---=the ones not passed univariable logistic regression analysis

4.5.2. Attitudes towards Antimicrobial Use and Resistance

The questionnaire revealed mixed attitudes of the study participants towards AMU and AMR. Although 61.3% understood the importance of using the right amount of antimicrobials every time, only 42.4% recognized that random use leads to resistance. Additionally, while 53.8% knew that not completing the full course of antimicrobials leads to resistance, 73.6% believed that regularly adding antimicrobials to feed is necessary despite the resistance risks (Table 7).

Table 7. Questionnaire section on Attitudes of respondents towards AMU and AMR

Attitudes-based questions	Responses	
	Intended (%)	Unintended (%)
Using antimicrobials randomly leads to antimicrobial resistance.	45 (42.4)	61 (57.6)
Not completing the full course of antimicrobials leads to resistance.	57 (53.8)	49 (46.2)
Regularly adding antimicrobials to poultry feed is necessary to prevent illness, despite the risk of antimicrobial resistance.	28 (26.4)	78 (73.6)
Limiting the use of antimicrobials causes more harm than good.	52 (49.1)	54 (50.9)
Using the right amount of antimicrobials every time is important.	65 (61.3)	41 (38.7)
Antimicrobials should be stored securely and handled only by trained personnel.	61 (57.6)	45 (42.4)
Using antimicrobials before they expire is better than discarding them.	49 (46.2)	57 (53.8)
Using herbal or medicinal alternatives to antimicrobials is preferable.	7 (6.6)	99 (93.4)
If people knew that careless use of antimicrobials could affect future recovery, they would use it less.	29 (27.4)	77 (72.6)
	43.7(41.2)	62.3 (58.8)

The logistic regression analysis results on the attitudes of poultry farm owners and workers towards AMU and AMR revealed several significant findings. Specifically, agreement on “the impact of random AMU” significantly increased the odds of having a desirable attitude towards AMU and AMR compared to being uncertain. In the univariable analysis, those who agreed were nearly four times more likely to have a desirable attitude (OR=2.32, 95% CI: 1.02-5.28, p=0.044), which was increased in the multivariable analysis (OR=3.94, 95% CI: 1.2-13.1, p=0.026), suggesting an even higher likelihood when adjusting for other variables.

The agreement on the statement “missing a dose matters” significantly increased the odds of having a desirable attitude towards AMU and AMR (OR=25.9, 95% CI: 3.1-215.5, p=0.003),

indicating a very strong association. This effect was still more noticeable in the multivariable analysis comparing the disagreed ones to those who were uncertain (OR=0.01, 95% CI: 0.003-0.502, $p=0.013$), underlining the critical importance of this belief. Disagreeing to regular addition of antimicrobials to poultry feed for disease prevention found to improve the likelihood of having desirable attitude (OR=4.04, 95% CI: 1.4-11.9, $p=0.011$). In the multivariable analysis, the odds of likelihood rose to about twenty-one times higher (OR=20.91, 95% CI: 3.8-115.0, $p<0.001$), indicating a stronger association when other factors were considered.

Agreeing that correct antimicrobial dosage was important significantly increased the odds of having a desirable attitude towards AMU and AMR (OR=5.87, 95% CI: 1.5-23.1, $p=0.011$) compared to disagreeing, indicating a very strong association. This effect was further supported in the multivariable analysis (OR=11.82, 95% CI: 1.8-76.7, $p=0.010$), highlighting the critical importance of this belief. Agreeing that access to antimicrobials should be controlled increased the odds of desirable attitudes by about five times (OR=4.71, 95% CI: 1.4-15.9, $p=0.013$), this association was found to be stronger after adjustment (OR=7.02, 95% CI: 1.4-34.0, $p=0.016$). Disagreeing with the idea “better to finish antimicrobials before expiration” considerably increased the odds of having desirable attitude about AMU and AMR (OR=9.79, 95% CI: 3.2-30.1, $p<0.001$), indicating a very strong association, which was slightly increased in the multivariable analysis (OR=10.01, 95% CI: 2.6-38.4, $p=0.001$).

Agreeing that “minimizing AMU for future recovery was important” significantly increased the odds of having a desirable attitude towards AMU and AMR (OR=9.95, 95% CI: 3.4-29.0, $p<0.001$) compared to disagreeing, indicating a strong association. This effect was even more pronounced in the multivariable analysis (OR=15.37, 95% CI: 4.0-59.0, $p<0.001$), highlighting the significant impact of this belief (Table 8).

Table 8. Attitudes of respondents on AMU and AMR analyzed using binary logistic regression

Variable	Category	No. (%) respondents	No. (%) with desirable attitude	Univariable logistic regression analysis		Multivariable logistic regression analysis	
				OR [95% CI]	P-value	OR [95% CI]	P-value
Location	Harar	36 (33.9)	15 (41.7)	Ref*	*	---	---
	Dire Dawa	48 (45.3)	23 (47.9)	1.29[.5387, 3.0793]	0.569	---	---
	Jigjiga	22 (20.8)	13 (59.1)	2.02 [.6884, 5.9409]	0.200	---	---
Impact of random AMU	Disagree	10 (9.4)	4 (40.0)	1.03[.2588, 4.1256]	0.963	3.31 [.4901, 22.3116]	0.220
	Uncertain	51 (48.1)	20 (39.2)	Ref*	*	Ref*	*
	Agree	45 (42.5)	27 (64.4)	2.32 [1.0244, 5.2766]	0.044	3.94 [1.1810, 13.1129]	0.026
Missing a dose matters	Disagree	13 (12.3)	1 (7.7)	Ref*	*	.04 [.0031, .5021]	0.013
	Uncertain	36 (33.9)	11 (30.6)	5.28 [.6091, 45.7715]	0.131	Ref*	*
	Agree	57 (53.8)	39 (68.4)	25.9 [3.1363, 215.5426]	0.003	3.07 [.9008, 10.4674]	0.073
Regular addition of AMs to feed for prevention	Agree	36 (34.0)	8 (22.2)	Ref*	*	Ref*	*
	Uncertain	42 (39.6)	28 (66.7)	7 [2.5384, 19.3035]	<0.001	13.45 [3.6369, 49.7656]	<0.001
	Disagree	28 (26.4)	15 (53.6)	4.04 [1.3698, 11.9061]	0.011	20.91 [3.8036, 115.0144]	<0.001
Restricting AMU harms	Agree	36 (33.9)	21 (58.3)	Ref*	*	---	---
	Uncertain	18 (17.0)	10 (55.6)	.89[.2851, 2.7964]	0.846	---	---
	Disagree	52 (49.1)	20 (38.5)	.45[.1876, 1.0621]	0.068	---	---
Correct antimicrobial dosage	Disagree	14 (13.2)	3 (21.4)	Ref*	*	Ref*	*
	Uncertain	27 (25.5)	8 (29.6)	1.54 [.3375, 7.0628]	0.576	3.79 [.5462, 26.2643]	0.178
	Agree	65 (61.3)	40 (61.5)	5.87 [1.4894, 23.1085]	0.011	11.82 [1.8209, 76.6710]	0.010
Controlling access to antimicrobials	Disagree	18 (17.0)	4 (22.2)	Ref*	*	Ref*	*
	Uncertain	27 (25.5)	12 (44.4)	2.8 [.7289, 10.7547]	0.134	4.36 [.7664, 24.8282]	0.097
	Agree	61 (57.5)	35 (57.4)	4.71 [1.3888, 15.9841]	0.013	7.02 [1.4483, 34.0426]	0.016
Finish antimicrobials before expiring	Agree	31 (29.2)	5 (16.1)	Ref*	*	Ref*	*
	Uncertain	26 (24.5)	14 (53.8)	6.07 [1.7750, 20.7356]	0.004	6.43 [1.4598, 28.3503]	0.014
	Disagree	49 (46.2)	32 (65.3)	9.79 [3.1828, 30.1020]	<0.001	10.01 [2.6094, 38.3876]	0.001
Prefer herbal remedies to AMs	Disagree	42 (39.6)	13 (30.9)	Ref*	*	---	---
	Uncertain	57 (53.8)	34 (59.6)	3.29 [1.4216, 7.6493]	0.005	---	---
	Agree	7 (6.6)	4 (57.1)	2.97 [.5806, 15.2363]	0.191	---	---
Minimizing AMU for future recovery	Disagree	50 (47.2)	12 (24.0)	Ref*	*	Ref*	*
	Uncertain	27 (25.5)	17 (62.9)	5.38 [1.9499, 14.8626]	0.001	5.21 [1.6230, 16.7095]	0.006
	Agree	29 (27.3)	22 (75.9)	9.95 [3.4142, 29.0110]	<0.001	15.37 [4.0081, 58.9476]	<0.001

4.5.3. Self-reported Practices Regarding Antimicrobial Use in Farms

The self-reported practices of the respondents revealed significant gaps regarding AMU and AMR. Although 77.4% found it unnecessary to use antimicrobials during the brooding stage, only 21.7% consult a veterinarian about drug withdrawal time. Furthermore, while 74.5% check the validity of drugs before purchase, a mere 31.1% have personally administered antimicrobials to their poultry. With an overall 43.8% intended responses, there is a critical need for appropriate practices and education to combat resistance risks (Table 9).

Table 9. Questionnaire section regarding Respondents' Practices on AMU and AMR

Practices-based questions	Responses	
	Intended (%)	Unintended (%)
Have you ever had to personally administer antimicrobials to your poultry?	33 (31.1)	73 (68.9)
Do you find it necessary to use antimicrobials during the brooding stage of chicks, even if it might cause harm?	82 (77.4)	24 (22.6)
Before buying drugs, do you check if they are still valid for use?	79 (74.5)	27 (25.5)
Do you use antimicrobials to promote the growth of your poultry, considering both the benefits and potential risks?	43 (40.6)	63 (59.4)
Have you ever followed advice on using antimicrobials from someone who is not an animal health professional?	62 (58.5)	44 (41.5)
Do you consult a veterinarian about the appropriate withdrawal period after administering antimicrobials?	23 (21.7)	83 (78.3)
Do you ensure there is a gap between the last antimicrobial treatment and the use of poultry products for consumption?	32 (30.2)	74 (69.8)
If there is no sign of recovery, do you increase the dosage or frequency of antimicrobial treatment?	23 (21.7)	83 (78.3)
Do you stop treatment with antimicrobials as soon as the chickens start to show signs of improvement?	55 (51.9)	51 (48.1)
Do the benefits outweigh the risks for you to consume the meat from birds that have been treated with antimicrobials towards the end of their life?	43 (40.6)	63 (59.4)
During an illness, do you switch to different antimicrobials if the initial ones do not seem effective?	36 (33.9)	70 (66.1)
	46.4 (43.8)	59.6 (56.2)

The logistic regression analysis results on the self-reported practices of commercial poultry farm owners and workers towards AMU and AMR revealed several significant findings. Individuals who personally administered antimicrobials were found to be 44 times more likely to have performed better practices compared to those who did not (OR = 44, 95% CI: 11.2-173.4, $p < 0.001$). This suggests that personal involvement in administering antimicrobials may lead to a greater sense of responsibility and adherence to best practices, even after adjusting for

other factors (OR=11.8, 95% CI: 1.8-77.4, $p=0.010$). Those who used to check the expiry date of antimicrobials were seven times more likely to have engaged in better practices compared to those who did not (OR = 6.95, 95% CI: 1.5-32.4, $p = 0.014$), indicating that a careful approach to verifying the validity of antimicrobials is independently associated with improved practices. Respondents who followed non-professional recommendations were sixteen times more likely to have performed better practices compared to those who did not (OR = 16.23, 95% CI: 5.8-45.0, $p < 0.001$). The increase in odds after adjustment (OR = 28.9, 95% CI: 1.9-445.9, $p = 0.016$) highlights the potential influence of other confounding factors, suggesting that non-vet recommendations might sometimes align with better practices when considered in the broader context of other variables.

Individuals who received professional advice on antimicrobial withdrawal time were twenty times more likely to have engaged in better practices compared to those who did not (OR = 19.7, 95% CI: 5.3-73.0, $p < 0.001$). Respondents who noted the withdrawal time were thirty-six times more likely to have performed better practices compared to those who did not (OR = 35.78, 95% CI: 10.1-127.2, $p < 0.001$). Despite the slight decrease in odds after adjustment (OR=30.9, 95% CI: 5.3-181.1, $p<0.001$), it indicated that this practice is still a significant predictor of better AMU. Those who adjusted the dose when there was no recovery were fifty-three times more likely to have followed better practices compared to those who did not (OR = 52.8, 95% CI: 6.5-427.9, $p < 0.001$). The significant decrease in odds after adjustment (OR=13, 95% CI: 5.2-76.3, $p=0.002$) suggests that this proactive and adaptive approach to treatment is a strong and independent predictor, emphasizing the importance of responsiveness in antimicrobial management. Respondents who did not stop treatment only because the symptoms disappear were seventeen times more likely (OR=17.05, 95% CI: 4.8-63.6) to have performed better practices. The association became stronger (OR=30.9, 95% CI: 2.5- 381.9, $p=0.007$) after adjusting for other variables. Individuals who did not consume treated chicken products were about fifty times more likely to have performed responsible AMU practices (OR=50.37, 95% CI: 12.6-201.1, $p<0.001$). The study participants who did not switch antimicrobials mid-term were 99.6% less likely to have performed better practices (OR=0.004, 95% CI: 0.0004-0.1132, $p=0.001$), as compared to those who did (Table 10).

Table 10. Self-reported practices of participants analyzed using binary logistic regression

Variable	Category	No.(%) respondents	No. (%) with better practice	Univariable logistic regression		Multivariable logistic regression	
				OR (95% CI)	P-value	OR (95% CI)	P-value
Location	Harar	36 (33.9)	13 (36.1)	Ref*	*		
	Dire Dawa	48 (45.3)	19 (39.6)	1.16[.4747, 2.8307]	0.746	---	---
	Jigjiga	22 (20.8)	9 (40.9)	1.22 [.4124, 3.6376]	0.715		
Personal administration of antimicrobials	Not-sure/don't know	19 (17.9)	1 (5.3)	.24 [.0291, 2.0519]	0.194	.02 [.0006, .7622]	0.035
	No	54 (50.9)	10 (18.5)	Ref*	*	Ref*	*
	Yes	33 (31.1)	30 (90.9)	44 [11.1681, 173.3505]	<0.001	11.83 [1.8090, 77.3621]	0.010
AMU during brooding	Not-sure/don't know	15 (14.1)	3 (20.0)	Ref*	*	Ref*	*
	No	82 (77.4)	31 (37.8)	2.43 [.6356, 9.3002]	0.194	8.52 [.3785, 192.0001]	0.177
	Yes	9 (8.5)	7 (77.8)	14 [1.8619, 105.2681]	0.010	5.18 [.0311, 62.8695]	0.592
Checking expiry date	Not-sure/don't know	10 (9.4)	1 (10.0)	.83 [.0658, 10.5529]	0.888	.18 [.0028, 12.0047]	0.428
	No	17 (16.1)	2 (11.8)	Ref*	*	Ref*	*
	Yes	79 (74.5)	38 (48.1)	6.95 [1.4902, 32.4247]	0.014	2.58 [.2455, 27.1377]	0.430
Antimicrobials as growth promoters	Not-sure/don't know	36 (33.9)	3 (8.3)	.01 [.0021, .0612]	<0.001	.05 [.0028, .8233]	0.036
	Yes	27 (25.5)	24 (88.9)	Ref*	*	Ref*	*
	No	43 (40.6)	14 (32.6)	.06 [.0155, .2349]	<0.001	1.82 [.1490, 22.2447]	0.639
Non-vet recommendations	Not-sure/don't know	8 (7.5)	2 (25.0)	1.54 [.2746, 8.6988]	0.621	2.67 [.0818, 87.0338]	0.581
	No	62 (58.5)	11 (17.7)	Ref*	*	Ref*	*
	Yes	36 (33.9)	28 (77.8)	16.23 [5.8471, 45.035]	<0.001	28.93 [1.8772, 445.8813]	0.016
Professional advice on withdrawal time	No	83 (78.3)	21 (25.3)	Ref*	*	Ref*	*
	Yes	23 (21.7)	20 (87.0)	19.68 [5.3080, 72.9842]	<0.001	11.8 [.8414, 165.3439]	0.067
Noting withdrawal time	Not-sure/don't know	19 (17.9)	4 (21.1)	1.36 [.3663, 5.0720]	0.644	7.03 [.9909, 49.8653]	0.051
	No	55 (51.9)	9 (16.4)	Ref*	*	Ref*	*
	Yes	32 (30.2)	28 (87.5)	35.78 [10.0674, 127.1486]	<0.001	30.9 [5.2809, 181.0556]	<0.001
Adjust dose when no recovery	Not-sure/don't know	32 (30.2)	4 (12.5)	.34 [.1024, 1.1480]	0.083	.76 [.1108, 5.2830]	0.786
	No	51 (48.1)	15 (29.4)	Ref*	*	Ref*	*
	Yes	23 (21.7)	22 (95.6)	52.8 [6.5139, 427.9846]	<0.001	13 [5.1838, 76.28]	0.002
Ceasing Rx when symptoms go	Not-sure/don't know	21 (19.8)	2 (9.5)	.95 [.1441, 6.2272]	0.955	2.25 [.0974, 51.7674]	0.613
	Yes	30 (28.3)	3 (10.0)	Ref*	*	Ref*	*
	No	55 (51.9)	36 (65.4)	17.05 [4.5739, 63.5754]	<0.001	30.9 [2.5048, 381.8808]	0.007
Consumption of treated chicken	Not-sure/don't know	20 (18.9)	4 (20.0)	3.33 [.6694, 16.5978]	0.142	.13[.0074, 2.2190]	0.158
	Yes	43 (40.6)	3 (6.9)	Ref*	*	Ref*	*
	No	43 (40.6)	34 (79.1)	50.37 [12.6175, 201.0836]	<0.001	.16[.0135, 1.8622]	0.143
Switching AMs mid-treatment	Not-sure/don't know	32 (30.2)	1 (3.1)	.001 [.0001, .0154]	<0.001	.003 [.0001, .0682]	<0.001
	No	38 (35.8)	5 (13.2)	.004 [.0005, .0390]	<0.001	.004 [.0004, .1132]	0.001
	Yes	36 (33.9)	35 (97.2)	Ref*	*	Ref*	*

4.6. Factors Associated with Emergence of AMR and Related Interventions

Scenario analysis helps understand how various factors influence outcomes. The study identified several contributors to AMR in poultry farms, primarily due to knowledge gaps about AMU. Only 36.7% of farmers understood antimicrobials (OR = 24.7, $p < 0.001$), leading to improper use. This dictates education programs on antimicrobials, their usage, and emergence of AMR. Similarly, 67.9% of farmers were unaware of AM residues (OR = 0.02, $p < 0.001$), necessitating targeted training on drug residue impacts. Furthermore, 65.1% of the respondents did not know disease-specific antimicrobials (OR = 54.2, $p < 0.001$), paving a way to boost possibilities of occurrence of AMR. Moreover, 64.2% did not know that AM residues could affect humans (OR = 0.01, $p < 0.001$), requiring awareness programs. Again, 35.8% of the study participants reported that antimicrobials to be effective for treating all kinds of diseases (OR = 8.79, $p = 0.033$), highlighting the need for education on disease-specific antimicrobials and misconceptions about that (Figure 4).

In addition, attitudes towards AMU significantly contributed to AMR emergence. Only less than half of respondents (42.5%) agreed to the impact of random AMU (OR = 3.94, $p = 0.026$), underscoring the need for educational initiatives. Ordinarily, 12.3% did not accept the idea that missing doses matters (OR = 0.04, $p = 0.013$), emphasizing the completion of prescribed treatments. While 39.6% were uncertain about preventive AMU (OR = 13.45, $p < 0.001$), 26.4% did not abide with its benefits (OR = 20.9, $p < 0.001$), noticing the potential risk of using antimicrobials for prevention purpose. Agreeing (61.3%) to the use of correct antimicrobial dosage (OR = 11.82, $p = 0.010$) boosted the odds of being with desirable attitudes as compared to those who disagreed (13.2%) and uncertain (25.5%), suggesting a vitality of education regarding dosage accuracy. More than half (57.5%) of the respondents agreed that controlling access to antimicrobials is beneficial (OR=7.02, $p=0.016$), suggesting a strict prescription-only policies to ensure responsible AMU and reduce misuse. Only 46.2% of the respondents recognized the negative effect of finishing all AMs before expiration (OR=10.01, $p=0.001$), necessitating educational initiatives to clarify the risks associated with unnecessarily finishing antimicrobials rather than safely discarding them. Moreover, only 27.4% of respondents agreed to the benefit of minimizing AMU (OR=15.37, $p<0.001$), emphasizing the critical role of reduced AMU in combating AMR (Figure 4).

In the same way, practices toward the usage of antimicrobials also found to influence emergence of AMR. In detail, 31.1% administered antimicrobials themselves (OR=0.02, 95% CI: 0.001–0.762, $p=0.035$), personally administering antimicrobials assist better practices that mitigate AMR risk. 33.9% were unsure (did not know) about usage, while 25.5% actively use them as growth promoters (OR=0.05, 95% CI: 0.003–0.823, $p=0.036$), indicating that uncertainty or lack of awareness about using antimicrobials as growth promoters is significantly associated a risky behavior linked with AMR. 33.9% rely on non-veterinarian advice (OR=28.93, 95% CI: 1.9–445.9, $p=0.016$). Dependence on non-veterinarian recommendations significantly increased the likelihood of poor practices that promote AMR, emphasizing the importance of consulting veterinary professionals. 30.2% note withdrawal times (OR=30.9, 95% CI: 5.3–181.1, $p<0.001$), indicating that those who adopted this practice were less likely to contribute to AMR emergence. Only 21.7% used to adjust dosages (OR=13, 95% CI: 5.2–76.3, $p=0.002$), underscoring the risks of unsupervised dosing adjustments. 51.9% did not cease treatment early (OR=30.9, 95% CI: 2.5–381.9, $p=0.007$), highlighting the importance of completing prescribed treatment courses. 33.9% switch antimicrobials (OR=0.003, 95% CI: 0.0001–0.0682, $p<0.001$), reinforcing the need for consistent treatment under proper supervision (Figure 4).

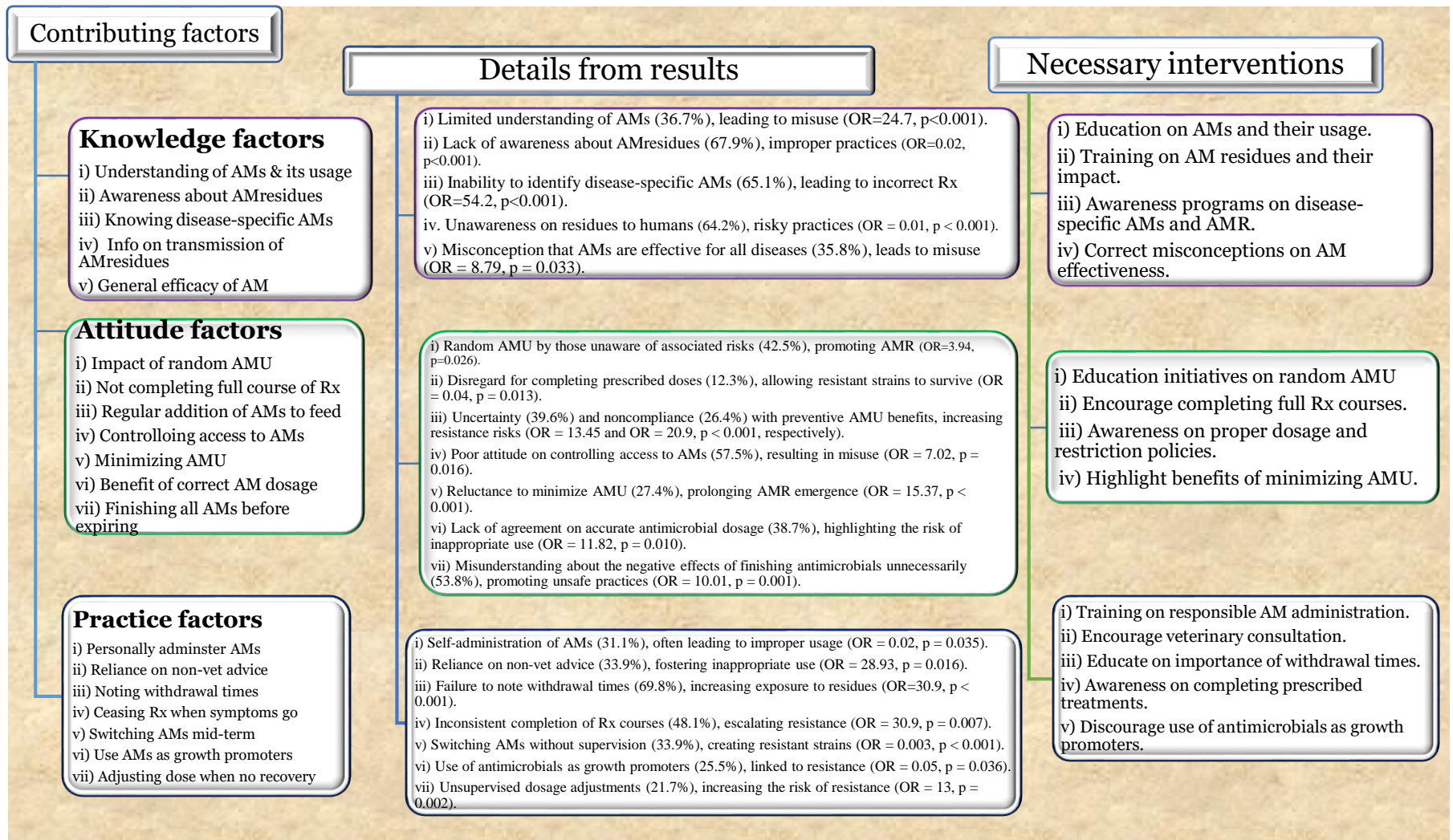


Figure 4. Scenario analysis indicating associated factors to emergence of AMR and equitable interventions

4.7. Associations among KAPs Level of Study Participants

The analysis of the Spearman's rank-order correlation between the mean scores of knowledge, attitudes, and practices among commercial poultry farm owners/workers revealed significant results. The correlation coefficient between the mean scores of knowledge and attitudes was found to be 0.3278, indicating a moderate positive association. This suggests that as knowledge about AMU and AMR increases, attitudes towards these issues also tend to improve. The p-value of 0.0006 confirms the statistical significance of this relationship. Similarly, the correlation between mean scores of knowledge and practices was 0.4300, which also indicates a moderate positive association. This implies that higher levels of knowledge are associated with better practices, and the extremely significant p-value of <0.0001 further supports this correspondence. Additionally, Spearman's correlation coefficient between mean scores of attitudes and practices was 0.2278, indicating weak positive association. This implies that positive attitudes towards AMU and AMR are linked to better practices to some extent, with a more significant p-value of 0.0189. Overall, these results demonstrate that enhancing knowledge and attitudes is crucial for improving practices related to AMU and AMR among commercial poultry farm owners and workers (Table 11).

Table 11. Spearman's rank-order correlation between mean scores of the respondents' knowledge, attitudes and practices

Serial No.	Variables in Association	Spearman's rho		
		(ρ_s)	Remarks	P-value
1.	Knowledge versus Attitudes	0.3278	Moderate positive association	0.0006
2.	Knowledge versus Practices	0.4300	Moderate positive association	<0.0001
3.	Attitudes versus Practices	0.2278	Weak positive association	0.0189

Note that: ρ_s ranges from -1 to +1; $\rho_s = -1$ (perfect negative correlation), $\rho_s = 0$ (no association), $\rho_s = 1$ (perfect positive correlation), $0 < \rho_s < 0.3$ implies weak positive correlation, $0.3 \leq \rho_s < 0.5$ implies moderate positive correlation, $0.5 \leq \rho_s < 1$ implies strong positive correlation.

5. DISCUSSION

This section integrates the critical links between knowledge, attitudes, and practices (KAPs) regarding AMU and AMR among commercial poultry farm owners and workers in eastern Ethiopia. Incorporating the findings within socio-demographic factors and AMU patterns, the current study underscored key gaps and challenges, dictating the need for targeted interventions and sustainable practices to mitigate the risks of AMR in this region and beyond. Subsequently, the current study, involving 106 participants from commercial poultry farms in Dire Dawa, Harar, and Jigjiga, eastern Ethiopia, revealed that 30.2% (95% CI: 22.1%-39.7%) were with good knowledge, 48.1% (95% CI: 38.6%-57.7%) had desirable attitudes, and 38.7% (95% CI: 29.8%-48.4%) demonstrated better practices. These results were comparable to the study by Geta and Kibret (2021), where 52.5% of animal farm owners/workers had positive attitudes towards AMU and AMR, 50.5% had good knowledge, and 52.75% demonstrated poor practices. Younger individuals (below 25) exhibited slightly similar knowledge level (16.7%) with the 15% reported by Hassan *et al.* (2021) and that 10% by Al Sattar *et al.* (2023). Among those aged 36-45, knowledge levels (35.6%) were slightly lower than those reported by Al Sattar *et al.* (45%) and Hassan *et al.* (50%). Married individuals exhibited higher knowledge (37.9%) and better practices (51.7%) compared to unmarried respondents (20.8% and 18.8%, respectively), possibly due to greater responsibilities among married individuals. Conversely, Oloso *et al.* (2022) found that, married individuals (35.9%) were less knowledgeable than unmarried (57.7%) and separated ones (81.8%), likely due to varying educational opportunities.

Higher education levels were positively correlated with better KAPs, as evidenced by 61.1% demonstrated better knowledge ($X^2=24.9$, $p<0.001$), 86.1% desirable attitudes ($X^2 = 22.3$, $p < 0.001$), and 97.2% better practices ($X^2=79.4$, $p<0.001$), where X^2 indicates a Chi-square. Likewise, Hossain *et al.* (2022) found that graduate-level respondents exhibited adequate knowledge (85%), positive attitudes (70%), and good practices (50%). Additionally, animal health experts displayed satisfactory knowledge (68.4%), attitudes (57.9%), and practices (43.6%), aligning with Geta and Kibret (2021), who found that individuals with specialized roles or training in health-related fields tend to have better KAPs towards AMU and AMR. Respondents for whom poultry farming was a primary source of income had a marginally better knowledge (30.6%) and practices (44.9%) compared to those for whom it was not (29.8% and 33.3%) in consistent with Al Sattar *et al.*

(2023), who found that dependency on farming as a primary income source improved AMU and AMR practices. Regarding farm types, layer farms accounted for 58.5% (95% CI: 48.8-67.7%) and mixed-type farms (layer and broiler) for 24.5% (95% CI: 17.2-33.8%), with the latter showing better practices (50%), good knowledge (30.5%), and desirable attitudes (58.8%). Al Sattar *et al.* (2023) also observed that mixed-type farms demonstrated better KAPs due to diversified management. Participants rearing exotic breeds (93.4%) showed 30.3% knowledge, 50.5% desirable attitudes, and 38.4% better practices, while those rearing mixed breeds had 28.6% knowledge, 14.3% desirable attitudes, and 42.9% better practices, likely due to diverse management practices. In the same proportion, Shahi and Jeamsripong (2024) noted that while exotic breeds are more common, they may not always exhibit better practices without proper management. Individuals practicing intensive housing (96.2%) showed 30.4% knowledge, 50% positive attitudes, and 38.2% improved practices. In contrast, semi-intensive systems (3.8%) had 25.0% knowledge and 75.0% positive attitudes towards AMU and AMR. Likewise, Hassan *et al.* (2021) suggested that intensive systems generally have better KAPs due to structured management.

Respondents with less than 3 years of farming experience had lower knowledge (9.8%), positive attitudes (37.2%), and better practices (23.5%), compared to those with over 5 years of experience who demonstrated higher knowledge (77.8%, $p < 0.001$), positive attitudes (66.7%, $p < 0.001$), and better practices (74.1%, $p < 0.001$), indicating that experience enhances KAPs. Additionally, respondents using market-sourced feed had better KAPs compared to those using homemade feed, aligning with Mulchandani *et al.* (2023). Farms reporting only coccidiosis had lower KAPs compared to those encountering NCD, suggesting that disease prevalence impacts KAPs, as noted by Shahi and Jeamsripong (2024). Purely therapeutic AMU was relatively low at 16.9% (95% CI: 10.9-25.5), possibly indicating a preference for preventive measures, aligning with Adebowale *et al.* (2016) in Nigeria with 15% (95% CI: 8-22). Additionally, 29.2% (95% CI: 21.3-38.7) used antimicrobials non-therapeutically, about half of the pooled estimate (61%, 95% CI: 42-80). Most respondents (53.8%, 95% CI: 44.1-63.1) used antimicrobials for dual purposes, reflecting a broader trend in developing countries.

Moreover, 19.8% (95% CI: 13.2-28.6) of respondents relied only on animal health professionals for information, nearly half of the 39% (95% CI: 27-50) reported by Gebeyehu *et al.* (2021). Conversely, only 1.9% (95% CI: 0.5-7.4) relied on peers (farm owners/workers) for AMU

information, much lower than findings from Nigeria (19%; 95% CI: 12-26) by Al-Mustapha *et al.* (2020) and Kenya (8%; 95% CI: 4-13) by Ndukui *et al.* (2021). The majority (69.8%; 95% CI: 60.3-77.9) used biosecurity measures plus vaccines, aligning with Ndahi *et al.* (2023) that ranged from 22% to 96%, emphasizing vaccination and biosecurity in AMU reduction. In contrast, 30.2% relied solely on vaccines, aligning with Hedman *et al.* (2020) highlighting the need for comprehensive biosecurity measures.

Enrofloxacin and tetracyclines were the most commonly used drugs, aligning with Nhung *et al.* (2017) on their widespread use and high resistance levels among poultry pathogens, underscoring the need for harmonized testing and improved treatment guidelines for AMR. Respondents reported 17% (95% CI: 10.9-25.5) used antimicrobials only when chickens were sick, much lower than the 65% (95% CI: 50-80) reported by Al Sattar *et al.* (2023). Regular use (2-5 times per month) was reported by 29.25% of participants, reflecting a higher frequency than the USPEA (2022) report of 1-2 times per month in U.S. poultry production. Additionally, 42.45% (95% CI: 33.3-52.2) reported significant barriers like limited availability and insufficient information, consistent with USPEA (2022) findings.

Adjusted logistic regression analysis showed 71.8% of respondents who understood antimicrobials were twenty-five times more likely to be knowledgeable about AMU and AMR (95% CI: 1.5-441.2, $p < 0.001$), much higher than Chah *et al.* (2022) in Enugu State, Nigeria (48%) and aligned with the pooled estimate (76%) by Kosiyaporn *et al.* (2020). Awareness of antimicrobial residues was also influential, with 67.9% not knowing what they are (OR=0.02, 95% CI: 0.0037-0.1161, $p < 0.001$) and 64.2% of them did not know whether or not antimicrobials residue be transmitted to humans (OR=0.01, 95% CI: 0.001-0.083, $p < 0.001$). Salam *et al.* (2023) reported very low awareness of the drug withdrawal period (17%) and about drug residues (5%). After adjustment, information on AMR did not significantly affect knowledge, suggesting that access to information alone is insufficient without proper education and context, conforming to Hedman *et al.* (2020). Understanding disease-specific antimicrobials significantly increased knowledge (OR=54.3, 95% CI: 5.7-514.8, $p = 0.001$). on the contrary, Hassan *et al.* (2021) noted that familiarity with disease-specific antimicrobials improved knowledge about AMU and AMR, but was not strong enough to suggest that familiarity alone was sufficient, emphasizing the need for focused instructive programs on the appropriate AMU. Awareness of herbal alternatives (19.8%) was a marginally

non-significant factor in determining knowledge towards AMU and AMR (OR = 2.6, 95% CI: 1.0-7.0, $p = 0.057$), contrasting with Hassan *et al.* (2021), where 71.7% thought herbal drugs could be used as alternatives to antimicrobials, demanding a more targeted education to improve understanding and use of both herbal and conventional antimicrobials.

Participants who agreed that "using antimicrobials randomly leads to antimicrobial resistance" had a significantly higher likelihood (64.4%) of desirable attitudes (OR=3.94, 95% CI: 1.2-13.1, $p=0.026$), similar to Islam *et al.* (2022). Those individuals who disagreed to the statement "not giving the full course of antimicrobials leads to resistance" were 96% less likely to have desirable attitudes towards AMU and AMR (7.7%, OR=0.04, 95% CI: 0.003-0.502, $p=0.013$), aligning with Hinchliffe *et al.* (2024). Those who disagreed to "regular addition of antimicrobials to poultry feed for prevention purpose" had higher desirable attitudes (53.6%, OR=20.91, 95% CI: 3.8-115.0, $p<0.001$), aligned with Shahi and Jeamsripong (2024) in Nepal. Agreement on "using the right amount of antimicrobials" also increased desirable attitudes (61.5%, OR=11.82, 95% CI: 1.8-76.6, $p=0.010$), comparable to Gray *et al.* (2021). Staying uncertain and disagreeing about finishing antimicrobials before expiration increased desirable attitudes by 53.8% (OR=6.43, 95% CI: 1.5-28.4, $p=0.014$) and 65.3% (OR=10.01, 95% CI: 2.6-38.4, $p=0.001$) respectively, highlighting the need for broader instructional campaigns (Adeyonu *et al.*, 2021; Banjoko *et al.*, 2015; Ebong, 2023). Additionally, those who agreed to use fewer antimicrobials if careless use could affect future recovery had a higher likelihood (75.9%) of desirable attitudes (OR=15.37, 95% CI: 4.01-58.95, $p<0.001$), supported by studies in Bangladesh and Nepal (Hassan *et al.*, 2021; Shahi and Jeamsripong, 2024).

Individuals who personally administered antimicrobials had a significantly higher likelihood (90.9%) of better practices compared to those who did not (OR=11.83, $p=0.010$). Similar trends were observed in the Amhara region, where 96.7% of them used to administer without veterinary guidance (Geta and Kibret, 2021), indicating a widespread practice of self-administration which leads to misuse and resistance. Respondents who used antimicrobials as growth promoters (25.5%) also had a higher likelihood (88.9%) of better practices, aligned with a pooled estimate by Al Sattar *et al.* (2023) where 29% of poultry farmers used antimicrobials to boost growth, a common but controversial practice due to its contribution to drug resistance. Individuals who followed other than veterinary advice showed higher likelihood (77.8%) of performing better practices

(OR=28.93, 95% CI: 1.9-445.9, $p=0.016$), in line with previous studies in Bangladesh and Kenya found that individuals who received advice from colleagues or local community were more likely to adopt responsible AMU compared to those who relied solely on veterinarians (Al Sattar *et al.*, 2023; IPC, 2019), emphasizing the influence of non-professional advice.

Of the 30.2% individuals, who ensured a gap between last antimicrobial treatment and poultry product consumption, 87.5% had a higher likelihood of performing better practices (OR=30.9, 95% CI: 5.3-181.1, $p<0.001$). However, awareness and practice of withdrawal periods were inadequate in countries like Nepal with 14% compliance (Poudel *et al.*, 2024) and Kenya shorter than recommended periods (Rware *et al.*, 2024). Those who adjusted dosage or frequency of antimicrobials (21.7%) as needed had a higher likelihood (95.6%) of performing better practices (OR=13, 95% CI: 5.2-76.3, $p=0.002$). Quite the reverse, Odey *et al.* (2024) noted that adjusting dosages without proper guidance often leads to under- or over-dosing, contributing to resistance. Participants who did not switch antimicrobials when initial ones were ineffective had a lower likelihood (13.2%) of performing better practices (OR=0.004, 95% CI: 0.0004-0.1132, $p=0.001$). Gjini *et al.* (2020) and Tamma *et al.* (2023) highlighted that while switching can be beneficial, it must be managed carefully to avoid resistance. Abreu *et al.* (2023) also emphasized that switching often leads to resistant strains, making future treatments more challenging.

A moderate positive association ($\rho_s=0.3278$) existed between knowledge and attitude, indicating that increased knowledge about AMU leads to more positive attitudes towards responsible use and AMR awareness, consistent with Geta and Kibret (2021) in the Amhara region, reporting a slightly moderate correlation, and weaker than Hassan *et al.* (2021) in Bangladesh (strong positive association), where attitudes towards AMU and AMR be well improved by educational interventions. Likewise, a correlation coefficient ($\rho_s=0.4300$) between knowledge and practices indicated that good knowledge on AMU and AMR leads to appropriate practices, also in liine with Hassan *et al.* (2021), indicating the use of knowledge in promoting responsible practices. Furthermore, a weak positive correlation ($\rho_s=0.2278$) between attitudes and practices emphasized the importance of positive attitudes for optimal practices, slightly aligned with the study among poultry drug and feed sellers in Ethiopia (Geta and Kibret, 2021), indicating that raising positive attitudes likely leads to improved AMU practices.

7. LIMITATIONS OF THE STUDY

This study provided an all-encompassing survey of 106 poultry farms, offering valuable local insights. However, the reliance on self-reported data may limit generalizability. The focus on specific cities in eastern Ethiopia may also affect applicability to other regions. Therefore, future research should utilize a variety of precise data collection techniques incorporating appropriate study designs in order to promote both accuracy and comprehensiveness.

8. CONCLUSION AND RECOMMENDATIONS

The current study has revealed significant gaps and influencing factors contributing to AMR. While participants demonstrated a basic understanding of antimicrobials, there is an urgent need for comprehensive education on AMR mechanisms and consequences. The study showed that socio-demographic factors, including marital status, education level, farming experience, and role in the farm, significantly influenced KAPs towards AMU and AMR. Notably, respondents with higher education levels, and more farming experience exhibited better knowledge, attitudes, and practices. Yet overall, only few respondents had good knowledge, with desirable attitudes, and demonstrated better practices regarding AMU and AMR. Practices were particularly enhanced among individuals aged 36-45 and married participants, where poultry health experts displayed good knowledge, positive attitudes, and practices in comparison to respondents with other roles in the farms. Despite these findings, which emphasize the necessity for targeted interventions to improve knowledge, foster positive attitudes, and promote appropriate practices towards AMU, addressing the gaps through comprehensive educational efforts and systemic improvements is needed to curb the rise of AMR in this region and beyond.

Based on the above conclusion, therefore, the following recommendations are forwarded:

- ♦ Comprehensive educational campaign has to be set to improve knowledge on AMU and AMR.
- ♦ Veterinary guidance should be promoted to prevent misuse and resistance of antimicrobials.
- ♦ Mentorship programs need to be made for experienced farmers to guide less experienced ones.
- ♦ Access to reliable information and resources on AMU and AMR has to be facilitated.
- ♦ Regular regional and national AMR surveillance programs should be established to monitor and address the evolving trends in AMR.
- ♦ Systems for regular monitoring and feedback have to be formulated to track changes in KAPs.

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10. APPENDICES

Appendix-1: Participant Information Sheet with Consent Form

Please read this consent letter before you decide to allow us take an information from you.

The Study Title: Assessment of Knowledge, Attitude, and Practices on Antimicrobial Use and Resistance among Commercial Poultry Farm owners and workers in Selected Cities of Eastern Ethiopia

Purpose of the study: This study assesses Antimicrobial Use (AMU) and Resistance (AMR) among poultry farmers in three eastern Ethiopian cities (Dire Dawa, Harar, and Jigjiga). It explores the poultry farm owners’/workers’ knowledge level, attitude, and practice on AMU and AMR, and determines the frequency and patterns of AMU and AMR on the farm. It additionally recognizes the elements that impact AMU and AMR, and proposes strategies to enhance the utilization of antimicrobials while mitigating the spread of AMR within the poultry industry.

Possibilities to occur during the study: You can stop the interview anytime if you are not comfortable with the questions. Just feel free to participate, it depends on your sole preference.

Potential benefits for participating in this study: This study will give you advice and suggestions on optimizing your AMU and AMR practices, and accessing resources and support for proper use of antimicrobials. It can enhance your poultry’s health and productivity, and lower the economic and environmental costs of AMR. The study will raise awareness about AMR, and improve the sustainability and resilience of the poultry sector. Thank you for your cooperation.

Contact Address of the Investigator

Name: Dr. Bekiyad Shasho

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Agreement: I have read the above information and decided to accept it voluntarily.

Participant’s name	Signature	Date
_____	_____	____/____/____
Name of the investigator	Signature	Date
_____	_____	____/____/____

Appendix-2: Questionnaire

This questionnaire aims to gather data on the attributes, methods, and obstacles encountered in poultry farming, as well as the incidence and trends of AMU and AMR in poultry farms located in Dire Dawa, Harar, and Jigjiga cities, Eastern Ethiopia. The collected information is intended solely for research purposes and will be treated with strict confidentiality.

Section A: Socio-Demographic Information

Kindly provide the necessary information for the questions below. Mark your choice with a tick “√” or give the answer in the space provided.

1. **Location/address:** _____
2. **Gender**
 - Male
 - Female
3. **Age (in years):** _____
4. **Marital Status**
 - Married
 - Divorced
 - Unmarried
 - Prefer not to say
5. **Highest Level of Education**
 - No formal education
 - Primary education
 - Secondary education
 - Tertiary education
 - Prefer not to say
6. **Farm experience (in year):** _____.
7. **Role in the Farm** (*Multiple selections possible*)
 - Farm owner
 - Manager
 - Poultry health expert
8. Poultry farming as primary income source
 - No
 - Yes

Section B: Characteristics of the Poultry Farm

9. Type of Poultry Farm

- Broiler
- Layer
- Both
- Neither (Starter/grower)

10. Number of poultry on the farm (farm size): _____.

11. Breeds of poultry (*Multiple selections possible*)

- Exotic
- Mixed

12. Poultry Management System

- Semi-intensive
- Intensive

13. Source of poultry feed

- From market
- Homemade
- Both

14. Disease(s) encountered within the last six months: _____

15. Prevalent diseases in your farm (*give them a number in the ascending order*).

- Newcastle disease
- Fowl cholera
- Fowl typhoid
- Marek's disease
- Coccidiosis
- Some other diseases: _____

Section C: Antimicrobial Use (AMU) in the Poultry Farm

16. Purpose of AMU (multiple selections possible)

- For treatment purpose
- For prevention
- For growth promotion
- For production performance
- Other purposes: _____

17. Preferred Information Sources for Antimicrobial Use (*Multiple selections possible*)

- Veterinarians
- Extension workers
- Poultry associations
- Government agencies
- Research institutions
- Media or social media
- Online platforms

- Colleagues
 Other (please specify): _____

18. Disease Prevention Measures in Poultry: (Please describe)

19. Most commonly used drugs in your farm (*list them down in the ascending order*).

20. Frequency of Antimicrobial Use

How often do you use antimicrobials on your farm?

- Once per month
 2-5 times per month
 More than 5 times per month
 Once every 2-6 months
 Only when chickens are ill
 Do not remember
 Not used at all

21. Barriers to Changing Antimicrobial Practices

What obstacles prevent you from altering your AMU? (Multiple selections possible)

- Limited availability or high cost of antimicrobials
 Insufficient information or guidance on proper use
 No alternatives or incentives to reduce use
 Lack of regulations or enforcement
 Low awareness or concern about resistance
 Poor trust or collaboration among stakeholders
 Other (please specify): _____

Section D: Knowledge of Antimicrobial Use and Resistance Among Poultry Farmers

This section assesses your knowledge regarding the use of antimicrobials and the issue of resistance in the context of poultry farming.

22. Understanding of Antimicrobials

Do you understand what antimicrobials are and their purposes?

- Yes
 No

23. Knowledge of Prescription Authority

Do you know a legally permitted body (individual) to prescribe antimicrobials?

- Yes
 No

24. Understanding about Antimicrobial Residues

Do you understand what antimicrobial residues are and their implications?

- Yes
 No

25. Information on Antimicrobial Resistance

Do you understand the concept of antimicrobial resistance and its consequences?

Yes

No

26. Knowledge of Disease-Specific Antimicrobials

Can you identify specific antimicrobials that are effective against particular diseases?

Yes

No

27. Transmission of Antimicrobial Residues to Humans

Do humans get affected by antimicrobials from eating poultry products?

Yes

No

28. Treatment Protocols for Flock Health

Is it necessary to treat the entire flock when only a few birds show symptoms of illness to prevent an outbreak, even if it might lead to antimicrobial resistance (AMR)?

Yes

No

Reason out: _____.

29. Applicability of Antimicrobials for Diseases

Can antimicrobials be used to treat any type of disease in poultry?

Yes

No

Reason out: _____.

30. Consistency of Antimicrobial Effectiveness

Do all antimicrobials have the same healing effect on poultry diseases?

Yes

No

31. Herbal Drug Alternatives

Do you suggest that it is better to use herbal medications as substitutes for antimicrobials?

Yes

No

If yes, can you give examples? _____

32. General Efficacy of Antimicrobials

Do you consider antimicrobials to be effective for treating all kinds of diseases?

Yes

No

Section E: Poultry Farmers' Attitudes on the Use of Antimicrobials and Resistance

Please indicate how much you agree with each of the following statements regarding antimicrobial use and resistance.

33. Certainty on impact of Random Antimicrobial Use

Using antimicrobials randomly, even when necessary, leads to antimicrobial resistance.

- Agree
- Uncertain
- Disagree

34. Consequences of Missing a Dose

Not completing the full course of antimicrobials, even when other factors are considered, still leads to resistance.

- Agree
- Uncertain
- Disagree

35. Regular Addition of Antimicrobials to Feed for Prevention

Regularly adding antimicrobials to poultry feed is necessary to prevent illness, despite the risk of antimicrobial resistance.

- Agree
- Uncertain
- Disagree

36. Restricting Antimicrobial Use Matters

Limiting the use of antimicrobials causes more harm than good.

- Agree
- Uncertain
- Disagree

37. Importance of Correct Antimicrobial Dosage

Using the right amount of antimicrobials every time is important.

- Agree
- Uncertain
- Disagree

38. Controlled Access to Antimicrobials

Antimicrobials should be stored securely and handled only by trained personnel.

- Agree
- Uncertain
- Disagree

39. Finishing Antimicrobials Before Expiring

Using antimicrobials before they expire is better than discarding them.

- Agree
- Uncertain
- Disagree

40. Preference for Herbal or Medicinal Alternatives

Using herbal or medicinal alternatives to antimicrobials is preferable.

- Agree
 Uncertain
 Disagree

41. Reduced Antimicrobial Use for Future Recovery

If people knew that careless use of antimicrobials could affect future recovery, they would use it less.

- Agree
 Uncertain
 Disagree

Section F: Practices Regarding Antimicrobials Use and Resistance

This section seeks to understand your practices regarding the use of antimicrobials and your approach to managing resistance.

42. Personal Administration of Antimicrobials

Have you ever had to personally administer antimicrobials to your poultry?

- Yes
 No
 Don't know

43. Antimicrobial Use During Brooding

Do you find it necessary to use antimicrobials during the brooding stage of chicks, even if it might cause harm?

- Yes
 No
 Don't know

44. Checking Expiry Dates of Drugs

Before buying drugs, do you check if they are still valid for use?

- Yes
 No
 Don't know

45. Antimicrobials as Growth Promoters

Do you use antimicrobials to promote the growth of your poultry, considering both the benefits and potential risks?

- Yes
 No
 Don't know

46. Non-Veterinarian Recommendations

Have you ever followed advice on using antimicrobials from someone who is not an animal health professional?

- Yes
- No
- Don't know/not sure

47. Professional Advice on Withdrawal Periods

Do you consult a veterinarian about the appropriate withdrawal period after administering antimicrobials?

- Yes
- No
- Don't know

48. Noting Withdrawal Periods

Do you ensure there is a gap between the last antimicrobial treatment and the use of poultry products for consumption?

- Yes
- No
- Don't know

49. Adjusting Dosage When No Recovery Is Evident

If there is no sign of recovery, do you increase the dosage or frequency of antimicrobial treatment?

- Yes
- No
- Don't know

50. Ceasing Treatment When Symptoms Improve

Do you accept the idea that stopping treatment with antimicrobials as soon as the chickens start to show signs of improvement can lead to resistance?

- Yes
- No
- Don't know

51. Consumption of Treated Poultry Meat

Do the benefits outweigh the risks for you to consume the meat from birds that have been treated with antimicrobials towards the end of their life?

- Yes
- No
- Don't know

52. Switching Antimicrobials Mid-Treatment

During an illness, do you switch to different antimicrobials if the initial ones do not seem effective?

- Yes
 - No
 - Don't know
-

Table in the Appendix 1. Checklist of registered commercial poultry farms in Harar city

ትኩረት ለማድረግ ይጠቀሙ _____ 2000
 ትኩረት ለማድረግ ይጠቀሙ _____ 2250
 ትኩረት ለማድረግ ይጠቀሙ _____ 2000
 ትኩረት ለማድረግ ይጠቀሙ _____ 2000
 የተገኘው ትኩረት 1997 ክፍለ-ዓመት ለማድረግ ይጠቀሙ

1.5 ዘመናዊ ትኩረት ለማድረግ ይጠቀሙ ክፍለ-ዓመት 2015ን ታላቅቶ የተገኘው የገቢ ለማድረግ ይጠቀሙ ደጋፊ ለማድረግ ይጠቀሙ

ሰነድ ቁጥር	የገቢ ለማድረግ ይጠቀሙ	የገቢ ለማድረግ ይጠቀሙ	የገቢ ለማድረግ ይጠቀሙ	የገቢ ለማድረግ ይጠቀሙ
1	ደብረ ገቢ	10000	10000	20000
2	ደብረ ገቢ	5000	5000	10000
3	ደብረ ገቢ	5000	5000	10000
4	ደብረ ገቢ	5000	5000	10000
5	ደብረ ገቢ	5000	5000	10000
6	ደብረ ገቢ	5000	5000	10000
7	ደብረ ገቢ	5000	5000	10000
8	ደብረ ገቢ	5000	5000	10000
9	ደብረ ገቢ	5000	5000	10000
10	ደብረ ገቢ	5000	5000	10000
11	ደብረ ገቢ	5000	5000	10000
12	ደብረ ገቢ	5000	5000	10000
13	ደብረ ገቢ	5000	5000	10000
14	ደብረ ገቢ	5000	5000	10000
15	ደብረ ገቢ	5000	5000	10000

1. ለማድረግ ይጠቀሙ
 2. ለማድረግ ይጠቀሙ
 3. ለማድረግ ይጠቀሙ
 4. ለማድረግ ይጠቀሙ
 5. ለማድረግ ይጠቀሙ

Table in the Appendix 2. Checklist of registered commercial poultry farms from Dire Dawa city administration

ተ.ቁ	የባለቤቱ ስም	ቀበሌ	የሰው ሀብት መጠን		ድምር	በቀን የተገኙ የእንቁላል ምርት	በወር የተገኙ የእንቁላል ምርት (በቁጥር)	በአጠቃላይ በአመት የተገኙ የእንቁላል ምርት
			እንቁላል ጣይ	ጭጭ/ቁጥ				
1	*****	በረን	3000	3000	6000	2,580	77,400	774,000
2	*****	03	1500	3000	4500	1,290	38,700	387,000
4	*****	03	2000	2000	4000	1,720	51,600	516,000
5	*****	03	1000	1500	2500	860	25,800	258,000
6	*****	03	1000		1000	860	25,800	258,000
7	*****	03	2500	1500	4000	2,150	64,500	645,000
8	*****	03	1500	2500	4000	1,290	38,700	387,000
9	*****	03	1000		1000	860	25,800	258,000
10	*****	03	1000	1000	2000	860	25,800	258,000
11	*****	03	1500		1500	1,290	38,700	387,000
12	*****	03	500		500	430	12,900	129,000
13	*****	03	1000		1000	860	25,800	258,000
14	*****	03	1000		1000	860	25,800	258,000
15	*****	03	1000	3000	4000	860	25,800	258,000
16	*****	03	1000	1500	2500	860	25,800	258,000
17	*****	03	500		500	430	12,900	129,000
18	*****	02	1000		1000	860	25,800	258,000
19	*****	09	1000		1000	860	25,800	258,000
20	*****	09	1500		1500	1,290	38,700	387,000
21	*****	09	1500		1500	1,290	38,700	387,000
22	*****	02		1500	1500			
23	*****	09		2500	2500			
24	*****			1000	1000			
25	*****	02	4000	3000	7000	3440	103200	1238400
26	*****	03	120		120	100	3000	36000
27	*****		1500		1500	1,290	38,700	387,000
28	*****	ገ/ረጌ	330		330	283	8514	102168
ድምር			31,9500	27,000	58,950	24,473	824,214	8471568



Figure in the Appendix 1. A commercial poultry farm practicing cage system of housing



Figure in the Appendix 2. Photos of poultry farms practicing cage, and deep litter housing



Figure in the Appendix 3. Photo captured while interviewing a poultry health expert in Harar

HARAMAYA UNIVERSITY
COLLEGE OF VETERINARY MEDICINE



ሐረማያ ዩኒቨርሲቲ
የእንስሳት ሀኪምና ኮሌጅ

College of Veterinary Medicine is in the Community!

የእንስሳት ሀኪምና ኮሌጅ ማህበረሰብ ውስጥ ነው!

Ref. No./ ቁጥር CUM/490/24

Date ቀን: 27/06/2024

To: Jigjiga Agriculture and Natural Resources Office

Subject: Request for Cooperation

Dr. Bekiyad Shasho, a graduate student at College of Veterinary Medicine, Haramaya University has proposed to conduct his MSc Thesis research on "Knowledge, attitude and practices on antimicrobial use and antimicrobial resistance among commercial poultry farmers in three cities of eastern Ethiopia" The proposed research will help us to better understand antimicrobial use and resistance in poultry farms.

Therefore, we would like to request your valued cooperation for the successful completion of this study.

With regards

Dr. Amare Eshetu (PhD)
ዶ/ር አማራ ለሸቲ (ፌ.ዲ.ሳ.)
Dean, College of Veterinary
Medicine
የእንስሳት ሕክምና ኮሌጅ



Tel. +251-025-553 03 34 - Fax: +251-0255530460/0325 - P.O.Box: 138 Dire Dawa
In replying quote our reference number ሲጻጻፍን የደንበኞችን የቁጥር ይጠቅሙ

Figure in the Appendix 4. Cooperation Letter from Haramaya University's College of Veterinary Medicine to Jigjiga Agricultural Office

Dawladda Deegaanka Soomaalida
Xafiiska, Beeraha, Xoolaha &
Ilaalinta Deegaanka Ee maamulka
magaalada jijiga



የሱማሌክልል መንግስት የጅግጅጋ
ከተማአስተዳደር የግብራና እንስሳት አካባቢ
ጥበቃ ጽ/ቤት

Somali Regional State
Jigjiga City Administration Agricultural
Livestock & Environmental Protection office

Sum/Riff/ቁ፡ጥር/ቁ፡ባ/ደ/1340/16

Tarikh/date/ቀን/ወር/ዓ.ም/2016

KU:-ISKAASHATOYINKA DIGAAGA DHAQDA EE MAAMULKA MAGAALDA JIGJIGA

UJEEEDO: CODSI GACANSIIN (TAAKULAYN) ARDAY .

Sida ujeedada kor kuxusan waxaanu ka codanaynaa in ardaga sita warqadani oo magaciisu **Dr. Bekiyad Shasho oo** cilmi baadhis digaaga ah wada kana socda jaacada Haramaayo University, aad gacan kasiisaan wixii uu idiinka baahdo.

Hadaba waxaanu marlabaad idinka codsanaynaa in aad ardaygan macasiise sare kucad yahay ee wada cilmi baadhista aad gacansiisaan.

Wada shaqay wacan

Cabdi Muuse Xasan (C/teol)
Agaasime (H/W) (H/W) (H/W)
Madaxa Xafiiska Xoolaha
Iyo Beeraha MMJ
የጅግጅጋ ከተማ አስተዳደር
እንስሳት ጽ/ቤት



Tel: +251257 75 4603/2143 Fax +251 2575 2605

P.O. Box 298 Jijjiga Ethiopia

Figure in the Appendix 5. Permission letter from the Jigjiga City Administration Agricultural, Livestock and Environmental Protection Office to Poultry Farms in the City

Bulchiinsa Magaalaa Maayaatti
Wajjiraa Qonna kut/mag/Haramaayaa
Maya City Administration
Haramaya Sub City Urban Agricultural Office



የብሔራዊ የሥነ ምግባርና የሥነ ምግባር ማህተም ማስፈጸሚያ ቤቅ
የግብርና ማስፈጸሚያ ቤቅ
ማ.የ

Bulchiinsa Magaalaa Maayaatti
Oromiyachii Wajjiraa Qonna Magaalaa
የግብርና ማስፈጸሚያ ቤቅ
የግብርና ማስፈጸሚያ ቤቅ

Guxyaa 3/10/2016
Lakk WQIMM/785/16

Horsitsa Lukkuu Magaalaa Maayaa Hundaaf

Dhimmi:-**Odeeffannoo Barbaachisu Hunda akka kennitaniif isin gaafachuu ta'a**

Akkuma armaan olitti ibsamuuf yaalame. Yuunivarsiititi barbaa Maasteraa kan ta'e Dr. Beekiyaaad Shaashoo kan jedhamu qu'annoo fi qorannoo itti-fayyadama qorichaa fi diimmoota sanaan walqabatan irratti mataa durce "**Knowledge, Attitudes, and Practices on Antimicrobial Use and Resistance among Commercial Poultry Farmers in Three Cities of Eastern Ethiopia**" gaggeessuuf waan deemuuf jecha isinis kana ta'uu beektanii gama keessaniin deeggarsaa fi odeeffannoo barbaachisu akka isaaniif kennitan kabajaan isin gaafanna.

Horaa Bilaa

Umer Mahammed
B/B 2/10/16/2016/mag.may

Tele 0256591480/6593303 H/ Maayaa /ማ.የ/Maya
Deebii Yeroo Kennitan lakkoofsa xalayaa keenyaan caqasaa!
እባክዎ መልስ ሲሰጡ የደብዳቤያችንን ቁጥር መጥቀስ እንዲያረጋግጡ!
Please quote our Ref. No. while replying!

Figure in the Appendix 6. Permission Letter from Maya City Agricultural Office to Poultry Farms in the city



#T.C:- 28176/2016
ቀን : 18/10/2016

ለድራ ደዋ ዶሮ እርባታ ማስከላት በሙሉ

ድራደዋ

ጉዳዩ በዶሮ መዳኒት አጠቃቀም ዙሪያ ያሉት ሁኔታዎችን ስለማጥናት ይመለከታል

ከላይ ለመግለፅ እንደተሞከረው ዶ/ር በኪያድ ሸሾ የሐረማያ ዩንቨርሲቲ የማስተርስ ተማሪ የሆኑት በዶሮ መዳኒት ዙሪያ ያሉ ሁኔታዎች ላይ ምርምር ለማካሄድ ስለሚፈልግ አስፈላጊውን ትብብር እንድታደርጉለት በእኩብሮት እንጠይቃለን።



ከሠላምታ ጋር

Figure in the Appendix 7. Permission letter from Dire Dawa Administration Agriculture Development Office to Poultry Farms in the City

ሕደሪ ኡምመት ሁሰኒ ተተውማ
ሐራሽነት ኢዳራሌ

OOTUMMAA NAANNOO UMMATA
HARARIITII Biiroo Misooma Qonna



በሀረሪ ሕዝብ ክልላዊ መንግስት
ግብርና ልማት ቢሮ

HARARII PEOPLE REGIONAL STATE
Agriculture Development Bureau

ቁጥር 20/929/ደረግ/ግህ
ቀን 16/9/201

ለሀረሪ ከተማ ዶሮ እርባታ ማእከላት በሙሉ

ጉዳዩ:- በዶሮ መዳኒት አጠቃቀም ዙርያ ያሉ ሁኔታዎችን ስለማጥናት ይመለከታል

ከላይ ለመጥቀስ እንደተሞከረው ዶ/ር ቤኪያድ ሻሾ የሐረማያ ዩንቨርሲቲ የማስተርስ ተማሪ የሆኑት በዶሮ መዳኒት አጠቃቀም ዙርያ ያሉ ሁኔታዎችን ላይ ምርምር ለማካሄድ ስለሚፈልጉ አስፈላጊውን ትብብር እንድታደርጉላቸው በእኩብርት እንጠይቃለን።



//ከሠላምታ ጋር //

ነስረዳን ስህመድ አብደሽ
Nesredin Ahmed Abdosh
የግብርና ልማት ቢሮ
ምክትል ጋላፊ
Agricultural Dev't Bureau
Deputy Head

☎025 666 1794

P.O.Box 105

Fax 025 666 85

E.Mail:- hararagi123@gmail.com

Scanned with CamScanner

Figure in the Appendix 8. Permission letter from Harari Agriculture Development Bureau to poultry farms in the city