SITUATION ANALYSIS AND KAP ON ANTIMICROBIAL USE AND RESISTANCE AMONG VETERINARIANS AND BROILER POULTRY FARMERS OF NEPAL

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A Thesis Submitted in Partial Fulfillment of the Requirements
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การวิเคราะห์สถานการณ์และความรู้ ทัศนคติ และการปฏิบัติเกี่ยวกับการใช้ยาต้านจุลชีพและการดื้อยาของสัตวแพทย์และเกษตรกรในฟาร์มเลี้ยงไก่เนื้อของประเทศเนปาล

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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Thesis Title	SITUATION ANALYSIS AND KAP ON ANTIMICROBIAL USE AND RESISTANCE AMONG VETERINARIANS AND BROILER POULTRY FARMERS OF NEPAL
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Field of Study	Veterinary Public Health
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เป้าหมายหลักของงานวิจัยนี้ เพื่อประเมินสถานการณ์ ความรู้ ทัศนคติ และการปฏิบัติของสัตวแพทย์ที่ทำงานเกี่ยวข้องกับสัตว์ปีก และเกษตรกรผู้เลี้ยงไก่เนื้อเกี่ยวกับการใช้ยาต้านจุลชีพและการดื้อยาต้านจุลชีพในประเทศเนปาล โดยการศึกษาครอบคลุมพื้นที่ 88.1% ของประชากรสัตว์ปีกในประเทศเนปาล สัตวแพทย์ จำนวน 327 คน มาจาก 56 อำเภอ ใน 7 จังหวัด และเกษตรกรผู้เลี้ยงไก่เนื้อ จำนวน 500 คน มาจาก 40 อำเภอ ใน 7 จังหวัด สถานการณ์ของการใช้ยาต้านจุลชีพและข้อมูลของผู้ตอบแบบสอบถาม มีการรวบรวมและวิเคราะห์ข้อมูล โดยใช้สถิติเชิงพรรณนาและการวิเคราะห์การถดถอยโลจิสติก เพื่อหาความสัมพันธ์ระหว่างตัวแปรทางด้านสถานการณ์ ความรู้ ทัศนคติ และการปฏิบัติตน เกี่ยวกับการใช้ยาและการดื้อยาต้านจุลชีพ ส่วนใหญ่สัตวแพทย์ที่ทำงานเกี่ยวข้องกับสัตว์ปีก เป็นเพศชาย 85.0% มีอายุเฉลี่ย 31.9±7.8 ปี โดยครึ่งหนึ่งสัตวแพทย์มาจากจังหวัดบักมาตี (49.2%) สัตวแพทย์เกือบทั้งหมด (99.4%) รู้เรื่องเชื้อดื้อยา และ 93.0% ของสัตวแพทย์ ระบุว่าการขาดการควบคุมในการขายยาปฏิชีวนะมีส่วนทำให้เกิดการดื้อยา เกษตรกรผู้เลี้ยงไก่เนื้อจำนวน 500 คน 81.0% เป็นชาย ส่วนใหญ่ (57.8%) มีฟาร์มขนาดเล็ก จำนวนสัตว์ปีกน้อยกว่า 1,500 ตัว และ 60.0% ของเกษตรกร มีประสบการณ์ทำงานในฟาร์มสัตว์ปีก 0-4 ปี และ 50.8% ของเกษตรกรมีการศึกษาระดับมัธยมปลาย พบการใช้ยาต้านจุลชีพในสัตว์ปีกทั้งหมด 27 ชนิด จากยาต้านจุลชีพ 13 กลุ่มในฟาร์มสัตว์ปีก ยาต้านจุลชีพที่นิยมใช้ในฟาร์ม ได้แก่ doxycycline (23.5%), neomycin (17.1%) และ colistin sulfate (9.6%) เกษตรกรส่วนใหญ่จะปรึกษาสัตวแพทย์ (53.2%) และผู้ขายยา (21.0%) ก่อนทำการรักษาสัตว์ปีก แม้ว่าเกษตรกรจะมีความรู้ (62.6%) และการปฏิบัติตน (55.5%) เกี่ยวกับการใช้ยาต้านจุลชีพและการดื้อยาต้านจุลชีพค่อนข้างจำกัด แต่มีทัศนคติที่ดีต่อการใช้ยาและการดื้อยาต้านจุลชีพ (91.6%) โดยปัจจัยที่เกี่ยวข้องต่อทัศนคติของเกษตรกร คือ กลุ่มอายุ 31-40 ปี เมื่อเทียบกับกลุ่มอายุอื่น (OR=4.2, p=0.03) และเกษตรกรที่ใช้ยาต้านจุลชีพเพื่อการป้องกัน มีคะแนนทัศนคติสูงกว่ากลุ่มการใช้ยาต้านจุลชีพด้วยวัตถุประสงค์อื่น (OR=5.9, p=0.02) เกษตรกรที่ได้รับคำปรึกษาจากสัตวแพทย์เมื่อสัตว์ปีกป่วย (OR=21.0, p<0.001) มีความสัมพันธ์เชิงบวกกับการใช้ยาต้านจุลชีพในฟาร์ม ผลจากการศึกษานี้ บ่งชี้ว่าจำเป็นต้องมีกลไกการควบคุมการใช้ยาต้านจุลชีพในสัตว์ปีกอย่างเหมาะสม การขยายการบริการสัตวแพทย์ การฝึกอบรม และเพิ่มความตระหนักของสัตวแพทย์และเกษตรกรผู้เลี้ยงไก่เนื้อ เพื่อลดปัญหาการดื้อยาในการผลิตสัตว์ปีก

สาขาวิชา	สัตวแพทยสาธารณสุข	ลายมือชื่อนิสิต	....
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Manoj Kumar Shahi : SITUATION ANALYSIS AND KAP ON ANTIMICROBIAL USE AND RESISTANCE AMONG VETERINARIANS AND BROILER POULTRY FARMERS OF NEPAL. Advisor: ASSIST. PROF. DR. SAHARUETAI JEAMSRIPONG, D.V.M., M.V.P.M., Ph.D.

The primary goal of this research was to assess the situation analysis and knowledge, attitude, and practices (KAP) of poultry practitioner veterinarians (PPV) and broiler poultry farmers (BPF) regarding antimicrobial use (AMU) and antimicrobial resistance (AMR) in Nepal. The study area covered approximately 88.1% of Nepal's poultry population. A total of 327 PPV from 56 districts and 500 BPF from 40 districts of seven provinces participated. AMU situation and demographic information were collected and analyzed using descriptive statistics and logistic regression analysis to determine associations between variables. Most PPV were male (85.0%) with a mean age of 31.9±7.8 years. Half of the PPV participated from Bagmati province (49.2%), almost all of them (99.4%) knew about AMR and stated that the lack of control in the sale of antibiotics contributes to AMR (93.0%). Among the 500 farmers, 81.0% were male. The majority of the farmers (57.8%) had small farms (<1,500 heads), 59.6% of the farmers had 0-4 years of experience working in poultry farms, and 50.8% had a high school education. The 27 different types of antimicrobials from 13 different antimicrobial classes were used in poultry farms. The most commonly used antimicrobials on the farm were doxycycline (23.5%), neomycin (17.1%), and colistin sulfate (9.6%). Most farmers consulted veterinarians (53.2%) and drug sellers (21.6%) before treating their poultry. Despite limited knowledge (62.6%) and practice (55.5%), the BPF had a favorable attitude toward AMU and AMR (91.6%). The risk factors associated with the farmers' attitudes toward AMU and AMR were the 31-40 years age group compared with other age groups (OR=4.2, p=0.03), and the farmer who used antimicrobials for prevention had a higher attitude score than those who used for other purposes (OR=5.9, p=0.02). The farmers who consulted with a veterinarian when their poultry was sick (OR=21.0, p<0.001) had a positive association with AMU practices. Findings of this study indicate that proper regulation mechanisms in veterinary drugs, an extension of veterinary services, training, and awareness related to AMU and AMR for PPV and BPF are needed to mitigate the AMR problem in poultry production.

Field of Study:	Veterinary Public Health	Student's Signature ....
Academic Year:	2022	Advisor's Signature ....

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AMR	Antimicrobial resistance
AMU	Antimicrobial use
AST	Antibiotic susceptivity test
BPF	Broiler poultry farmer
CBS	Central Beauro of Statistics
CIA	Critically important antimicrobial
DLS	Department of Livestock Services
et al.	Others
FAO	Food and Agriculture Organization
KAP	Knowledge, attitude, and practice
MDR	Multidrug resistance
NVC	Nepal Veterinary Council
PPV	Poultry practitioner veterinarian
spp.	Species
WHO	World Health Organization
WOAH	World Organization for Animal Health

CHAPTER 1 INTRODUCTION

Antimicrobial resistance is a global threat from the perspective of One Health. The misuse of antimicrobials in both human and veterinary medicine is a crucial element that can lead to the development and dissemination of resistant bacteria (Osman et al., 2021). The emergence of AMR in animal production can spread to humans through the food production chain (Xiong et al., 2018). Globally, AMR causes 700,000 human deaths per year. By 2050, the estimated cost of AMR infections could reach 100 trillion US dollars, potentially resulting in 10 million human deaths if urgent action is not taken (O'Neill, 2016). The burden of the AMR problem is much higher in low-income and middle-income countries than in other developed countries (Pokharel et al., 2019). Therefore, increasing awareness of antimicrobial use (AMU) among multiple stakeholders associated with livestock production is needed to control and prevent AMR effectively.

The purposes of AMU in poultry are to treat bacterial infections, promote the growth of animals, and control and prevent of bacterial diseases (Poole and Sheffield, 2013). However, the use of antimicrobials as growth promoters in animal feed has been banned in livestock production in Sweden, Europe, and the United States (Casewell et al., 2003; Roth et al., 2019). In addition, Nepal has banned AMU for growth promoter since 2017 (Upadhyaya et al., 2020). The use of antimicrobials in poultry has been shown to lower disease incidence, morbidity, and mortality rates, improve animal health and increase productivity, resulting in higher economic returns (Sarwar et al., 2018). Common antimicrobials used in poultry production in Nepal are amikacin, gentamicin, streptomycin, cefotaxime, ceftazidime, ciprofloxacin, ampicillin, colistin, sulfamethoxazole and tetracycline (Upadhyaya et al., 2020). The dissemination of multidrug resistance (MDR) of commensal and pathogenic bacteria worldwide continues to reduce the efficacy of available antimicrobials (Poole and Sheffield, 2013).

In 2021, the Nepal government declared that the country is self-sufficient in poultry meat and egg production. Poultry meat and eggs significantly contribute to the origin of animal protein supply and Nepal's economy. Nepal's Ministry of Health and Population has approved the National Antibiotic Containment Action Plan, 2016 and the National Antibiotic Treatment Guideline, 2014 (NPHL, 2018). However, Nepal's Drug Act, 1978 did not provide an explicit provision for regulating veterinary drugs. Therefore, AMU in animals needs to be handled legally and efficiently in Nepal. The misuse of antimicrobial agents can develop a favorable environment for increasing resistant bacteria, which can transfer resistant determinants within and between bacterial species (Khan et al., 2020; Rahman et al., 2020). The lack of awareness of veterinarians and farmers using antimicrobials may elevate the problem of AMR impacting public health. The rational use of antimicrobials is related to the knowledge, attitude, and practice (KAP) of the farmer and the veterinarian. Therefore, responsible veterinarians and farmers are the key people associated with using antimicrobials in livestock production.

The KAP study is the most widely used quantitative research method that reveals misconceptions or misunderstandings that can be difficulties in actions and potential barriers to change in human behavior (WHO, 2008). Human behavior changes have three successive processes: the acquiring of knowledge, the generation of attitudes, and the development of behavior (Kim et al., 1969). Currently, the KAP survey is the research of health-seeking behavior, which is representative of a specific target group to gather information on what is known, believed, and performed regarding a particular topic (WHO, 2008).

In poultry industries, the self-prescription of farmers, unauthorized users, and lack of regulatory authorities would be the key drivers of the emergence of AMR in animals. To efficiently reduce the problem of AMR, rational use of antimicrobials, monitoring trends of AMR occurrence, increasing awareness of AMR, the practice of reasonable use of antimicrobials, promulgating legislation, and building a regulatory mechanism are required to promote the reduction of AMR. Understanding AMU and AMR in animals and public health would decrease the haphazard of AMU in poultry. More information is required on the economic and livestock health consequences of AMR in developing nations (FAO, 2022). As part of the solution in veterinary services, veterinarians must be well-trained and supervised by authorized veterinary statutory bodies (WOAH, 2022). Understanding the use of antimicrobials in farmers and veterinarians is needed to implement other AMR prevention and control strategies because the KAP of veterinarians and farmers about AMR can significantly influence the AMU in the livestock farm (Caudell et al., 2017). Therefore, a situation analysis of the current KAP on AMU and AMR is required to inform policymakers to tackle AMR in the country.

Objectives of the study

1. To examine the situation of AMU in broiler poultry farms in Nepal.
2. To assess the KAP of AMU and AMR in veterinarians and farmers associated with broiler poultry production in Nepal.

CHAPTER 2 LITERATURE REVIEW

2.1. Poultry production in Nepal

Globally, poultry is one of the extensive food industries, with more than 90 billion tons of chicken meat produced annually (Nhung et al., 2017). Nepal has a varied land topography and climate, where commercial and backyard poultry farming is in all regions from Mountain to Terai (Pradhanang et al., 2015). Two-thirds of Nepal’s population is directly engaged in agriculture, contributing almost 34.0% of the national gross domestic product, of which 15.0% comes from the livestock sector (DLS, 2021). The poultry sector contributes about 3.5% of Nepal's gross domestic product.

In Nepal, the poultry population has increased about four times from 23.9 to 82.6 million between 2007 and 2020 (CBS, 2017; DLS, 2021). Indigenous poultry is widely prevalent and accounts for approximately 55.0% of the total poultry population of Nepal. Poultry meat production increased from 14,299 tons to 255,388 tons between 2001 and 2020 out of 198,895 and 552,256 tons of annual total meat production, respectively. Similarly, Nepal's total egg production per year in 2001 and 2020 was 538,420 thousand and 1,620,000 thousand, respectively (DLS, 2021). The per capita meat consumption of poultry alone contributes to 4.1 kg of the total 11 kg per capita meat consumption in Nepal (AITC, 2022).

2.2. Legal framework on AMR

International law provides a robust implementation mechanism for countries, and they can commit themselves to act (Hoffman et al., 2015). The government must develop and enforce laws and other policies according to international law or its commitment to reducing the use of antimicrobials in animals (Khouja et al., 2022).

The World Health Organization Assembly adopted a Global Action Plan on AMR, 2015 to address the global threat of AMR (WHO, 2015). The WOAH and FAO adopted it in 2016. In May 2021, 144 countries promulgated a national action plan based on the objectives of the Global Action Plan (GAP) on AMR (WHO, 2021). WOAH further developed a Strategy on AMR and Prudent Use of Antimicrobials (WOAH, 2016) to harmonize national and regional legal frameworks on AMR and was also addressed in the G7 and G20 forums (EU, 2017). Since 2016, the implementation of the GAP on AMR has started with the collaboration between the World Health Organization (WHO), World Organization for Animal Health (WOAH), Food and Agriculture Organization (FAO), and United Nations Environment Programme (UNEP). In 2019, the UN Secretary-general delivered a report on AMR, which is the progress made by the tripartite and the member states in implementing the political declaration. All WHO member states committed to having NAP for AMR. Although more than 100 countries have published projects, many of which are under development in NAP (Weldon et al., 2022).

The government of Nepal regulates the national AMU and AMR issues with the promulgation of the Drug Act, 1967; Animal Health and Livestock Service Act, 1999; National Drug Policy, 1995; Drug Sales and Distribution Code, 2014; and One Health Strategy, 2019. Nepal developed the National Antimicrobial Resistance Containment Action Plan in 2016, which includes measures for improving surveillance, rational use of antimicrobials, prevention and control, and public awareness (DoHS, 2021). The Ministry of Health and Population has also created guidelines for the rational use of antimicrobials and a national surveillance system to monitor resistance patterns. Furthermore, the National One Health Technical Committee was established in 2019 to coordinate a One Health approach to control AMR in Nepal. The committee comprises experts from different sectors, including human health, animal health, environment, agriculture, and food (MoALD, 2019). In general, Nepal has recognized the threat of AMR and has implemented a legal framework and a strategic plan to address it.

2.3. AMU in livestock production

Global consumption of antimicrobials was estimated at more than 35 billion daily doses in 2015 (Klein et al., 2018). The livestock sector is estimated to consume 70.0% of total antimicrobials worldwide (Van Boeckel et al., 2015; Obimakinde et al., 2017). Globally, the average annual estimated consumption of antimicrobials in poultry is 172 mg/kg, followed by swine at 148 mg/kg and cattle at 45 mg/kg (Van Boeckel et al., 2015). Currently, more than 40 antimicrobials are used in clinical setting, but none adequately address the problem of most resistant bacteria, fueling the failure to treat bacterial infection (CDDEP, 2021).

In 2010, global antimicrobial consumption (228 countries) in food animals was estimated at 63,151±1,560 tons, but by 2030, it is projected to increase by 67.0% to 105,596 ±3,605 tons (Van Boeckel et al., 2015). The increase in antimicrobial consumption is due to increased commercial farming of livestock animals. Asia alone will consume up to 46.0% of antimicrobials by 2030 due to increased livestock commercialization (Van Boeckel et al., 2015; FAO, 2022). China, India, Russia, Brazil, and South Africa have been reported to be the top antimicrobial consumers worldwide. The livestock industry in China could consume one-third of the global antimicrobials (FAO, 2022). The use of critical antimicrobials in humans increased from 91.0% to 165.0% in low-middle-income countries between 2000 and 2015 (WHO, 2021). In the U.S., 80.0% of the national consumption of antimicrobials is used in food animals; however, most developed countries use 50.0-80.0% of the total antimicrobials in livestock sectors (Cully, 2014; Obimakinde et al., 2017). Antimicrobial consumption in some developing countries such as Myanmar (205.0%), Indonesia (202.0%), Nigeria (163.0%), Peru (160.0%), and Vietnam (157.0%) is projected to increase significantly by 2030 due to increased demand for animal protein from livestock (Van Boeckel et al., 2015).

In food producing animals, penicillin and tetracyclines are the most widely used antibiotics (De Briyne et al., 2014). Macrolides, polymyxins, aminoglycosides, and third generation cephalosporins are widely used in human therapeutic antimicrobials and food animals (Kimberly et al., 2017; Lekshmi et al., 2017; WHO, 2021). The antimicrobials most frequently used in poultry were sulfamethoxypyridazine (28.8%), oxytetracycline (18.5%), tylosin (13.9%), and enrofloxacin (9.6%) (Azabo et al., 2022). Among 223 broiler poultry farms, 10.8% of the farms were not used, 33.2% were used once, and 56.0% were used two or more times of antimicrobials in broiler production (Gibson et al., 2020). The most common antimicrobials used in broiler poultry (n=223) were colistin sulfate (42.2%), enrofloxacin (27.4%), amoxicillin (18.4%) and amoxicillin (16.6%) (Gibson et al., 2020). The previous study showed that the largest poultry producer, such as the United States, China, and Brazil, approved macrolides, third generation cephalosporins, and polymyxins for use in poultry (Roth et al., 2019). The FDA banned fluoroquinolone, enrofloxacin, and all antibiotics as growth promoters in poultry production in the USA (Roth et al., 2019).

In poultry, a significant portion of antimicrobials for animals are sold over the counter without a prescription (60.0%) in poultry (Masud et al., 2020). About 63.0% of antimicrobials used in animals are similar to therapeutic drugs used in humans (Woolhouse et al., 2015), which could indicate that there is no proper regulation of AMU in animals, and a large proportion of AMU in humans and animals is for treatment purposes.

Imported antimicrobials in Nepal account for 30.0% of the total medicine used annually, which costs approximately 1 million U.S. dollars (Acharya and Wilson, 2019). In Nepal, 365 different types of antimicrobials are sold, and 50 companies produce antimicrobials for human and veterinary medicine (Acharya and Wilson, 2019). The total amount of AMU in animal sectors in 2018 was 91.1 tons in Nepal (Upadhyaya et al., 2020). In 2019, livestock consumed 48 tons of antimicrobials alone, including tetracycline (9.7 tons), third and fourth generation cephalosporin (9.1 tons), fluoroquinolones (6.5 tons), aminoglycosides (2.8 tons), penicillin (2.2 tons), nitrofurans (1.9 tons), macrolides (1.8 tons), sulfonamides (1.3 tons) amphenicols (0.1 tons), and other antimicrobials 2.2 tons (Upadhyaya et al., 2020).

In Nepal, tetracycline, enrofloxacin, neomycin-doxycycline, levofloxacin, colistin, and tylosin are the top seven antimicrobials consumed, while ampicillin, amoxicillin, ceftriaxone, and gentamicin are the antibiotics prescribed the most inappropriately (Upadhyaya et al., 2020). Ciprofloxacin, amoxicillin, and tetracycline are the most widely used antimicrobials to treat respiratory tract infections in poultry, such as Gumboro and New Castle disease. Ciprofloxacin, amoxicillin, and tiamulin are usually used in layer farms, while colistin, doxycycline, and neomycin are frequently used in broiler farms (Nepal et al., 2019). The previous study of AMU in poultry showed that doxycycline (25.9%) was the most used antibiotic, followed by tylosin (21.5%), colistin (18.8%), ciprofloxacin (13.4%) and neomycin (12.5%) in Kathmandu and Chitwan district (Dhakal and Gompo, 2022).

2.4. Antimicrobial resistance

The process of AMR in microorganisms is a natural phenomenon, but the selection of AMR has been led by its exposure to humans, animals, and the environment (Holmes et al., 2016). A previous study estimated that 4.9 million deaths were associated with bacterial AMR in 2019, and the highest AMR-attributed death was found in western sub-Saharan Africa (27 deaths per 100,000) and the lowest death rate in Australasia (6.5 deaths per 100,000) (Murray et al., 2022). The cumulative increase in AMR may result in more than 3.4 trillion USD in the world's annual gross domestic product (GDP) in ten short years if action is not taken correctly (Murray et al., 2022). The inaccessibility of effective antimicrobials for animal treatment has a significant impact on food production, food security, and farmer livelihoods. This is due to regulations that limit their use to address the global public health threat of AMR, which can lead to increased animal mortality, reduced productivity, and lower incomes for farmers (FAO, 2022). This risk is high in countries with weak or inadequate legislation, regulatory functions, and monitoring systems related to the control and prevention of AMU and AMR (FAO, 2022).

For many decades, AMR has become a major global threat to public health (Hoque et al., 2020; Moffo et al., 2020). The increase in mortality and morbidity in the human population due to the infection of AMR bacteria is a significant problem in public health (Hedman et al., 2020). The six leading bacteria (*Escherichia coli*, followed by *Staphylococcus aureus, Klebsiella pneumonia, Streptococcus pneumonia, Acinetobacter baumannii,* and *Pseudomonas aeruginosa)* were responsible for 0.9 million (0.7-1.3) deaths attributable to AMR and 3.6 million (2.6-4.8) deaths associated with AMR in 2019 (Murray et al., 2022). Primarily, *E. coli, Salmonella enterica, K. pneumonia*, and other gram-negative bacteria have harbored MDR (Dahal and Chaudhary, 2018).

Resistant gram-negative bacteria can transfer different resistance genes through horizontal gene transfer (Johnson and Lang, 2012). AMR genes can be inserted into plasmid genetic load regions via conjugative transposons or integrons (Lindsey et al., 2011). The problem of MDR-associated plasmids is a significant concern in poultry, including IncF, IncI1, and IncA/C (Martin et al., 2012). Several studies demonstrated a positive association between AMU and AMR (Lai et al., 2011; Agyare et al., 2018). Two-thirds of the future's AMU growth will be directly related to animal production (FAO, 2022). MDR of *S. aureus, P. aeruginosa, E. coli,* and *M. tuberculosis* are the main problems for public health concerns (Dahal and Chaudhary, 2018). The significant AMR trends were examined in the serovars from *Salmonella* spp., *Shigella* spp., and *Vibrio cholera* with changing AMR trends (Malla et al., 2014). In recent years, AMR has increased in ampicillin, amoxicillin, cotrimoxazole, chloramphenicol, ciprofloxacin, nalidixic acid, gentamicin, and ceftazidime, helping to increase dissemination of resistant bacteria (Dahal and Chaudhary, 2018).

There is evidence that poultry and its products act as an AMR reservoir that can pose serious threats to humans and domestic and wild animals (Van Boeckel et al., 2019). A study in Nepal showed that *E. coli, Klebsiella* spp., *Citrobacter* spp., *S. aureus, Salmonella* spp., and *Proteus* spp. of buffalo and poultry meat had resistance to tetracycline, amoxicillin, cotrimoxazole and nalidixic acids (Saud et al., 2019). The resistance of *E. coli* isolated from the chicken was found to be 100.0%, 93.0%, 25.0%, and 19.0% to amoxicillin, tetracycline, nalidixic acid, and cefotaxime, respectively (Bantawa et al., 2019). The antibiogram profiles of 50 *E. coli* strains showed the highest resistance to ampicillin (98.0%), followed by cotrimoxazole (90.0%) and doxycycline (62.0%) (Subedi et al., 2018). Previous studies have demonstrated an increasing trend of resistance with time for *S. rosophila* serovar Pullorum/Gallinarum, *M. gallisepticum,* and *G. anatis*. Among *Enterobacteriaceae*, Avian Pathogenic *Escherichia coli* (APEC) isolates showed considerably higher AMR levels than *S.* serovar Pullorum/Gallinarum, with a prevalence of resistance of more than 80.0% for ampicillin, amoxicillin, and tetracycline. *Salmonella* resistance was observed most frequently to amoxicillin (100.0%), tetracycline (24.0%), chloramphenicol (11.0%), and nalidixic acid (11.0%) in chicken, buffalo, pig, and goat meat (Bantawa et al., 2019). A previous study in Nepal showed that 94.0% of *E. coli* were MDR and mainly resistant to amikacin (84.0%), nitrofurantoin (55.0%), and colistin (50.0%), respectively (Subedi et al., 2018). A high prevalence of MDR was observed at 79.6% in raw chicken meat (Shrestha et al., 2017). Furthermore, MDR *Salmonella* spp., *S. aureus*, *Shigella,* and *E. coli* were found in the isolate of chicken, buffalo, pig, and goat meat (Bantawa et al., 2019). The previous study found that antimicrobial administration in the early stages of a chicken's life can have long-lasting effects on gut microbiota composition and function. The study suggests that these changes may result in increased susceptibility to diseases and a decreased in overall animal health (Schokker et al., 2017).

2.5. Knowledge, attitude, and practice

KAP is a health behavior theory that was established in 1960. There are three sequential processes in human behavioral change: knowledge acquisition, attitude generation, and behavior formation (Kim et al., 1969). The KAP survey mainly uses quantitative methods to reveal misconceptions that can be difficulties in actions to change behavior. The KAP study is representative of a specific target group to gather information on what is known, believed, and performed regarding a particular topic (WHO, 2008). Assess knowledge to examine how closely community knowledge is associated with health beliefs. Attitudes are trained propensities to think, feel, and act in particular ways about issues because of a complex interplay of thoughts, feelings, and values. In most of the KAP surveys, respondents are asked about preventive measures or the use of various health options. Hypothetical questions are usually asked. It provides information about what people do and what they think they should do (Ul Haq et al., 2012).

2.6. KAP of PPV on AMU and AMR

Veterinarians are typically responsible for prescribing and monitoring AMU in animals. The farmer-veterinarian relationship is essential to reduce the inappropriate use of antimicrobials in livestock (Farrell et al., 2021). AMU in farm animals may contribute to the development of AMR in humans and animals. Many studies of KAP for AMU and AMR in veterinarians were observed in multiple types of animals, such as companion animals, poultry, and other species of livestock (Alcantara et al., 2021; Hassan et al., 2021; Kalam et al., 2021). A thorough understanding of veterinarians' current prescribing practices and their reasons could offer leads for interventions to reduce AMU in farm animals (Speksnijder et al., 2015).

A previous KAP study was observed among 220 registered veterinarians, indicating that 52.8% belong to the age group of 30–29; 72.2% were men, 42.4% had a master's degree, and 44.4% worked in public service (Aworh et al., 2021). In Nigeria, 51.0% of veterinarians stated that the prophylactic use of antimicrobials is appropriate under poor biosecurity conditions (Aworh et al., 2021). Laboratory services (82.0%) and excessive laboratory fees (72.0%) were reported as primary barriers to performing the antimicrobial susceptibility test (AST) (Aworh et al., 2021). According to a study conducted in Bangladesh, most veterinarians (91.4%) were aware that antimicrobials could not cure viral infections, and almost all of them (97.6%) believed that frequent antimicrobial prescriptions could make less effective. Approximately 80.0% of veterinarians disagreed with the use as a growth promoter in Bangladeshi cattle (Sarker et al., 2022). Almost all (93.0%) of veterinarians in the USA indicated that improper AMU contributed to AMR, and 52.0% believed that antimicrobials were prescribed appropriately (Odoi et al., 2021). Similarly, most (88.0%) veterinarians assumed that improper AMU contributed to AMR (Samuels et al., 2021). Many veterinarians (61.5%) believed that antimicrobials are appropriately prescribed, and 88.7% agreed that improper AMU contributed to the selection of AMR organisms (Samuels et al., 2021).

It is interesting that most veterinarians (90.6%) use their own experiences for the selection of antimicrobials (Vijay et al., 2021). A previous study observed that the clinical signs and symptoms of the animals (88.9%), the route of administration (81.5%), and the cost of antimicrobials (77.2%) were affected in the selection of antimicrobials (Samuels et al., 2021). Two-thirds of veterinarians had good knowledge of antimicrobials, and 47.2% had received training in stewardship, while 88.9% believed that overuse of antimicrobials was the main factor contributing to AMR (Aworh et al., 2021). A previous study in India showed that most veterinarians had good knowledge (69.5%), good attitude (93.2%), and moderate practice (51.3%) for AMU, and factors including KAP score, farm management, and antimicrobial stewardship were factors associated with AMR in veterinarians (Vijay et al., 2021). However, previous studies in Nepal and Bhutan reported that animal health workers and farmers had poor knowledge of AMU and AMR (Lambrou et al., 2021; Wangmo et al., 2021).

2.7. KAP of BPF on AMU and AMR

The livestock sector is estimated to consume 70% of total antimicrobials worldwide, and farmers are the main end users of antimicrobials (Van Boeckel et al., 2015; Obimakinde et al., 2017). Due to the increasing demand for animal protein, there has been a significant rise in the use of antimicrobials in poultry farming. This has led to concerns about the development of AMR in animal and public health (Caudell et al., 2017). Therefore, the farmer is one of the important stakeholders of AMU and a contributing factor to AMR. The purpose of AMU in commercial poultry was varied, including 22.6% for prophylactic, 15.3% for therapeutic, and 13.3% for growth promotion (Imam et al., 2020; Lambrou et al., 2021).

A previous study in Nepal indicated that only 19.6% (11/56) farmers of Kathmandu Valley and 16.1% (9/56) of those in the Chitwan district knew about AMR (Dhakal and Gompo, 2022). A previous KAP study in Bangladesh demonstrated that farmers' age, farming experiences, education level, economic status, farm type, and farm size influenced AMU and AMR in poultry production (Hassan et al., 2021). More importantly, veterinarians and drug sellers were indicated to be responsible for AMU on livestock farms (Masud et al., 2020). Another study in Nepal indicated that 51.3% of respondents did not ensure that skipping antimicrobial doses causes AMR, and higher levels of farmer education were likely to have a better KAP of AMU (Nepal et al., 2019). Gender was also associated with attitude towards AMU and AMR, and good attitude was observed in female respondents (OR=2.2, 95% CI 1.0–4.6, $p<0.05$) (Wangmo et al., 2021). Among 150 poultry farmers, most of them had a low understanding of the antimicrobial withdrawal period (27.3%), were unaware of AMR (82.0%), and did not know about AMR (77.0%) (Lambrou et al., 2021). One-third of the farmers administered antimicrobials without a prescription from veterinarians.

Similarly, demographic and socioeconomic factors were significant factors associated with the KAP of farmers (Hassan et al., 2021).

For a public health perspective, farmer behavior and practice could affect AMR development. Almost half (47.7%) of farmers believed that antimicrobials could help cure if they had a fever; however, 84.6% at least sometimes preferred an antibiotic when they had a cough and sore throat (Nepal et al., 2019). A similar study indicated that most farmers needed to be aware of the contribution of skipping the dose in the development of AMR (50.9%), and 88.2% replaced the doctor if an antimicrobial was not prescribed if the farmer thought it was necessary. These findings were related to cases where usual clinical signs included respiratory (71.8%) and gastrointestinal (32.0%) (Imam et al., 2020). Antimicrobials are widely used in human and veterinary medicine, but there is a need to improve awareness of AMU and the development of AMR. A lack of understanding about the use, dosage, and misuse of recommended antimicrobials can contribute to the development of AMR.

CHAPTER 3 MATERIAL AND METHODS

The cross-sectional questionnaire survey was conducted to examine the situation of AMU and KAP on AMU and AMR of veterinarians and farmers working related to broiler poultry. This study was divided into two phases, consisting of phase I, the design and development of questionnaires for the field survey, and phase II, the questionnaire interview (Fig. 1).

Phase 1: Design and development of questionnaires for field survey (PPV: n=327 and BPF: n=500)

- Demographic characteristics of respondents
- Situation of AMU in poultry farm
- KAP on AMU and AMR of PPV and BPF

Phase 2: Questionnaire interview (n=827)

- IOC Index and pre-test of the questionnaire for data validity

- Interview PPV (n=327) and BPF (n=500)
- Statistical analysis

Goal: to study situation and KAP on AMU and AMR in PPV and BPF

Figure 1 Conceptual framework of research

3.1. Phase I: design and development of questionnaires

The questionnaires for veterinarians and farmers include demographic information, situation analysis on AMU, knowledge, attitude, and practice associated with AMU and AMR. The KAP questionnaire for PPV and BPF was designated separately. There were 47 and 61 questions for PPV (Annex I) and BPF (Annex II), respectively. Most of the questions were multiple-choice questions.

3.1.1. Demographic information

The questionnaire related to demographic information comprised of age, sex, educational level, work experience, province, and ecozone of the respondent.

3.1.2. Situation analysis

The questions related to the situation analysis of AMU were interviewed to PPV and BPF. Questions pertaining to the prudent use of antimicrobials were directed toward PPV, while BPF was asked about various aspects such as the type, frequency, source, and storage of antimicrobials used, in addition to information regarding flock size, bird health, farm biosecurity, mortality, clinical sign, and disease occurrence.

3.1.3. KAP for PPV

The KAP questionnaire is divided into three parts: knowledge, attitude, and practice. For PPV, the knowledge questions were related to AMU in food-producing animals, antimicrobial residues, the effect of inappropriate use, public health issues of antimicrobials and AMR, and government policy and regulation on AMU and AMR. The attitude questions were related to the safety and priority of AMU, problems of AMR, strategy used to combat AMR, withdrawal period of antimicrobials, etc. Similarly, the practice section of the questionnaire included questions about the purpose of AMU, prescription on demand and patterns, the use of single or combination AMUs, frequency of AMU, dose calculation, national guidelines, and continuing education or training programs.

3.1.4. KAP for BPF

The knowledge questions for BPF were related to AMU, the withdrawal period of antimicrobials, AMR transmission, and government policy on AMU. Regarding the perception about AMU and AMR, the safety of AMU and using non-prescribed antimicrobials were asked in the attitude question. The practice questions directed inquiries to complete the full course of AMU, skipping doses, checking the expiration dates of antimicrobials, and the frequency of AMU in poultry.

3.1.5. Validation of the questionnaire

Five veterinarians and five farmers were selected for the pretest of the questionnaires before starting the actual survey. The questionnaire was validated and submitted to three experts for the item-objective congruence (IOC) index along with the study objectives. The Content Validity Index (CVI) is used to assess the degree of agreement between different sections of a questionnaire, and the objectives that intended to measure. In this process, experts rate each section of the questions based on their relevance and clarity in relation to the objectives. The resulting CVI ranges from 0 to 1, with higher values indicating greater content validity. The IOC point was rated for each section of both sets of questionnaires. A rating of three scales was made for the consistency and congruencies of all items, and the experts had to choose only one mark from these alternatives, which is given as follows.

+1 = Congruent with a clear understanding

0 = Uncertain whether the item related to the study was related to

-1 = Not understandable or not congruent or related to this study.

The total item must have a consistency value equal to or above 0.05, which is calculated using the equation:

$$IOC = \sum R/N$$

Where,

IOC = Item-Objective Congruence Index

ΣR = total points of each specialist

N = number of specialists

The evaluation of the IOC index is shown in Tables 1 and 2.

Table 1 IOC index of veterinarian questionnaire

Category	Practitioner	Scientist	Epidemiologist	Count	Item CVI
S1 demographic	1	1	1	3	1.0
S2 situation analysis	1	1	0	2	0.7
S3 knowledge	1	0	1	2	0.7
S4 attitude	1	1	1	3	1.0
S5 practice	0	1	1	2	0.7
IOC index					0.8

Table 2 IOC index of BPF's questionnaire

Category	Practitioner	Scientist	Epidemiologist	Count	Item CVI
S1 demographic	1	1	1	3	1.0
S2 situation analysis	1	1	1	3	1.0
S3 knowledge	1	0	1	2	0.7
S4 attitude	1	1	0	2	0.7
S5 practice	1	1	1	3	1.0
IOC index					0.9

3.2. Phase II: questionnaire interview

3.2.1. Study area

The questionnaire was distributed to all PPV in Nepal for an online survey, and 327 PPV from 56 districts participated. The study area for PPV included 56 districts from seven provinces: Sudurpaschim province (Baitadi, Bajura, Dadeldhura, Darchula, Kailali, and Kanchanpur); Karnali province (Jajarkot, Rukum West, Salyan, and Surkhet); Lumbini province (Banke, Bardia, Dang, Gulmi, Kapilvastu, Palpa, Rolpa, Rukum East, Nawalparasi West, and Rupandehi); Gandaki province (Nawalparasi East, Arghakhanchi, Baglung, Gorkha, Kaski, Lamjung, Manang, Syangjya, and Tanahun); Bagmati province (Bhaktapur, Chitwan, Dhading, Dolakha, Kathmandu, Kavreplachowk, Lalitpur, Makawanpur, Nuwakot, Ramechhap, Sindhuli, and Sindhupalchok); Madhesh province (Bara, Dhanusha, Parsa, Rautahat, Saptari, Sarlahi, and Siraha); and Koshi province (Bhojpur, Dhankuta, Ilam, Jhapa, Morang, Sankhuwasabha, Sunsari, and Udayapur) (Fig. 2).

For a BPF questionnaire survey, 500 BPF from 40 districts from the seven provinces, including Sudurpaschim, Karnali, Lumbini, Gandaki, Bagmati, Madhesh, and Koshi, were selected based on the high density of the broiler population. At least three districts were selected from each province of Nepal. The study area covered 88.1% of Nepal's broiler population. Forty districts from seven provinces comprising: Sudurpaschim province (Bajura, Kailali, and Kanchanpur); Karnali province (Surkhet, Dailekh, and Jajarkot); Lumbini province (Banke, Bardia, Dang, Gulmi, Palpa, Pyuthan, and Rupandehi); Gandaki province (Baglung, Gorkha, Kaski, Nawalparasi East, Syangjha, and Tanahun); Bagmati province (Bhaktapur, Chitwan, Dhading, Kathmandu, Kavreplanchok, Lalitpur, Makawanpur, Nuwakot, Sindhuli, and Sindhupalchok); Madhesh province (Bara, Mahottari, Rautahat, Saptari, and Siraha); Koshi province (Ilam, Jhapa, Morang, Okhaldunga, Sunsari, and Udayapur) were selected for the farmer questionnaire survey (Fig. 2).

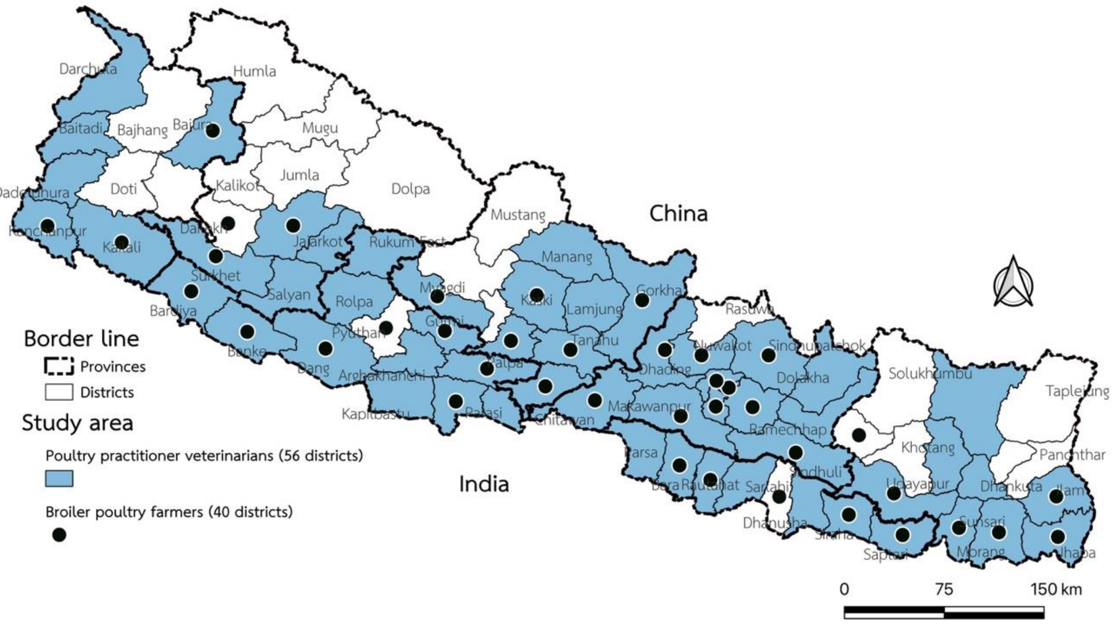


Figure 2 Geographical distribution of study area

3.2.2. Study population

There are 1,622 registered veterinarians, and 481 are assumed to work as poultry practitioners in Nepal (NVC, 2022). The study population consisted of all PPV of Nepal. The veterinarians providing veterinary services to poultry farms, such as diagnosis, treatment, and vaccination, were selected as a respondent to this study.

In Nepal, 52.7 million broiler poultry were reared in 20,483 farms in 2017. Forty selected districts have 46.4 million broiler poultry and 17,601 farms (CBS, 2017). Farmers were those engaged in poultry farming as owners or staff, technicians or veterinarians who take care of the farm management, and medication was included. The inclusion criteria of this study for the farmer were full-time broiler poultry farm staff, owner, technician, or veterinarian, and one of them accepted the proposal as a respondent. The number of samples per district was calculated based on the proportion of the broiler population. A respondent per farm was selected for the questionnaire survey.

3.2.3. Sample size calculation

The sample size for two different groups of the study population (veterinarians and farmers) was calculated separately. There are 481 poultry practitioner veterinarians in Nepal. The size of the sample was calculated based on a 95% confidence interval and 5% desired precision. The required sample size was at least 219 veterinarians.

There were 17,601 broiler farms in 40 districts of the study area. The total number of sample farms was calculated based on a 95% confidence interval and 5% desired precision. The sample size of the respondent was at least 392 farms.

3.2.4. Questionnaire survey and data collection

The PPV questionnaire survey was conducted using Google Form (Google LLC, Mountain View, CA, USA), which was prepared in both Nepali and English languages. The questionnaire link was disseminated to PPV via email and social media platforms such as Facebook Messenger, WhatsApp, and Viber. The contact details of the PPV were obtained from the Nepal Veterinary Council.

A semi-structured questionnaire was used for face-to-face interviews with the BPF, which were conducted by trained veterinarians. The video tutorial on "How to use Epicollect5?" was prepared. All participating veterinarians for the farmer's survey had received the training in seven provinces, while the rest received their orientation from online or over the phone. The farmers' record-keeping books, photos of antimicrobials, and antimicrobial labels or packaging materials were used to verify the information about the use of antimicrobials provided by the farmers. Both Nepali and English questionnaires were used, and data were collected in EpiCollect5 (GitBook, NY, USA). Each farmer was informed about the objectives and purpose of the survey as per Annex III. Only farmers who consented to participate were included in the study (Annex IV).

3.3. Ethical approval

Ethical approval was granted from the Nepal National Health Research Council (Reference number 3029) (Annex V). All participants signed or accepted a written consent before the start of the questionnaire interview. All data collected in the study were anonymized before statistical analysis.

3.4. Statistical analysis

The data obtained from the questionnaire survey was cross-checked, tabulated, cleaned, processed, and verified in Microsoft Excel 365. The responses to the collected questionnaire were coded as 1 to 5 for “Completely agree," "Agree," “Disagree," “Completely disagree," and "Do not know" for the calculation of the overall KAP score. To categorize the KAP scores as “Good” or "Not good", the median value of each respondent was calculated based on their responses. If the overall median value of the respondent was below or equal to the median, it was considered a “good” level of KAP, whereas a value above the median was deemed to have a “not good" KAP level.

The study employed descriptive and analytical statistics to analyze the AMU situation and KAP, with logistic regression used to determine associations between the respondents' general information and the variables related to KAP on AMU and AMR of PPV and BPF. The selection of the independent variables was done based on the literature review. The variables with a p-value less than 0.1 in univariate analysis were selected for multivariate analysis. Results were considered statistically significant, with a 95% confidence interval and a $p\text{-value} < 0.05$. STATA/SE 14 (StataCorp, College Station, TX, USA) was used for data analysis, and QGIS 3.4 (Free Software Foundation, Boston, USA) was used to present the spatial distribution on a map.

CHAPTER 4 RESULTS

In this study, 372 veterinarians and 500 BPF participated from 56 and 40 districts, respectively. Among the 372 veterinarians, 327 were found to be PPV and included in this study. The number of districts and respondents per province is presented in Table 3.

Table 3 Broiler poultry population and respondents per province

Province	Broiler population (%)*	Number of districts per province		Number of responses	
		BPF	PPV	BPF	PPV
Bagmati	44.1	10	12	158	161
Gandaki	10.0	6	8	63	29
Karnali	2.0	3	4	27	14
Lumbini	15.7	7	11	86	54
Madhesh	9.9	5	7	51	27
Koshi	13.1	6	8	85	30
Sudurpaschim	5.1	3	6	30	12
Grand total	100	40	56	500	327

* Total broiler poultry population was approximately 52.7 million in 2015 (CBS, 2017)

4.1. Demographic distribution, situation analysis of AMU and KAP of PPV

4.1.1. Demographic characteristics of PPV

The study cohort comprised 327 PPV, with a nearly even distribution between the terai (50.5%) and the hill regions (45.9%) of Nepal. About half of the PPV (49.2%) were from Bagmati province, followed by Lumbini (16.5%) and Gandaki (8.9%) province. Most of the respondents (85.0%) identified themselves as male. The mean age of the PPV was 31.9±7.8 years, with a range of 24 to 74 years. The highest proportion (55.4%) of the PPV belonged to the 24- to 30-year age group, followed by the 31-60 years age group (38.2%). The majority of the PPV (53.8%) had bachelor level education, followed by a master's degree (43.8%) and PhD (2.4%). In terms of occupation, a significant proportion of the PPV reported owning private businesses (38.5%), followed by those employed in government service (29.1%), academia and research (22.6%), and non-government organizations (6.7%) (Table 4).

Table 4 Demographic distribution of the PPV (n=327)

Variables	**N (%)**
Ecozone	
Terai	165 (50.5)
Hill	150 (45.9)
Mountain	12 (3.7)
Province	
Bagmati	161 (49.2)
Gandaki	29 (8.9)
Karnali	14 (4.3)
Lumbini	54 (16.5)
Madhesh	27 (8.3)
Sudurpaschim	12 (3.7)
Koshi	30 (9.2)

Table 4 Demographic distribution of the PPV (n=327) (Continue)

Variables	**N (%)**
Gender	
Male	278 (85.0)
Female	49 (15.0)
Age group (years)	
24-30	181 (55.4)
31-45	125 (38.2)
46-60	17 (5.2)
>60	4 (1.2)
Educational level	
Bachelor	176 (53.8)
Master	143 (43.8)
PhD	8 (2.4)
Type of primary job	
Private business	126 (38.5)
Government service	95 (29.1)
Academia and research	74 (22.6)
Non-government organization	22 (6.7)
Poultry practice	10 (3.1)

4.1.2. AMU situation of PPV

The survey conducted among 327 PPV on their perceptions and practices toward AMU and AMR sheds light on the understanding and prescribing practices of PPV in combating AMR. Among the 625 responses received for the important strategies to combat AMR, 34.4% chose for using appropriate treatment guidelines could combat AMR, 19.7% thought about improving biosecurity and hygiene, 17.1% thought that increasing education, 15.7% antimicrobial sales control could help alleviate AMR impact. Most (51.1%) attributed the irrational use of antimicrobials as the main reason for AMR. The study also identified other reasons for AMR, including over-the-counter sales (27.8%), low-dose administration (12.3%), and low-quality antimicrobials (6.7%).

Based on the proportion of antibiotics prescribed, most PPV (50.8%) prescribed antimicrobials at a rate of 20-40% of their prescriptions, while 25.9% of PPV prescribed antimicrobials at a rate of less than 20.0% and 18.9% prescribed antibiotics at a rate of 40-60%. Only 4.3% of PPV prescribe antimicrobials at a rate of more than 60%. The majority of respondents (66.1%) answered that colistin sulfate is the CIA as specified by the WHO, while others provided incorrect answers (Table 5). The frequency of antimicrobials prescribed by the PPV in broiler poultry was classified by antimicrobial class is presented in Annex VI.

Table 5 Situation analysis of AMU and AMR in PPV

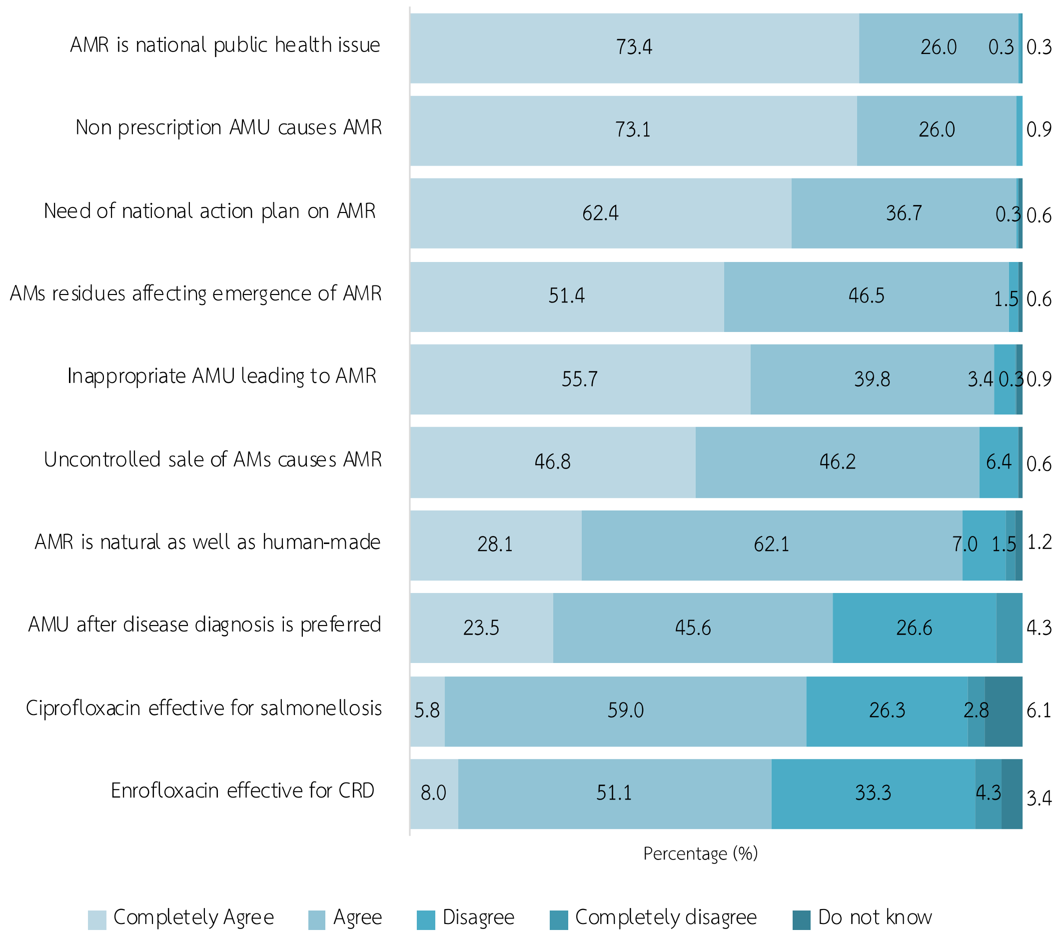
Variable	**N (%)**
Important strategies to combat AMR (n=625) *	
Use of appropriate treatment guideline	215 (34.4)
Improve biosecurity and hygiene of farm	123 (19.7)
Educational campaigns	107 (17.1)
Control of antimicrobial sells	98 (15.7)
Vaccination campaigns	54 (8.6)
Reduce AMU in animal	28 (4.5)
Primary reason for AMR (n=569) *	
Irrational use	291 (51.1)
Over-the-counter sell	158 (27.8)
Low dose administration	70 (12.3)
Low quality antimicrobial	38 (6.7)
Other	12 (2.1)
Proportion of antimicrobials in prescription (n=327)	
<20%	85 (25.9)
20-40%	166 (50.8)
40-60%	62 (18.9)
>60%	14 (4.3)
CIA as specified by WHO (n=327)	
Colistin sulfate	216 (66.1)
Chloramphenicol	29 (8.9)
Sulfamethoxazole	14 (4.3)
Don't Know	68 (20.8)

Note: * Multiple answers allowed

4.1.3. KAP of PPV on AMU and AMR

Knowledge of PPV on AMU and AMR

Based on the knowledge of veterinarians, it is apparent that the respondents agreed on several critical issues related to AMR. Almost PPV (96.6%) had good knowledge of AMU and AMR. The primary summary responses indicated that they completely agreed and agreed (1) AMR is a national public health problem (99.4%), (2) misuse and overuse of antimicrobials without prescription are the main factors affecting AMR (99.1%), and (3) the potential antimicrobial residue that leads to the development of AMR (97.9%). Furthermore, 93.0% of the PPV knew about the impact of the uncontrolled sale of antimicrobials causing the development of AMR, highlighting the importance of regulating the distribution and use of antimicrobials. About three-quarters (69.1%) of PPV agreed with the statement that the use of antimicrobials after disease diagnosis is preferred. Furthermore, most of the PPV provided correct answers on the choice of antimicrobials for treatment (64.8% for salmonellosis and 59.1% for chronic respiratory disease) (Fig. 3).

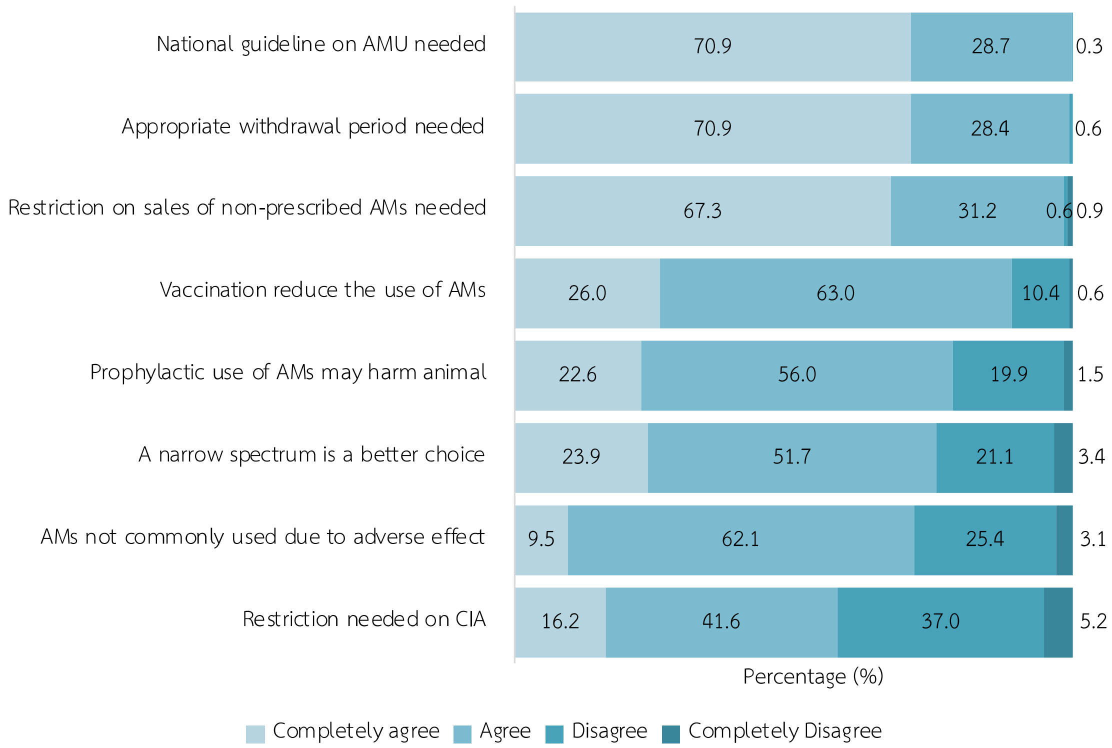


Note: AMs: Antimicrobials; CRD: Chronic Respiratory Disease

Figure 3 Knowledge of PPV on AMU and AMR

Attitude of PPV towards AMU and AMR

Almost PPV (98.8%) had a good attitude toward AMU and AMR. Almost PPV (99.6%) agreed on the National guideline on AMU is needed. Almost PPV (98.5%) said that the sale of nonprescribed antimicrobials should be prohibited. Likewise, 89.0% of the PPV agreed that vaccination could reduce the use of antimicrobials in poultry. There was a poor attitude (78.6%) towards the statement that prescribing antimicrobials to a healthy animal for the prevention of disease may harm the health of the animal. Three-quarters (75.6%) of the PPV believed that narrow-spectrum antimicrobials are a better choice than broad-spectrum. Most of the PPV (71.6%) agreed that antimicrobials are not commonly used in humans and animals due to their adverse effects (Fig. 4).

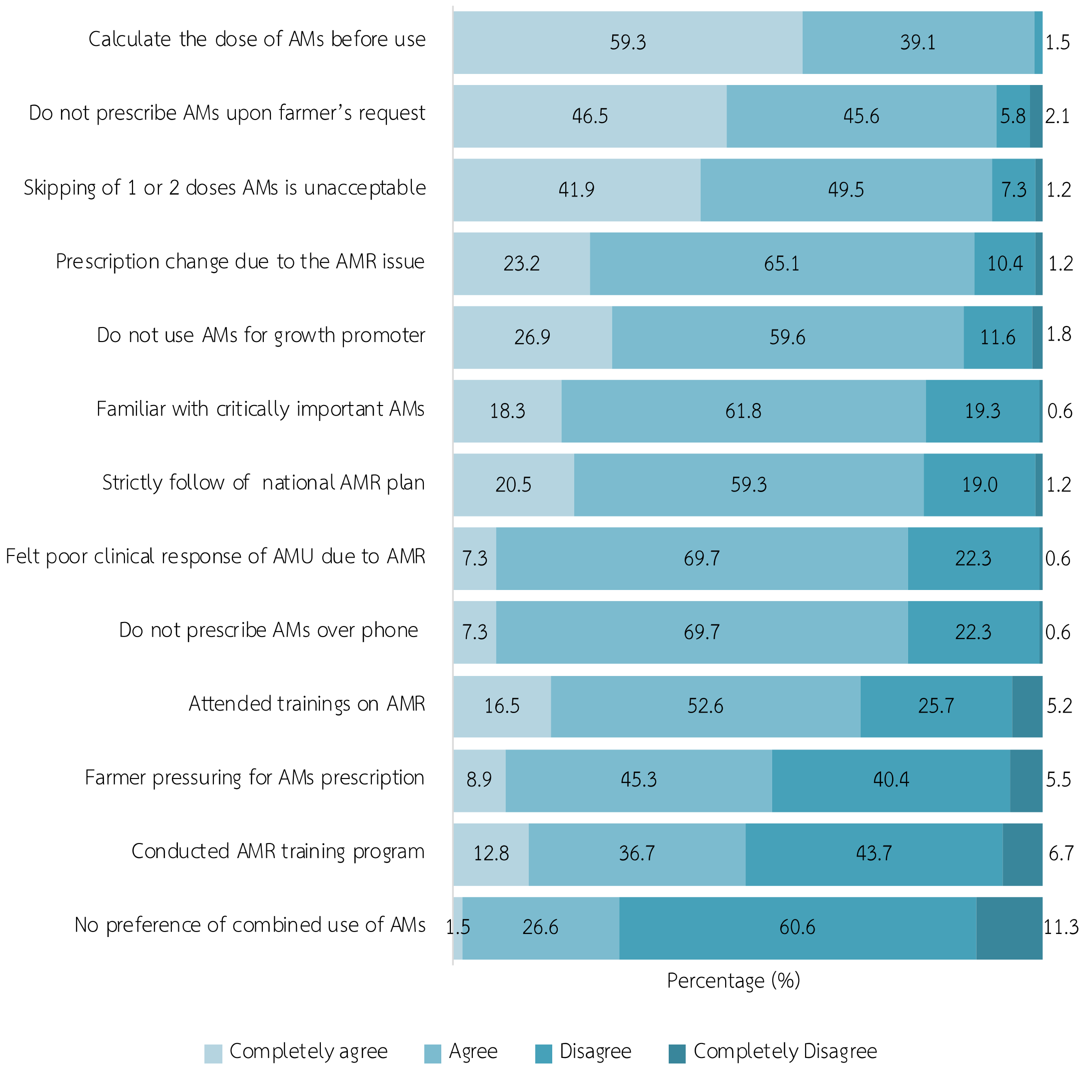


Note: AMs: Antimicrobials; CIA: Critically Important Antimicrobial

Figure 4 Attitude of PPV towards AMU and AMR Practice of PPV on AMU and AMR

Practice of PPV towards AMU and AMR

The survey results on the practices towards AMU among poultry veterinarians. Almost PPV (93.9%) had good practice of AMU and AMR. However, 88.3% of PPV changed their prescription practices due to the AMR in poultry. The survey showed that 86.5% of PPV do not use antimicrobials for growth promoters, and 71.9% do not prefer using combined antimicrobials for therapeutic success. Additionally, the survey revealed that only 69.1% of PPV attended training to update their knowledge about AMU and AMR. Interestingly, almost half (54.2%) of the PPV received pressure from farmers for an antimicrobial prescription, while 22.9% prescribed antimicrobials by phone or without examining birds (Fig. 5).



Note: AMs: Antimicrobials

Figure 5 Practice of PPV on AMU and AMR

4.2. Demographic distribution, situation analysis of AMU and KAP of BPF

4.2.1. Demographic characteristics of BPF

Among the 500 BPF, the participants were distributed in the Terai (53.8%), Hill (42.2%), and Mountain region (4.0%). The highest number of participants were from Bagmati province (31.6%), followed by Lumbini (17.2%), Koshi (17.0%), and Gandaki (12.6%), while the least number of participants were from Karnali provinces (5.4%). Most of the BPF were male (81.0%) and had an average of 36.7±9.0 (31-40) years (41.4%). Most farmers (59.6%) had 0-4 years of experience, half (50.8%) had a high school education, and 26.8% had primary education. In terms of farm size, 57.8% of farms were classified as small (<1,500 birds), while 29.4% and 12.8% were medium (1,501-5,000 birds) and large (>5,000 birds), respectively (Table 6). The mean flock size of the poultry farms was 3,155±10,967.0 (250-178,000). However, almost all farmers (98.6%) reported using commercial feed for their birds. Most of the respondents get their water from groundwater (47.4%), followed by the municipality (41.2%) and then the deep well (10.8%). Furthermore, the average mortality rate in broiler poultry flocks was 9.3±15.5%, ranging from 0 to 100%.

On average, the income per 100 birds and the income per batch of broiler poultry farming were 43.8±22.6 (0-105.7) USD and 1,617.2±279.0 (0 to 102,459.0) USD, respectively. The respondents (14.0%) earned less than 200 USD per batch, while the highest percentage (39.8%) earned between 201 and 500 USD per batch, and 10.8% earned between 1,000 and 2,000 dollars per batch. The average cost of medicine per 100 birds was 6.9±7.5 (0 to 49.8) USD.

Table 6 Demographic distribution on the BPF

Variables	**N (%)**
Ecozone	
Terai	269 (53.8)
Hill	211 (42.2)
Mountain	20 (4.0)
Province	
Bagmati	158 (31.6)
Gandaki	63 (12.6)
Karnali	27 (5.4)
Lumbini	86 (17.2)
Madhesh	51 (10.2)
Sudurpaschim	30 (6.0)
Koshi	85 (17.0)
Gender	
Female	95 (19.0)
Male	405 (81.0)
Age (years)	
18-30	134 (26.8)
31-40	207 (41.4)
41-60	155 (31.0)
>60	4 (0.8)

Table 6 Demographic distribution on the BPF (Continue)

Variables	N (%)
Farming experience (year)	
0-4	298 (59.6)
5-8	135 (27.0)
9-12	43 (8.6)
>13	24 (4.8)
Education level of respondent	
Illiterate	43 (8.6)
Primary school	134 (26.8)
High school	254 (50.8)
Graduate	69 (13.8)
Flock size (bird heads)	
Small (<1,500)	289 (57.8)
Medium (≥1,500-5,000)	147 (29.4)
Large (>5,000)	64 (12.8)
Source of feed	
Homemade	7 (1.4)
Commercial	493 (98.6)
Source of water	
Groundwater	237 (47.4)
Deep well	54 (10.8)
Municipality	206 (41.2)
Other	3 (0.6)

Table 6 Demographic distribution on the BPF (Continue)

Variables	N (%)
The income per batch (USD)	
<200	70 (14.0)
201-500	199 (39.8)
501-1,000	110 (22.0)
1,001-2,000	54 (10.8)
2,001-5,000	39 (7.8)
>5,000	28 (5.6)

4.2.2. Antimicrobial use in BPF

In Nepal, almost all BPF had access to antimicrobials in the study area. Twenty-seven different types of antimicrobials of 13 classes were found to be used in poultry. The class of antimicrobials most used (n=908) in broiler poultry was tetracyclines (28.0%), followed by aminoglycosides (21.5%), quinolones (13.0%), polymyxins (9.6%), penicillins (9.3%), macrolides (4.5%) and sulfonamides (3.5%) as shown in Fig. 6.

Neomycin-doxycycline (22.4%) was found most frequently used combined with antimicrobials, followed by colistin sulfate-amoxicillin (4.8%) in broiler poultry farms. Colistin sulfate was often combined with amoxicillin, gentamicin, tylosin, doxycycline, and tetracycline, while doxycycline was frequently combined with gentamicin, neomycin, and tylosin.

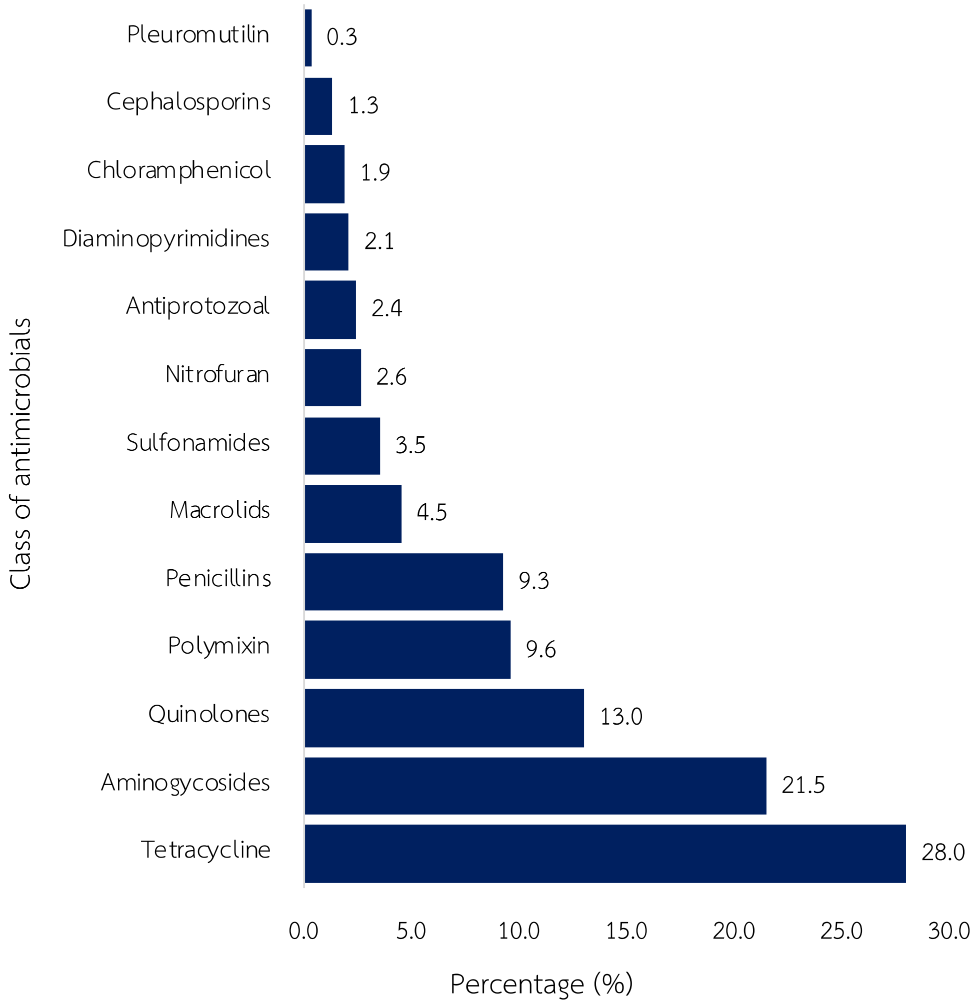


Figure 6 Classes of antimicrobials used in BPF (n=908)

On average, each broiler production cycle involved the use of antimicrobials 1.6 (0-4) times (781/500), and 9.2% of the farmers had never used them during the cycle. The remaining 90.8% of the farmers used antimicrobials at least once. Among the 908 multiple responses, the antimicrobials used most frequently were doxycycline (23.5%), neomycin (17.1%), colistin sulfate (9.6%), amoxicillin (7.5%), enrofloxacin (5.9%), gentamycin (4.4%), tylosin tartrate (3.7%), levofloxacin (3.4%), ciprofloxacin (2.9%), furaltadone (2.6%), tetracycline (2.5%), amprolium (2.4%), and sulfadiazine (2.2%) as shown in Fig. 7.

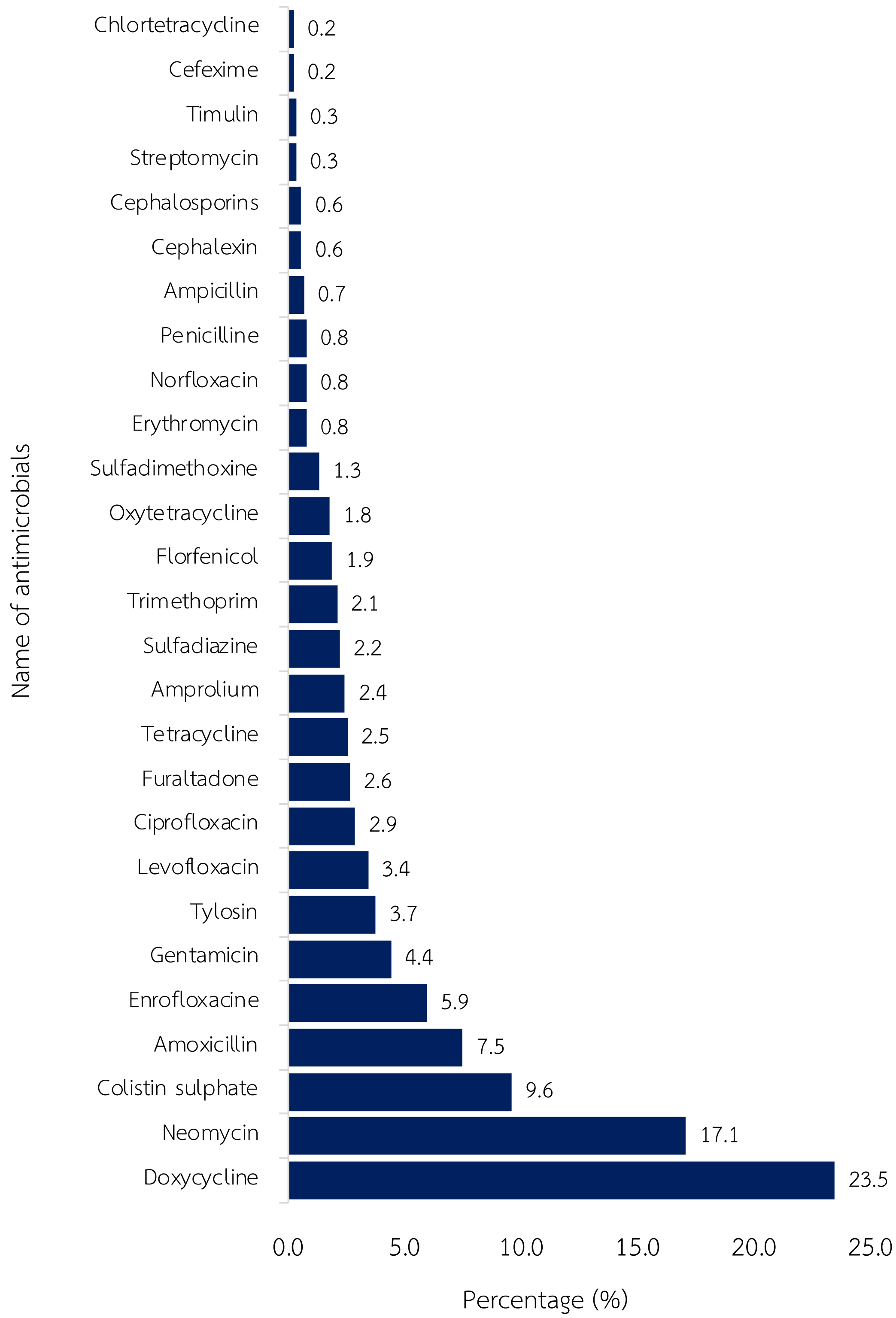


Figure 7 Frequency of AMU in BPF of Nepal (n=908)

About three-quarters (72.7%) of the farmer used antimicrobials for treatment of poultry disease, followed by prevention and control (18.2%) and growth promotion (3.1%). Over half (50.1%) of farmers purchased antimicrobials directly from drug seller. On the contrary, only 33.4% and 10.3% of farmers purchase antimicrobials with a prescription from veterinarians and para-veterinarians, respectively. According to the clinical signs, the most commonly observed by farmers (n=647) in broiler poultry were related to the digestive (39.6%), respiratory (37.7%), nervous (3.4%), and immune systems (1.5%). The use of antimicrobials in broilers started on days 0-3 (16.6%) and slightly on days 4-10 (12.3%), while it peaked on days 10-20 (25.4%) and then gradually decreased to 21.9% and 23.8% on days 21-30 and >30, respectively. When birds were sick or showed signs of disease, 53.2% of farmers consulted a veterinarian, while 21.6% asked the drug seller, 20.0% consulted para-veterinarians, and 4.4% used self-treatment, as shown in Table 7.

Table 7 Situation analysis of AMU in BPF

Variables	N (%)
Purpose of antimicrobials used in feed (n=682) *	
Treatment	496 (72.7)
Prevention and Control	124 (18.2)
Growth promotion	21 (3.1)
All above	26 (3.8)
Others	15 (2.2)
Source of antimicrobials (n=619) *	
Drug seller	310 (50.1)
Vet	207 (33.4)
Para-vet	64 (10.3)
Freely purchase from a drug seller	18 (2.9)
Others	20 (3.2)

*Multiple choice answers allowed

Table 7 Situation analysis of AMU in BPF (Continue)

Variables	N (%)
Frequently observed clinical signs (n=647) *	
Digestive signs	256 (39.6)
Respiratory signs	244 (37.7)
Nervous signs	22 (3.4)
Immune system	10 (1.5)
Skin and integument problem	2 (0.3)
Others	113 (17.5)
Age of bird at treatment (n=781) *	
0-3 days	130 (16.6)
4-10 days	96 (12.3)
11-20 days	198 (25.4)
21-30 days	171 (21.9)
>30 days	186 (23.8)
Consultation when birds are sick (n=500)	
Vet	266 (53.2)
Drug dealer	108 (21.6)
Para-vet	100 (20.0)
Self-treatment	22 (4.4)
Other	4 (0.8)

Note: *Multiple choice answers allowed

4.2.3. KAP of BPF on AMU and AMR

Knowledge of BPF on AMU and AMR

Most farmers (62.6%) had good knowledge of AMU and AMR. Most farmers (74.8%) (both completely agree and agree) understand that different antimicrobials have varying curative effects on different poultry diseases. About three-quarters of BPF (72.0%) knew that antimicrobials used in poultry production could be passed on to humans by consuming poultry meat and eggs. Furthermore, 71.6% of farmers recognized that antimicrobial residues in poultry meat could be dangerous to public health. Similarly, 70.6% knew that poultry should be sold after the proper antimicrobial withdrawal period to prevent antimicrobial residue in the meat. The results showed that the majority (50.4%) of BPF was aware that the use of antimicrobials in animal feed formulation is inappropriate. About half of the BPF (48.6%) believed antimicrobial-free poultry production could be a possible reason for AMR development. Only 41.2% of farmers are aware of the government's policies and plans regarding AMU and AMR. However, a quarter of farmer (16.0%) does not treat the entire flock when only one or a few birds are affected (Fig. 8).

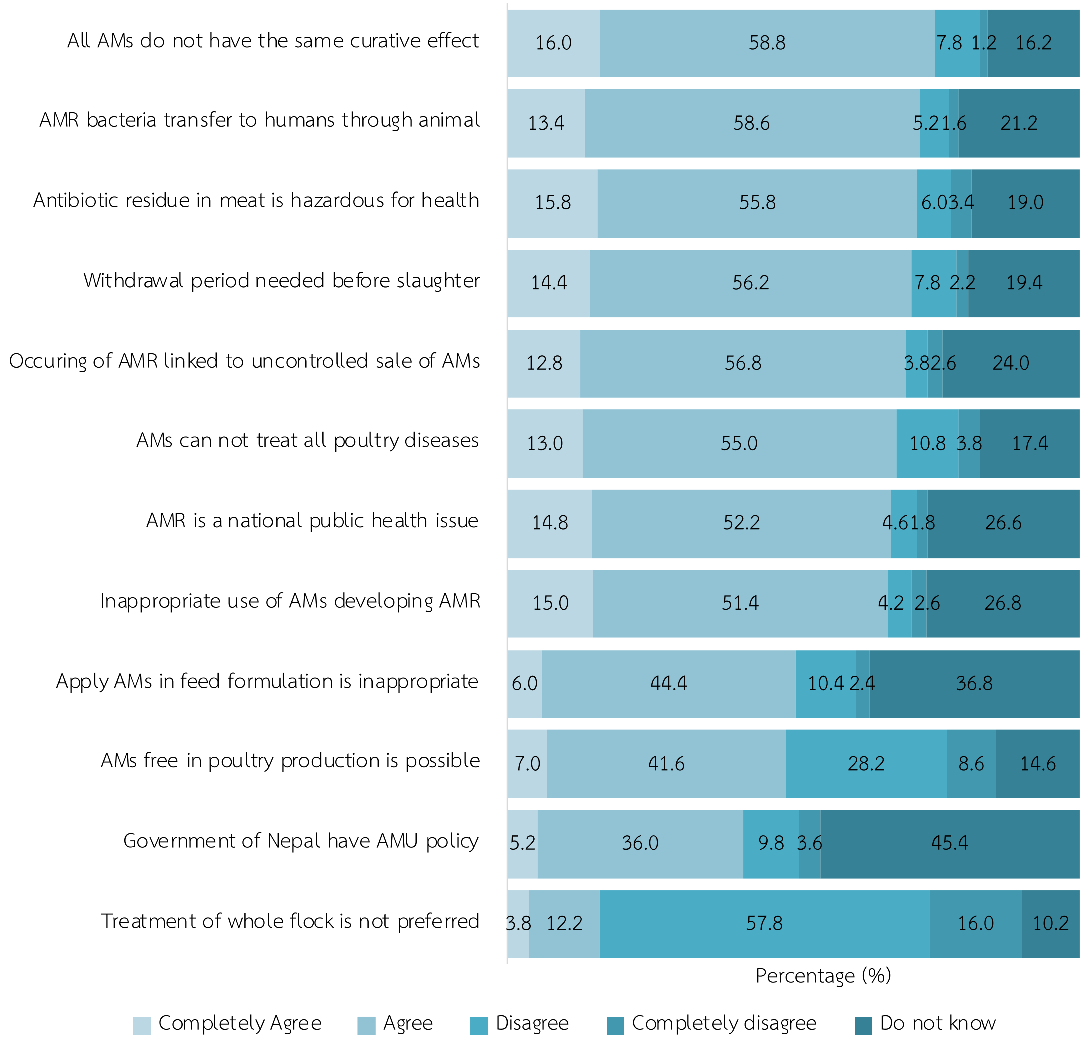


Figure 8 Knowledge of BPF on AMU and AMR

Attitude of BPF towards AMU and AMR

The study found that the significant majority of farmers (91.6%) had a positive attitude towards AMR and AMU. About three-quarters of BPC (73.4%) believed that expired antimicrobials should not be fed to birds and instead should be appropriately disposed. Most of the respondents (72.2%) had a better perception of vaccination as a potential strategy to reduce the use of antimicrobials in poultry farming. Furthermore, a significant proportion of the respondents (68.0%) believed that antimicrobials should only be used to prevent serious illnesses, similarly 60.0% of farmers recognized the potential contribution of improper doses of antimicrobials to AMR. In contrast, 54.6% of respondents believed that antimicrobials are not necessary for the treatment of fever or colds in humans. Similarly, 46.6% of them stated that antimicrobials are not necessary for birds during seasonal changes, and almost half of respondents (41.2%) did not consider that antimicrobials are necessary to treat any animal diseases. Finally, 24.2% of the respondents expressed their concerns about the adverse effects of certain antimicrobials on animal health (Fig. 9).

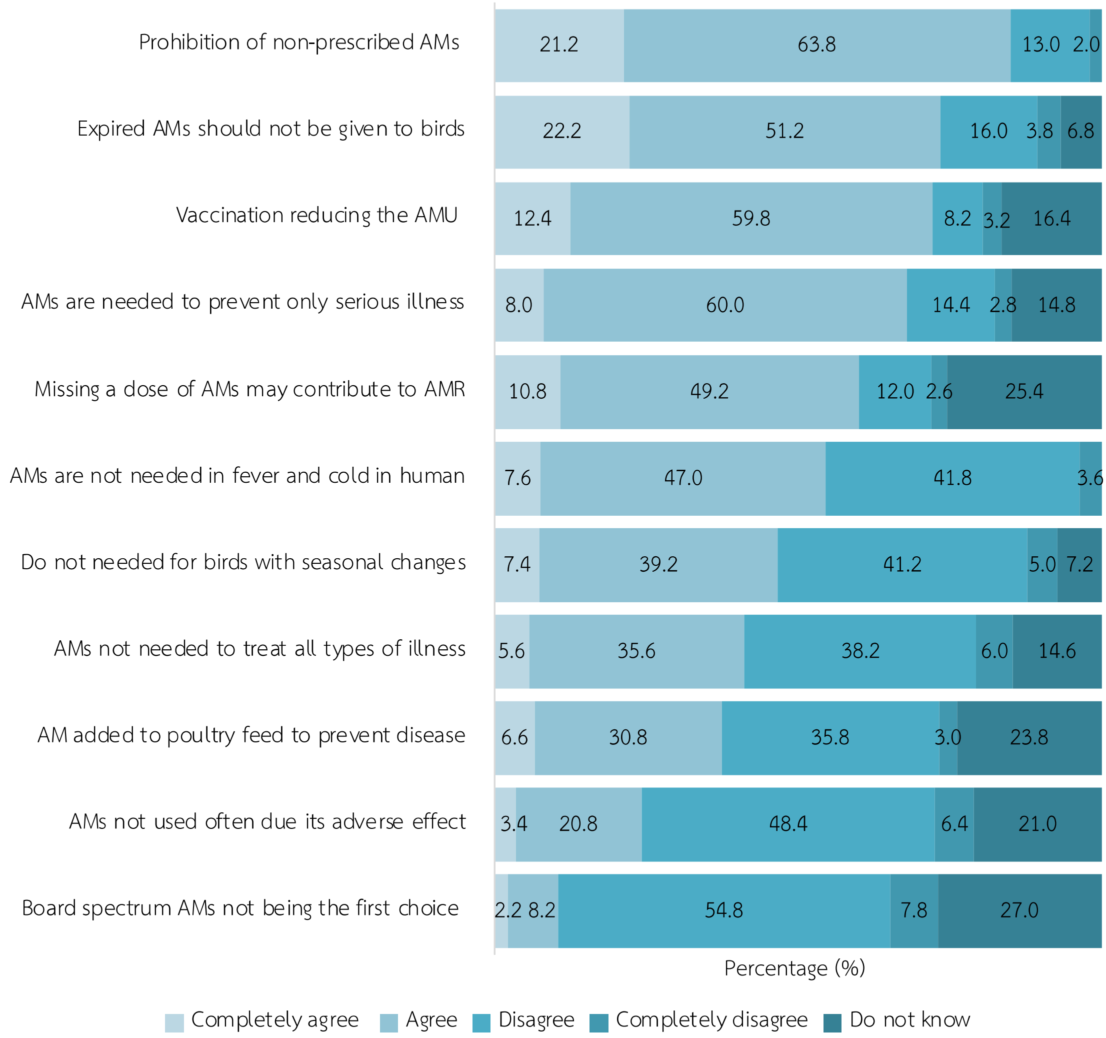


Figure 9 Attitude of BPF towards AMU and AMR

Practice of BPF on AMU and AMR

The study showed that 55.5% of farmers had good practices in AMU and AMR. Most farmers (93.2%) completed the entire course of the antimicrobial as prescribed by the veterinarian. Almost all farmers (88.0%) checked the expiration date of antimicrobials prior to use. Two-thirds of farmers (66.8%) did not practice skipping 1 or 2 doses of their entire antimicrobial courses. Almost half of the respondents (43.0%) did not increase the dose and frequency of prescribed antimicrobials when clinical symptoms did not disappear or subside with a similar proportion of farmers (42.0%) did not withdraw antimicrobials when symptoms disappeared. However, 37.2% of farmers preferred not to use antimicrobials to prevent disease. (Fig. 10).

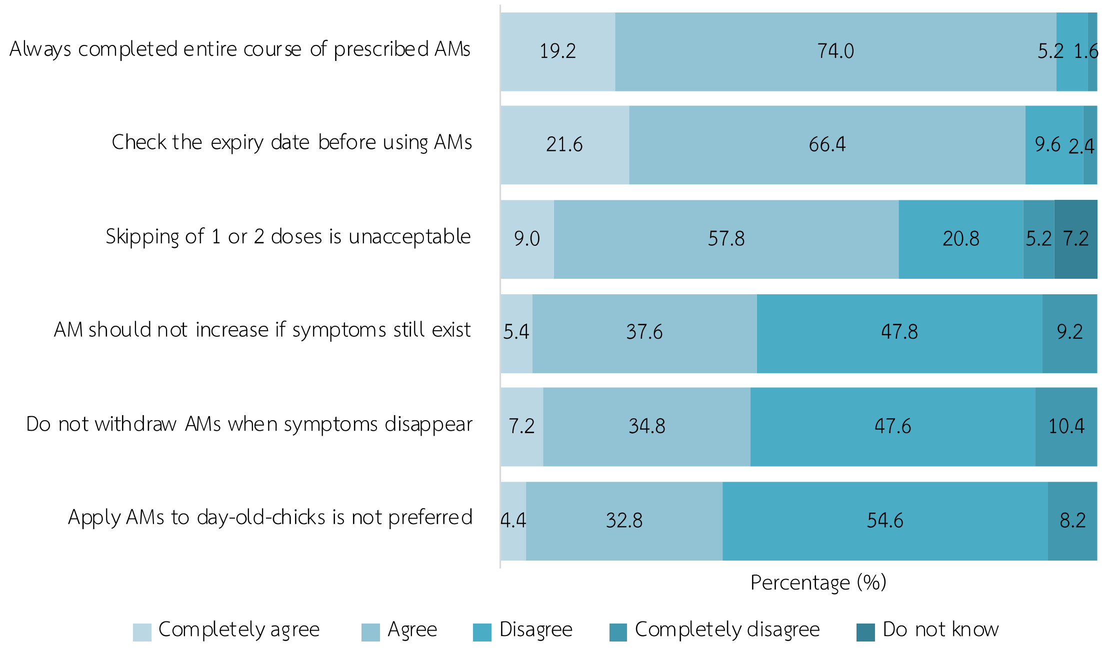


Figure 10 Practice of BPF on AMU and AMR

4.3. Potential risk factors affecting KAP awareness on AMR and AMU

4.3.1. Factors affecting KAP on AMU and AMR of PPV

The univariate analysis showed that PPV working in Karnali (OR=14.4, p=0.002) and Koshi province (OR=4.8, p=0.02) had significantly better knowledge and practice towards AMU and AMR than PPV living in Bagmati. PPV who believed in vaccines as an alternative to AMU had better practice (2.9 times, p=0.04) than who did not believe (Table 8). However, multivariate logistic regression analysis did not find and the significance association between knowledge, attitude, and practice on AMU and AMR among PPV.

Table 8 Univariate analysis of risk factors associated with the KAP of PPV on AMU and AMR

Variable		Knowledge			Attitude			Practice		
		Good N (%)	Not good N (%)	OR (95% CI), p-value	Good N (%)	Not good N (%)	OR (95% CI), p-value	Good N (%)	Not good N (%)	OR (95% CI), p-value
Province	Bagmati	158 (48.3)	3 (0.9)	Ref.	158 (48.3)	3 (0.9)	Ref.	156 (47.7)	5 (1.5)	Ref.
	Gandaki	28 (8.6)	1 (0.3)	1.9 (0.5-18.7), 0.5	29 (8.9)	0	Empty	26 (7.9)	3 (0.9)	3.6 (0.8-15.9), 0.09
	Karnali	11 (3.4)	3 (0.9)	14.4 (2.6-78.8), 0.002	14 (4.3)	0	Empty	12 (3.7)	2 (0.6)	5.2 (0.9-29.7), 0.06
	Lumbini	51 (15.6)	3 (0.9)	3.0 (0.6-15), 0.2	53 (16.2)	1 (0.3)	0.9 (0.1-9.7), 0.9	49 (14.9)	5 (1.5)	3.2 (0.9-11.4), 0.07
	Madhesh	27 (8.2)	0	empty	27 (8.2)	0	Empty	26 (7.9)	1 (0.3)	1.2 (0.1-10.7), 0.8
	Koshi	29 (8.9)	1 (0.3)	1.8 (0.2-18.1), 0.6	30 (9.2)	0	Empty	26 (7.9)	4 (1.2)	4.8 (1.2-19.0), 0.02
	Sudurpaschim	12 (3.7)	0	empty	12 (3.7)	0	Empty	12 (3.7)	0	empty
Vaccination reduces the AMU	Agree	280 (85.6)	11 (3.4)	Ref.	291 (88.9)	0	Ref.	276 (84.4)	15 (4.5)	Ref.
	Not agree	36 (11.0)	0	empty	32 (9.8)	4 (1.2)	Empty	31 (9.5)	5 (1.5)	2.9 (1.0-8.7), 0.04
Strictly follow the national AMR plan	Agree	252 (77.1)	9 (2.7)	Ref.	259 (79.2)	2 (0.6)	Ref.	248 (75.8)	13 (4.9)	Ref.
	Not agree	64 (19.6)	2 (0.6)	0.9 (0.2-4.1), 0.9	64 (19.6)	2 (0.6)	4.0 (0.5-29.3), 0.2	59 (18.0)	7 (2.1)	2.3 (0.8-5.9), 0.09
Prescription changed due to the AMR Issue	Agree	278 (85.6)	11 (3.4)	Ref.	286 (87.5)	3 (0.9)	Ref.	274 (83.8)	15 (4.5)	Ref.
	Not agree	38 (11.6)	0	empty	37 (11.3)	1 (0.3)	2.6 (0.3-25.4), 0.4	33 (10.1)	5 (1.5)	2.8 (0.9-8.1), 0.06
Attended trainings on AMR	Agree	219 (66.9)	7 (2.1)	Ref.	226 (69.1)	0	Ref.	213 (65.1)	13 (4.9)	Ref.
	Not agree	97 (29.7)	4 (1.2)	1.2 (0.3-4.5), 0.7	97 (29.7)	4 (1.2)	Omitted	94 (28.7)	7 (2.1)	1.2 (0.4-3.1), 0.7

4.3.2. Factors affecting KAP on AMU and AMR of BPF

Univariate analysis showed that there were many factors related to knowledge, attitude, and farmer practice as presented in Table 9. The predictors associated with the knowledge of AMU and AMR were provinces, gender, age group, flock size, a common source of advice for antimicrobials, the purpose of antimicrobials, antimicrobial free production is possible, etc. The farmers of Lumbini province had less knowledge than the farmers from Bagmati province (OR=0.4, p<0.0001). Farmers in the 41–60-year age group had 1.9 times more knowledge of AMU and AMR than those in the 10–30-year age group (OR=1.9, p=0.01). Furthermore, farmers with limited access to antimicrobials had 2.4 times more knowledge about AMU and AMR than those with easy access (OR=2.4, p=0.03). Farmers who believed in antimicrobial-free poultry production demonstrated a better understanding of AMU and AMR (OR=5.2, p=0.001) than those who did not. However, farmers who agreed that lack of control of antimicrobial sales contribute to AMR positively associated with knowledge of AMU and AMR (OR=17.7, p<0.0001).

Farmers who resided in Bagmati province had a higher perception of AMU and AMR than those living in Lumbini province (OR=10.0, p<0.0001). Farmers in the 41–60-year age group had 3.2 times more positive attitudes towards AMU and AMR compared to farmers in the age group of 18-30 years (OR=3.2, p<0.0001). Farmers who thought of selling poultry after the antimicrobial withdrawal period had 8.3 times more positive attitudes toward AMU and AMR than the farmer who did not care about the withdrawal period (OR=8.3, p=0.001). Furthermore, lack of antimicrobial control of sales (OR=9.0, p<0.0001), prohibition of the use of non-prescribed antimicrobials (OR=4.7, p=0.001), vaccination as a means of reducing AMU (OR=17.0, p<0.0001), and complete doses of antimicrobials (OR=4.7, p<0.0001) were significant factors that affected farmers' attitudes towards AMU and AMR.

Farmers of Karnali and Gandaki provinces had 0.4 and 0.1 times more good practices than farmers of Bagmati province, with p-value = 0.003 and 0.002, respectively. However, Male farmers had 0.6 times better practice than females (p=0.03). The size of the large flock was found to have a significantly positive association of good AMU practice, with farmers having a 1.9 times higher probability of good practice compared to small farmers (p=0.01). The practice of seeking the advice of AMU from a veterinarian was also found to have a positive association with AMU practice, and farmers who sought advice from a veterinarian had a 2.5 times greater probability of good AMU practice compared to those who sought advice from drug suppliers (OR=2.5, p=0.001). Additionally, BPF who followed a veterinarian for antimicrobial selection had a 1.8 times greater probability of good AMU practice than those who followed a drug seller (OR=1.8, p=0.02). The farmer who uses the antimicrobial for prevention purposes had 2.3 times better practice than the farmer who uses antimicrobials for all purposes. Farmers who had difficult access to antimicrobials were found to have a 3.8 times higher likelihood of good AMU practice compared to those operating inaccessible areas of poultry farming (OR=3.8, p<0.0001). The farmer who consults the veterinarian for the treatment of poultry had 3.4 times better practice than those consulted with the drug seller (p<0.0001), as shown in Table 9.

Table 9 Univariate analysis of risk factors associated with the KAP of BPF on AMU and AMR

Variable		Knowledge			Attitude			Practice		
		Good N (%)	Not good N (%)	OR (95% CI), p-value	Good N (%)	Not good N (%)	OR (95% CI), p-value	Good N (%)	Not good N (%)	OR (95% CI), p-value
Provinces	Bagmati	82 (16.4)	76 (15.2)	Ref.	137 (27.4)	21 (4.2)	Ref.	73 (14.6)	85 (17.0)	Ref.
	Gandaki	32 (6.4)	31 (6.2)	1.0 (0.6-1.9), 0.9	60 (12.0)	3 (0.6)	0.3, (0.1-1.1), 0.1	43 (8.6)	20 (4.0)	0.4 (0.2-0.7), 0.003
	Karnali	19 (3.8)	8 (1.6)	0.4 (0.2-1.1), 0.08	23 (4.6)	4 (0.8)	1.1 (0.3-3.6), 0.8	22 (4.4)	5 (1.0)	0.1 (0.1-0.5), 0.002
	Lumbini	64 (12.8)	22 (4.4)	0.4 (0.2-0.6), <0.0001	84 (16.8)	2 (0.4)	0.1 (0.03-0.7), <0.0001	48 (9.6)	38 (7.6)	0.7 (0.4-1.1), 0.1
	Madhesh	37 (7.4)	14 (2.8)	0.4 (0.2-0.8), 0.01	51 (10.2)	0 (0.0)	empty	31 (6.2)	20 (4.0)	0.5 (0.3-1.0), 0.1
	Koshi	61 (12.2)	24 (4.8)	0.4 (0.2-0.7), 0.03	76 (15.2)	9 (1.8)	0.7 (0.3-1.7), 0.5	36 (7.2)	49 (9.8)	1.2 (0.7-2.0), 0.5
	Sudurpaschim	18 (3.6)	12 (2.4)	0.7 (0.3-1.6), 0.4	27 (5.4)	3 (0.6)	0.7, 0.2-2.6, 0.6	22 (4.4)	8 (1.6)	0.3 (0.1-0.7), <0.0001
Gender	Female	48 (9.6)	47 (9.4)	Ref.	83 (16.6)	12 (2.4)	Ref.	43 (8.6)	52 (10.4)	Ref.
	Male	265 (53.4)	140 (28.0)	0.5 (0.3-0.8), 0.01	375 (75.0)	30 (6.0)	0.5 (0.3-1.1), 0.1	232 (46.6)	173 (34.6)	0.6 (0.4-0.9), 0.03
Age group (years)	18-30	96 (19.2)	38 (7.6)	Ref.	129 (25.8)	5 (1.0)	Ref.	72 (14.4)	62 (12.4)	Ref.
	31-40	128 (25.6)	79 (15.8)	1.5 (0.9-2.5), 0.06	188 (37.6)	19 (3.8)	2.6 (0.9-7.1), 0.1	128 (25.6)	79 (15.8)	0.7 (0.5-1.1), 0.1
	41-60	87 (17.4)	68 (13.6)	1.9 (1.2-3.2), 0.01	138 (27.6)	17 (3.4)	3.2 (1.1-8.9), <0.0001	72 (14.4)	83 (16.6)	1.3 (0.8-2.1), 0.2
	>60	2 (0.4)	2 (0.4)	2.5 (0.3-18.6), 0.4	3 (0.6)	1 (0.2)	9.6 (0.7-97.9), 0.1	3 (0.6)	1 (0.2)	0.4 (0.04-3.1), 0.4

Table 9 Univariate analysis of risk factors associated with the KAP of BPF on AMU and AMR (Continue)

Variable		Knowledge			Attitude			Practice		
		Good N (%)	Not good N (%)	OR (95% CI), p-value	Good N (%)	Not good N (%)	OR (95% CI), p-value	Good N (%)	Not good N (%)	OR (95% CI), p-value
Flock size	Small (<1,500)	171 (34.2)	118 (23.6)	Ref.	269 (53.8)	20 (4.0)	Ref.	171 (34.2)	118 (23.6)	Ref.
	Medium (≥1,500-5,000)	103 (20.6)	44 (8.8)	0.6 (0.4-0.9) 0.02	133 (26.6)	14 (2.8)	1.4 (0.7-2.9), 0.3	77 (15.4)	70 (14.0)	1.3 (0.9-1.9), 0.2
	Large farm (>5,000)	39 (7.8)	25 (5.0)	0.9 (0.5-1.6), 0.8	56 (11.2)	8 (1.6)	1.9 (0.8-4.5), 0.1	27 (5.4)	37 (7.4)	1.9 (1.1-3.4), 0.01
Source of advice	Drug suppliers	75 (15.0)	78 (15.6)	Ref.	132 (26.4)	21 (4.2)	Ref.	100 (20.0)	53 (10.6)	Ref.
	Para-vet	68 (14.0)	43 (8.6)	0.6 (0.4-0.9), 0.04	103 (20.6)	8 (1.6)	0.5 (0.2-1.1), 0.1	77 (15.4)	34 (6.8)	0.8 (0.5-1.4), 0.4
	Vet	164 (33.0)	48 (9.6)	0.3 (0.2-0.4), 0.001	203 (40.6)	9 (1.8)	0.3 (0.1-0.6), 0.001	92 (18.4)	120 (24.0)	2.5 (1.6-3.8), 0.001
	Yourself	6 (1.2)	18 (3.6)	2.9 (1.1-7.7), 0.03	20 (4.0)	4 (0.8)	1.2 (0.4-4.0), 0.7	6 (1.2)	18 (3.6)	5.7 (2.1-15.1), 0.01
Purpose of AMU	All purpose	73 (15.0)	44 (8.8)	Ref.	110 (22.0)	7 (1.4)	Ref.	74 (14.8)	43 (8.6)	Ref.
	Prevention	30 (6.0)	26 (5.2)	1.4 (0.7-2.7), 0.3	50 (10.6)	6 (1.2)	1.9 (0.6-5.9), 0.2	24 (4.8)	32 (6.4)	2.3 (1.2-4.4), 0.01
	Growth promotion	4 (0.8)	2 (0.4)	0.8 (0.1-4.7), 0.8	6 (1.2)	0 (0.0)	Empty	1 (0.2)	5 (1.0)	8.6 (0.9-76.0), 0.5
	Treatment	205 (41.0)	97 (19.4)	0.8 (0.5-1.2), 0.3	280 (56.0)	22 (4.4)	1.2 (0.4-2.9), 0.6	164 (32.8)	138 (27.6)	1.4 (0.9-2.2), 0.09
	Do not know	1 (0.2)	18 (3.6)	29.9 (3.8-231.5), <0.0001	12 (2.4)	7 (1.4)	9.1 (2.7-30.6), <0.0001	12 (2.4)	7 (1.4)	1.0 (0.3-2.7), 0.9

Table 9 Univariate analysis of risk factors associated with the KAP of BPF on AMU and AMR (Continue)

Variable		Knowledge			Attitude			Practice		
		Good N (%)	Not good N (%)	OR (95% CI), p-value	Good N (%)	Not good N (%)	OR (95% CI), p-value	Good N (%)	Not good N (%)	OR (95% CI), p-value
Method of selection of AMs	Drug seller	30 (6.0)	52 (10.4)	Ref.	68 (13.6)	14 (2.8)	Ref.	54 (10.8)	28 (5.6)	Ref.
	Neighbors	17 (3.4)	15 (3.0)	0.5 (0.2-1.2), 0.2	28 (5.6)	4 (0.8)	0.7 (0.2-2.9), 0.5	20 (4.0)	12 (2.4)	1.1 (0.5-2.7), 0.7
	Vet	194 (39.0)	65 (13.0)	0.2 (0.1-0.3), 0.001	242 (48.4)	17 (3.4)	0.3 (0.2-0.7), <0.001	134 (26.8)	125 (25.0)	1.8 (1.0-3.0), 0.02
	Laboratory result	21 (4.2)	10 (2.0)	0.3 (0.1-0.7), 0.001	31 (6.2)	0 (0.0)	Empty	14 (2.8)	17 (3.4)	2.3 (1.0-5.4), 0.05
	Previous symptoms	49 (9.8)	37 (7.4)	0.4 (0.2-0.8), 0.01	82 (16.4)	4 (0.8)	0.2 (0.07-0.7), <0.0001	49 (9.8)	37 (7.4)	1.4 (0.8-2.7), 0.2
	Other	2 (0.4)	8 (1.6)	2.3 (0.4-116.0), 0.3	7 (1.4)	3 (0.6)	2.1 (0.5-9.0), 0.3	4 (0.8)	6 (1.2)	2.8 (0.8-11.1), 0.1
Access of antimicrobial	Very easy	66 (13.0)	35 (7.0)	Ref.	92 (18.4)	9 (1.8)	Ref.	64 (12.8)	37 (7.4)	Ref.
	Easy	233 (46.6)	134 (26.8)	1.1 (0.6-1.7), 0.3	228 (45.6)	29 (5.8)	0.9 (0.4-1.9), 0.7	201 (40.2)	166 (33.2)	1.4 (0.9-2.2), 0.1
	Difficult	14 (2.8)	18 (3.6)	2.4 (1.1-5.4), 0.03	28 (5.6)	4 (0.8)	1.5 (0.4-5.1), 0.5	10 (2.0)	22 (4.4)	3.8 (1.6-8.9), <0.0001
Sell birds after withdrawal period	Agree	286 (57.2)	67 (13.4)	Ref.	342 (68.4)	11 (2.2)	Ref.	205 (41.0)	148 (29.6)	Ref.
	Not agree	27 (5.4)	120 (24.0)	18.9 (11.6-31.1), <0.0001	116 (23.2)	31 (6.2)	8.3 (4.0-17.1), 0.001	70 (14.0)	77 (15.4)	1.5 (1.0-2.2), 0.03
AM-free production possible	Agree	197 (39.4)	46 (9.2)	Ref.	235 (47.0)	8 (1.6)	Ref.	143 (28.6)	100 (20.0)	Ref.
	Not agree	116 (23.2)	141 (28.2)	5.2 (3.4-7.8), 0.001	223 (44.6)	34 (6.8)	4.4 (2.0-9.9), 0.001	132 (26.4)	125 (25.0)	1.3 (0.9-1.9), 0.09

Table 9 Univariate analysis of risk factors associated with the KAP of BPF on AMU and AMR (Continue)

Variable		Knowledge			Attitude			Practice		
		Good N (%)	Not good N (%)	OR (95% CI), p-value	Good N (%)	Not good N (%)	OR (95% CI), p-value	Good N (%)	Not good N (%)	OR (95% CI), p-value
Uncontrol sell of AMs contributes AMR	Agree	283 (56.6)	65 (13.0)	Ref.	338 (67.6)	10 (2.0)	Ref.	206 (41.2)	142 (28.4)	Ref.
	Not agree	30 (6.0)	122 (24.4)	17.7 (10.9-28.7), <0.0001	120 (24.0)	32 (6.4)	9.0 (4.3-18.9), <0.0001	69 (13.8)	83 (16.6)	1.7 (1.2-2.6), <0.0001
Prohibited non-prescribed AMs	Agree	290 (58.0)	135 (27.0)	Ref.	400 (80.0)	25 (5.0)	Ref.	240 (28.0)	185 (37.0)	Ref.
	Not agree	23 (4.6)	52 (10.4)	4.8 (2.8-8.2), 0.01	58 (11.6)	17 (3.4)	4.7 (2.4-9.2), 0.001	35 (7.0)	40 (8.0)	1.5 (0.9-0.4), 0.1
Vaccination can reduce AMU	Agree	272 (54.4)	89 (17.8)	Ref.	354 (70.8)	7 (1.4)	Ref.	203 (40.6)	158 (31.6)	Ref.
	Not agree	41 (8.2)	98 (19.6)	7.3 (4.7-11.3), <0.0001	104 (20.8)	35 (7.0)	17.0 (7.3-39.4), <0.0001	72 (14.4)	67 (13.4)	1.2 (0.8-1.8), 0.3
Complete the entire course of AM	Agree	307 (61.4)	159 (31.8)	Ref.	433 (86.6)	33 (6.6)	Ref.	265 (53.0)	201 (40.2)	Ref.
	Not agree	6 (1.2)	28 (5.6)	9.0 (3.6-22.2), <0.0001	25 (5.0)	9 (1.8)	4.7 (2.0-10.9), <0.0001	10 (2.0)	24 (4.8)	3.1 (1.5-6.8), <0.0001
Not skipping 1 or 2 doses of AMs	Agree	238 (47.6)	96 (19.2)	Ref.	314 (62.8)	20 (4.0)	Ref.	234 (46.8)	100 (20.0)	Ref.
	Not agree	75 (15.0)	91 (18.2)	3.0 (2.0-4.4), 0.001	144 (28.8)	22 (4.4)	2.4 (1.3-4.5), 0.001	41 (8.2)	125 (25.0)	7.1 (4.8-10.9), 0.01
Consultation when poultry are sick	Drug seller	53 (10.6)	55 (11.0)	Ref.	88 (17.6)	20 (4.0)	Ref.	73 (14.6)	35 (7.0)	Ref.
	Para-vet	56 (11.2)	44 (8.8)	0.7 (0.4-1.3), 0.3	90 (18.0)	10 (2.0)	0.5 (0.2-1.1), 0.1	89 (17.8)	11 (2.2)	0.2 (0.1-0.5), <0.01
	Self-treatment	9 (1.8)	13 (2.6)	1.4 (0.5-3.5), 0.4	21 (4.2)	1 (0.2)	0.2 (0.02-1.6), 0.1	9 (1.8)	13 (2.6)	3.0 (1.1-7.7), <0.0001
	Vet	194 (38.8)	72 (14.4)	0.3 (0.2-0.6), <0.0001	256 (51.2)	10 (2.0)	0.2 (0.07-0.4), <0.0001	101 (20.2)	165 (33.0)	3.4 (2.1-5.5), <0.0001
	other	1 (0.2)	3 (0.6)	2.8 (0.2-28.6), 0.3	3 (0.6)	1 (0.2)	1.5 (0.1-14.8), 0.7	3 (0.6)	1 (0.2)	0.7 (0.1-6.9), 0.7

Based on the multiple logistic regression analysis results, many factors were identified to be associated with AMU and KAP of AMU and AMR among BPF in Nepal. The study's results suggest valuable insights that can aid in the development of targeted interventions for promoting responsible practices of AMU and reducing the spread of AMR in the poultry sector in Nepal. The province of residence, the purpose of AMU, the belief in antimicrobial-free poultry production, the lack of control of the sales of antimicrobials that can contribute to AMR, and the adherence to the complete dose of antimicrobials prescribed were found to be significant risk factors linked to the KAP of BPF in AMU and AMR.

In particular, farmers residing in the Lumbini (OR=0.2, p=0.008), Koshi (OR=0.2, p=0.009), and Sudurpaschim (OR=0.2, p=0.004) provinces showed a significant lower level of knowledge on AMU and AMR than farmers of Bagmati province. Furthermore, BPF who did not know the purpose of AMU had 16.4 times more knowledge of AMU and AMR than farmers who used antimicrobials for all purposes, such as prevention, growth promotion, and treatment in poultry (p=0.02). On the other hand, those who believed in the possibility of antimicrobial-free poultry production exhibited significantly higher levels of knowledge of AMU and AMR than those who did not (OR=6.4, p<0.0001). Similarly, farmers who believed that the lack of antimicrobial sales control could contribute to AMR had 14.5 times more knowledge about AMU and AMR than their counterparts who did not believe (p<0.0001). Likewise, those who had faith that vaccines could reduce AMU had significantly better knowledge of AMU and AMR than those who did not believe in the reduction of AMU through vaccination (OR=3.5, p=0.002). Finally, this study found that farmers who agreed with the antimicrobial course completion as prescribed had 8.2 times more knowledge than those who did not believe (p=0.005).

Based on multiple logistic regression analyses, several factors were found to be associated with farmer’s attitudes toward AMU and AMR. Province, age group, purpose of AMU, belief in free poultry production, lack of antimicrobial sales control of antimicrobials, and the potential of vaccination to reduce AMU were identified as potential risk factors for farmers' attitudes toward AMU and AMR. Farmers of Bagmati province had a five times better perception of AMU and AMR among the farmers of the Lumbini province (p=0.03). Furthermore, farmers in the age group of 31-40 years had 4.2 times better attitudes towards AMU and AMR compared to the age group of 18-30 years (p=0.02). Furthermore, farmers who used antimicrobials for prevention and control purposes had a 5.9 times better attitude toward AMU and AMR compared to the farmers who used antimicrobials for all purposes in poultry (p=0.02). Furthermore, farmers who believed in the possibility of antimicrobial-free production had 1.9 times higher perception regarding AMU and AMR than those who did not believe (p=0.03). This result highlights the importance of attitude toward AMU and AMR in promoting antimicrobial-free production. Furthermore, farmers who believed in the ability of vaccines to reduce AMU exhibited attitudes that were 15.0 times better toward AMU and AMR than those who did not believe (p<0.0001).

The study results revealed that several factors were significantly associated with the practice of AMU among the BPF. These factors included the province of the respondents, the purpose of AMU, the belief in the possibility of antimicrobial-free poultry production, the completion of the entire dose of antimicrobial, and consultation for poultry treatment. These findings suggested that farmers in the Koshi province had significantly better AMU practices compared to those in the Bagmati province (OR=2.9, p=0.006). Additionally, farmers who believed in the possibility of antimicrobial-free poultry production exhibited 2.1 times better practices than those who did not (p=0.005). Furthermore, administering complete doses of antimicrobials was associated with practices that were 7.6 times better than those who did not complete the entire dose (p<0.0001). In addition, farmers who consulted with veterinarians when their poultry was sick had better practices regarding AMU than those who consulted with drug sellers (OR=21.0, p<0.0001). Farmers who practiced self-treatment had 8.7 times better practice on the use of antimicrobials than those who consulted with drug sellers (p=0.001) (Table 10).

Table 10 Multivariable logistic regression analysis: risk factors associated with KAP of BPF on AMU and AMR

Variable		Knowledge		Attitude		Practice	
		OR (95%CI)	*p*-value	OR (95%CI)	*p*-value	OR (95%CI)	*p*-value
Province	Bagmati	Ref		Ref.		Ref.	
	Gandaki	2.6 (0.9-7.6)	0.07	0.4 (0.1-1.8)	0.2	0.9 (0.4-2.4)	0.9
	Karnali	0.4 (0.1-1.9)	0.2	3.1 (0.6-15.7)	0.2	0.3 (0.07-1.2)	0.08
	Lumbini	0.2 (0.07-0.7)	0.008	0.2 (0.03-0.8)	0.03	0.7 (0.3-1.3)	0.3
	Madhesh	0.3 (0.08-1.2)	0.1	empty		1.2 (0.5-2.8)	0.7
	Koshi	0.2 (0.1- 0.7)	0.009	1.6 (0.5-4.7)	0.8	2.9 (1.3-6.1)	0.006
	Sudurpaschim	0.2 (0.06-0.9)	0.04	3.8 (0.6-24.9)	0.2	0.4 (0.1-1.4)	0.2
Age group (years)	18-30	Ref		Ref.		Ref.	
	31-40	1.1 (0.4-3.2)	0.8	4.2 (1.2-14.7)	0.02	0.6 (0.3-1.2)	0.2
	41-60	1.6 (0.5-5.3)	0.4	2.3 (0.6-8.4)	0.1	1.2 (0.5-2.4)	0.7
	>60	0.9 (0.004-1.7)	0.9	2.2 (0.04-101.0)	0.6	0.5 (0.02-9.4)	0.6
Purpose of AMU	All purpose	Ref.		Ref.		Ref.	
	Prevention	2.2 (0.7-6.9)	0.2	5.9 (1.5-27.7)	0.02	1.7 (0.7-4.2)	0.2
	Growth promotion	1.1 (0.1-13.9)	0.9	2.1 (0.7-6.2)	0.2	2.9 (0.2-33.6)	0.4
	Treatment	0.8 (0.4-1.9)	0.7	empty		2.1 (1.1-3.9)	0.01
	Do not know	16.4 (1.4-189.5)	0.02	3.9 (0.8-18.3)	0.08	0.4 (0.1-1.9)	0.2

Table 10 Multivariable logistic regression analysis: risk factors associated with KAP of BPF on AMU and AMR (Continue)

Variable		Knowledge		Attitude		Practice	
		OR (95%CI)	*p*-value	OR (95%CI)	*p*-value	OR (95%CI)	*p*-value
Antimicrobial free poultry production being possible	Agree	Ref		Ref.		Ref.	
	Not agree	6.4 (3.1-13.2)	<0.0001	1.9 (0.5-7.7)	0.03	2.1 (1.2-3.5)	0.005
Lack of sales control of AMs contributes to AMR	Agree	Ref		Ref.		Ref.	
	Not agree	14.5 (6.7-31.3)	<0.0001	2.6 (1.1-6.7)	<0.0001	1.4 (0.6-3.3)	0.4
Vaccination can reduce AMU	Agree	Ref		Ref.		Ref.	
	Not agree	3.5 (1.6-7.8)	0.002	15.0 (5.3-42.5)	<0.0001	0.7 (0.3-1.5)	0.3
Complete entire course of AM	Agree	Ref		Ref.		Ref.	
	Not agree	8.2 (1.9-35.6)	0.005	0.5 (0.03-7.5)	0.6	7.6 (2.5-23.0)	<0.0001
Skipping 1 or 2 doses of AMs is not acceptable	Agree	Ref		Ref.		Ref.	
	Not agree	1.2 (0.5-3.2)	0.5	3.3 (0.7-16.2)	0.6	12.0 (6.5-23.2)	<0.0001
Consultation when poultry are sick	Drug seller	Ref		Ref.		Ref.	
	Para-vet	0.8 (0.2-2.9)	0.8	0.6 (0.04-8.9)	0.7	0.4 (0.1-1.1)	0.07
	Self	5.7 (0.9-34.1)	0.05	0.06 (0.001-11.5)	0.3	8.7 (2.3-32.4)	0.001
	Vet	1.7 (0.5-5.3)	0.3	0.2 (0.02-2.5)	0.2	21.0 (9.2-47.9)	<0.0001
	Other	20.9 (0.04-9543.0)	0.3	0.8 (0.002-378.9)	0.9	5.7 (0.4-75.0)	0.2

Association among the KAP on AMU and AMR of BPF

There is a significant association between the knowledge and attitude of BPF toward AMU and AMR (OR=19.4, p<0.0001) and knowledge and practice (OR=1.7, p=0.004). However, the association between the attitude and practice of the farmers was not found to be significant, as shown in Table 11.

Table 11 Association among the KAP on AMU and AMR of farmers

Variable	Adjusted OR (95% C.I.)	p-value
Knowledge and attitude	19.4 (6.7-55.6)	<0.0001
Knowledge and practice	1.7 (1.2-2.5)	0.004
Attitude and practice	1.1 (0.6-2.1)	0.07

CHAPTER 5 DISCUSSION

The study revealed significant findings about AMU and AMR in the poultry sector of Nepal. Specifically, it identified substantial gaps in the knowledge, attitudes, and practices of veterinarians and poultry farmers regarding AMU and AMR and shed light on the current situation of AMU in poultry. The findings emphasized the need for policy interventions and strategies to promote the judicious use of antimicrobials in the poultry industry, to raise awareness among key stakeholders, such as veterinarians and farmers, to address the identified issues, and to promote sustainable AMU practices. Furthermore, the study highlighted the potential risks of AMR to human, animal, and environment health, contributing to the One Health approach to combating AMR by providing valuable information on AMU and AMR dynamics in the poultry industry.

Most PPV in Nepal are concentrated in the Terai and Hill regions, with a relatively small number of PPV working in the mountain region. Possible reasons for this could include higher human population density, increased commercial livestock farming, increased availability of academic institutions and public and private veterinary services in the Terai and Hill regions compared to the mountain region (CBS, 2017; NSO, 2023). Additionally, the majority of PPV were young, belonging to the age group of 24-30 years, whereas in a study conducted in Nigeria (Aworh et al., 2021) showed 52.8% of PPV belonged to the age group of 30-39 years. Our result indicates a greater inclination of young veterinarians for employment in poultry industry. Of the 327 PPV, 51.7% worked in public services such as civil service, academia, and research, which was similar to a previous study, where 44.4% of veterinarians worked in public service (Aworh et al., 2021). Only 15.0% were female PPV, which was fairly lower than the ratio of female veterinarian among registered veterinarians (22.9%) of Nepal (NVC, 2020). This could be due to the employment of female veterinarians in administrative and academic sectors rather than poultry practice.

Among the 625 responses of PPV, 34.4% agreed on the appropriate treatment guidelines are necessary for an effective strategy to combat AMR. On the contrary, 19.7% of the respondents believed that improving biosecurity and hygiene in farms and hospitals and 17.1% believed that increasing educational campaigns could help combat AMR. This is consistent with recent studies showing that veterinarians are involved in all aspects of AMR, including prescribing, monitoring, and educating farmers (Speksnijder et al., 2015; Odoi et al., 2021; Samuels et al., 2021; Vijay et al., 2021). The variation in PPV responses to strategies to combat AMR could be due to differences in educational specialization and experiences, as well as differences in the local context, such as the prevalence of AMR in humans and animals, allocation of resources, and the level of public awareness.

Numerous studies conducted in different countries have shown that veterinarians have good KAP related to AMU and AMR, which agreed with this study (Adekanye et al., 2020; Chan et al., 2020; Gozdzielewska et al., 2020; Sarker et al., 2022). Most of the PPV participants provided correct answers on the appropriate selection of antimicrobials for the treatment of salmonellosis (64.8%) and chronic respiratory disease (59.3%). Additionally, 97.9% of the PPV were aware that antimicrobial residue could contribute to the emergence of AMR, and 93.0% of PPV identified the lack of control in the sale of antimicrobials as a factor contributing to AMR. Almost 86.5% of PPV mentioned that they do not use antimicrobials as growth promoters, which was comparable (80.0%) to the finding of Sarker *et al.* (2022).

Approximately 89.0% of the PPV agreed that vaccination could reduce the use of antimicrobials in poultry and 75.6% of the PPV believed that narrow-spectrum antimicrobials are a better choice than broad-spectrum. Almost all PPV (98.5%) stated that the sale of non-prescribed antimicrobials should be prohibited. However, despite this overwhelming agreement, the regulation of antimicrobial prescription in animals in Nepal appears to be weak due to the lack of veterinary drug regulation authority and well-defined legal arrangements.

Only 54.2% of PPV reported being pressured by farmers to prescribe antimicrobials without conducting bird examinations and antibiotic susceptibility test (AST), and more than 22.9% prescribed antimicrobials over the phone. This finding reflected the farmer's influence over the veterinarian practices due to the limited availability of veterinarian services in the poultry farming area. The high demand for antimicrobials may be due to their belief that antimicrobials are necessary to maintain the health and productivity of their poultry and a lack of awareness of alternatives to antimicrobials. Therefore, the coverage of specialist veterinary services should be extended through both the private as well as public sectors. Furthermore, 69.1% of the PPV attended training to update their knowledge about AMU, which was higher than a previous study indicated that 47.2% attended the training (Aworh et al., 2021). This difference may be attributed to the availability of various AMR stewardship programs conducted by national and international organizations in Nepal, compared to the previous study conducted in Nigeria (Aworh et al., 2021). Additionally, approximately 16.2% of PPV were unfamiliar with the CIA listed by the WHO. This lack of awareness could result in the inappropriate use of antibiotics, especially in the last resort antibiotics such as carbapenems and polymyxin. The overuse or misuse of these antibiotics can lead to the emergence of multidrug-resistant bacteria, which causes significant problems to public health as these infections become more difficult to treat. WHO has identified this as a serious concern in their global priority list of antibiotic-resistant bacteria (Giamarellou, 2010; WHO, 2015).

Similarly, farmers in the 31-40-year-old age group had a better attitude than those of the 18-30 years age group. This could be due to the higher age group of people may have more chances of exposure to training and more experience than young people. A previous KAP study in Bangladesh demonstrated that the age of farmers and their farming experience influence AMU and AMR in poultry production (Hassan et al., 2021). This study observed that the mean mortality of broiler poultry flocks was 9.3±15.5%, which was slightly lower than in the previous study (Subedi et al., 2020; Sarker et al., 2022). The decrease in poultry mortality could be due to many reasons, such as the use of antimicrobials for prophylaxis, improvement of farm sanitation, increase biosecurity measures, and the availability of high-quality commercial feed and treated water. The study found that the average income per 100 birds was recorded at USD 43.8±22.6 (0-105.7), which is very low. This could be attributed to the high cost of feed, which is partly due to the fact that a large proportion of the raw materials used in poultry production are imported into Nepal. This importation was affected by the extensive import barriers imposed by the Nepali government in 2021 due to the economic recession. According to this study, most people involved in poultry farming had less than four years of experience, possibly due to experienced farmers abandoning poultry sector as a result of financial losses caused by various poultry disease outbreaks like New Castle Disease, Low Pathogenic Avian Influenza, etc. and the COVID-19 pandemic causing an influx of workers into the poultry sector due to reverse labor migration.

The results of the multivariate logistic regression revealed that the BPF of Bagmati province had a comparatively better knowledge of AMU and AMR than those of the Lumbini (OR=0.2, p=0.008), Koshi province (OR=0.2, p=0.009), and Sudurpaschim province (OR=0.2, p=0.04) provinces. Furthermore, farmers in Bagmati province demonstrated better attitudes than those in Lumbini province (OR=0.2, p=0.03) and better practices than those from the Koshi province (OR=2.9, p=0.006). The BPF of Bagmati province had a higher level of education and commercialization in poultry production, as well as hosting most of the veterinary research centers, academia, and veterinary training centers (CBS, 2017; DLS, 2021; NSO, 2023). This suggested that the better KAP in AMU and AMR among farmers in Bagmati province may be attributed to these factors.

The 27 different types of antimicrobials were used in poultry production in Nepal. A previous study showed that several antimicrobials indicated in this study were used to treat poultry diseases (Afakye et al., 2020; Imam et al., 2020). This study found that the classes and types of antimicrobials used in broiler poultry farms in Nepal were tetracyclines, followed by aminoglycosides, quinolones, polymyxin, penicillin, macrolides, and sulfonamides. Many previous studies showed similar findings. For example, doxycycline (25.9%) was the antimicrobial most used, followed by tylosin (21.5%), colistin (18.8%), ciprofloxacin (13.4%) and neomycin (12.5%) in Kathmandu and Chitwan district (Dhakal and Gompo, 2022). Tetracycline, enrofloxacin, neomycin-doxycycline, levofloxacin, colistin, and tylosin are the most consumed antimicrobials in Nepal (Upadhyaya et al., 2020; Dhakal and Gompo, 2022), while colistin, doxycycline, and neomycin are frequently used in broiler farms (Nepal et al., 2019; Afakye et al., 2020). This can be related to the availability of antimicrobials, the pattern of antimicrobial prescription by veterinarians or forced sale from drug sellers to reduce the extra stock of drugs, lack of awareness, and some of the antimicrobials are either relatively inexpensive or readily available to farmers. A possible reason for the illegal use of antimicrobials may be that these antimicrobials are effective against most bacterial infections commonly found in poultry, such as respiratory and gastrointestinal infections. However, large poultry producers, including the USA, Brazil, China, and Poland, used colistin legally until 2016 (Roth et al., 2019). Although the Nepali government banned colistin sulfate in food animals in August 2019, this antimicrobial was still found in poultry. The reason for this might be proper monitoring and regulation by the drug regulation authority and the lack of a veterinary drug act in Nepal, which indicated the need for the veterinary drug act and institutional arrangement for the veterinary drug regulation authority of Nepal (Okeke et al., 2005; Imam et al., 2020). Furthermore, the use of banned drugs in poultry production might be due to the open border with India, which might promote illegal drug trading.

In this study, 3.2% of farmers used antimicrobials as a growth promoter, which was lower than the previous study that observed 13.0% of farmers using antimicrobials as a growth promoter (Lambrou et al., 2021). It could be due to the differences in farmers' awareness and understanding of the potential risks associated with AMU. The use of antimicrobials as growth promoters may also be influenced by economic factors, such as the desire to maximize profits by promoting faster growth in broiler poultry. Approximately 9.2% of BPF reported not using antimicrobials throughout the broiler production cycle while remaining 90.8% of the farmers used antimicrobials at least once during the cycle, indicating that AMU is still prevalent in broiler production, although a small proportion of farmers can manage their flocks without the use of antimicrobials. Our descriptive study showed that farmers in Karnali province and Mountain region have limited access to antimicrobials, rear smaller flocks, and live in areas with comparatively lower incidences of poultry diseases. These regions also have a lower density and practice the seasonal broiler poultry farming, which attributed to reduced frequency of AMU.

Most farmers were unaware of the implication of AMU and AMR in farm practices despite having a good attitude toward it. These improper practices and limited knowledge might be due to inadequate veterinary services and awareness. Our study showed a better farmers' awareness of withdrawal periods (70.6%), the transmission of antimicrobial agents from animals to humans (72.0%), and the proper usage of antimicrobials for severe illnesses (68.0%). It also suggested that there is still room for improvement in educating and raising awareness among farmers about AMR to promote the responsible use of antimicrobials in livestock. However, a quarter of farmers (16.0%) do not treat the entire flock when only one or a few birds are affected, which could be due to the lack of diagnostic disease facilities and limitations in approaching specialist veterinary services.

The study suggested that most farmers (91.6%) had positive attitudes toward the responsible use of antimicrobials and the eradication of AMR but had limited knowledge and improper practices on AMU and AMR. These improper practices and limited knowledge, despite having a good attitude, could be due to the inadequate availability of veterinary services, such as qualified veterinarians, disease diagnostic facilities, and training about the prudent use of antimicrobials and AMR. Most farmers (85.0%) supported the prohibition of non-prescribed antimicrobial sales, possibly due to negative past experiences with these drugs and concerns about the impact of AMR on human and animal health. This statement was also supported by our finding in the knowledge part of the descriptive study, where about three quarters of the farmers were found to be aware of the national problem of AMR and the withdrawal period of antimicrobials.

The finding of our study showed that vaccination is considered a potential strategy to reduce the use of antimicrobials in poultry farming by 72.2% of the BPF which in turn highlighted that BPF understood the importance of promoting alternative strategies to reduce the use of antimicrobials in animal production. This statement was also justified by the results of a multivariable logistic regression analysis, farmers who had faith in the effectiveness of vaccines in minimizing the use of antimicrobials had attitudes towards AMU and AMR that were 15.0 times more positive than those who did not believe in the effectiveness of vaccines ($p<0.0001$).

In this study, 50.1% of farmers were found to purchase antimicrobials directly from the drug seller. In comparison, only 33.4% and 10.3% of farmers purchase antimicrobials after the prescription of veterinarians and para-veterinarians, respectively. Similarly, farmers most frequently receive antimicrobials from drug sellers (Imam et al., 2020; Masud et al., 2020). As a result, farmers must use antimicrobials willingly or unwillingly, as suggested by sellers (Masud et al., 2020; Hassan et al., 2021). An additional possible reason could be the lack of access to veterinary services in the area and leading farmers to seek advice and medication from non-experts. About 53.2% of farmers consulted the veterinarian for treatment, while the remaining farmers asked the drug seller (21.6%), para-veterinarians (20.0%), and self-treated the birds when they showed disease signs/symptoms of the disease (4.4%). The primary reasons for not seeking veterinarian services could be the availability of veterinarians in the field, the difficulty in finding laboratory services or getting ideas from neighboring farmers, and easy access to antimicrobials (Ozturk et al., 2019; Imam et al., 2020; Hassan et al., 2021).

Farmers who used antimicrobials for prevention and control purposes had 16.4 times better knowledge (p=0.02) than farmers who used antimicrobials without knowing its specific purpose. This kind of practice among farmer having a better knowledge had target of reducing poultry mortality as a preventive prophylaxis. Similarly, farmers who used antimicrobials for treatment purposes had a comparatively better practice of AMU in poultry farming than those who used antimicrobials for all purposes (OR=2.1, p=0.01). These results highlighted the need for targeted group education and training initiatives for farmers to improve their understanding of AMU, particularly with respect to the distinction between different types of use and their specific purposes.

The poultry farmers who believed in the possibility of antimicrobial-free production had a significant association with knowledge (OR=6.4, p<0.0001), attitude (OR= 1.9, p=0.03), and practice (OR=2.1, p=0.005) regarding AMU and AMR than who did not believe. This finding might highlight that farmer who are conscious about AMR and appropriate AMU reflected their interest in culture of organic poultry farming, responsible use of antimicrobials, and reducing the dependence on antimicrobials in the poultry industry. To achieve this, it may be necessary to develop and implement educational programs and policies that promote alternative approaches to disease prevention and control, such as improved biosecurity measures, vaccination, and genetic selection of poultry breeds for disease resistance. Such measures could help reduce the need for AMU in poultry farming and contribute to the global effort to combat the growing threat of AMR. A significant number of farmers believed that vaccines could reduce AMU, and this belief has a significantly positive association with both knowledge (OR=3.5, p=0.002) and attitude (OR=15.0, p<0.0001) of farmers towards AMU and AMR. This belief may be due to the awareness of government vaccination campaigns targeting major poultry diseases such as Newcastle Disease, Infectious Bursal Disease, and Fowl Pox (DLS, 2021). Therefore, the perceived effectiveness of vaccines among farmers may be high due to their demonstrated efficacy in protecting farm economies by reducing mortality. The farmers who consulted with a veterinarian (OR=21.0, p<0.0001) for the treatment of poultry had better practices of AMU than those who consulted with a drug seller. This which might be due to the proper delivery of information by veterinarians creating a better learning platform for farmer reflected in their AMU practice.

CHAPTER 6 CONCLUSION AND SUGGESTIONS

In conclusion, the study found that most PPV and BPF had positive attitudes towards responsible use of antimicrobials and addressing AMR, while the farmer had limited knowledge, and both had improper practices on AMU and AMR. There were still areas of concern, such as the weak regulation of antimicrobial prescription and the influence of farmers on PPV prescribing practices. Lack of access to veterinary services, purchase of antimicrobials directly from drug sellers, prescribing antimicrobials from para-veterinarians, and farmers themselves were identified as contributing factors to AMU and AMR in poultry farming. Therefore, promoting alternative strategies to reduce the use of antimicrobials, such as vaccination and improved biosecurity measures is very important. As per the finding of this study, following conclusion and suggestion are made:

1. Most of the PPV used combined antimicrobials for therapeutic success, were prescribed under farmers' pressure, and were preferred for broad-spectrum antimicrobials. Therefore, there is a need to increase continuing education for PPV and to regulate their adherence to the WHO list of CIA in order to limit their use in poultry. Additionally, an update of the WHO list of CIAs is needed to improve the proper use of antimicrobials.
2. Almost three-quarters of farmers use antimicrobials for all flocks when a few birds are sick, about half of the antimicrobials are used without the prescription of registered veterinarians, about half of the farmers taking consult other than veterinarians for birds treatment, and some PPV were found to prescribe the drugs over the phone without examination of birds and doing laboratory diagnosis like AST which reflecting the extension of specialist veterinary services at farm level and effective antimicrobial stewardship programs in the poultry industry to ensure the appropriate AMU and reduce the risk of AMR.

3. Most farmers and veterinarians used banned antimicrobials in poultry, even in day-old chickens. A combination of broad-spectrum antimicrobials such as colistin with amoxicillin, gentamicin, tylosin, and tetracycline was commonly used. Sometimes, combinations of more than two antimicrobials were used in broiler poultry. Most drug sellers and para-veterinarians prescribe all types of antimicrobials in poultry. Farmers are also purchasing antimicrobials directly from drug stores without a prescription from a registered veterinarian. Therefore, government authorities need to promogulated and implement the veterinary drug regulation and active monitor to ensure appropriate use of antimicrobials.
4. Analytical statistics showed that the provinces with low commercial poultry farming, the purpose of AMU, the age of farmers, lack of control over antimicrobial sales, use of vaccines, and the source of advice regarding AMU were the potential risk factors of the farmer’s KAP on AMU and AMR, which could be the significant intervention point for BPF to mitigate AMR issues.

REFERENCES

Acharya KP and Wilson RT. 2019. Antimicrobial resistance in Nepal. Front Med. 6: 105.

Adekanye UO, Ekiri AB, Galipo E, Muhammad AB, Mateus A, La Ragione RM, Wakawa A, Armson B, Mijten E, Alafiatayo R, Varga G and Cook AJC. 2020. Knowledge, attitudes and practices of veterinarians towards antimicrobial resistance and stewardship in Nigeria. Antibiotics. 9(8): 453.

Afakye K, Kiambi S, Koka E, Kabali E, Dorado-Garcia A, Amoah A, Kimani T, Adjei B and Caudell MA. 2020. The impacts of animal health service providers on antimicrobial use attitudes and practices: an examination of poultry layer farmers in Ghana and Kenya. Antibiotics. 9(9): 554.

Agyare C, Boamah VE, Zumbi CN and Osei FB. 2018. Antibiotic use in poultry production and its effects on bacterial resistance. IntechOpen. 10: 1-20.

AITC. 2022. Agriculture and livestock diary. Agriculture Information and Training Center, Kathmandu, Nepal. 2022:267-334.

Alcantara GLC, Pinello KC, Severo M and Niza-Ribeiro J. 2021. Antimicrobial resistance in companion animals - veterinarians' attitudes and prescription drivers in Portugal. Comp Immunol Microbiol Infect Dis. 76: 101640.

Aworh MK, Kwaga JKP and Okolocha EC. 2021. Assessing knowledge, attitude, and practices of veterinarians towards antimicrobial use and stewardship as drivers of inappropriate use in Abuja, Nigeria. One Health Outlook. 3(1): 1-12.

Azabo R, Mshana S, Matee M and Kimera SI. 2022. Antimicrobial usage in cattle and poultry production in Dar es Salaam, Tanzania: pattern and quantity. BMC Vet Res. 18(1): 1-12.

Bantawa K, Sah SN, Subba Limbu D, Subba P and Ghimire A. 2019. Antibiotic resistance patterns of *Staphylococcus aureus, Escherichia coli, Salmonella, Shigella* and *Vibrio* isolated from chicken, pork, buffalo and goat meat in eastern Nepal. BMC Res Notes. 12(1): 766.

Casewell M, Friis C, Marco E, McMullin P and Phillips I. 2003. The European ban on growth-promoting antibiotics and emerging consequences for human and animal health. J Antimicrob Chemother. 52(2): 159-161.

Caudell MA, Quinlan MB, Subbiah M, Call DR, Roulette CJ, Roulette JW, Roth A, Matthews L and Quinlan RJ. 2017. Antimicrobial use and veterinary care among agro-pastoralists in Northern Tanzania. PLOS ONE. 12(1): e0170328.

CBS. 2017. Nepal commercial poultry survey. Central Bureau of Statistics, Kathmandu, Nepal. 2015:1-75.

CDDEP. 2021. The state of the world's antibiotics. Center for Disease Dynamics, Economics & Policy, Washington, DC 20015, USA. 1: 10-29.

Chan KW, Bard AM, Adam KE, Rees GM, Morgans L, Cresswell L, Hinchliffe S, Barrett DC, Reyher KK and Buller H. 2020. Diagnostics and the challenge of antimicrobial resistance: a survey of UK livestock veterinarians' perceptions and practices. Vet Rec. 187(12): e125.

Cully M. 2014. Public health: the politics of antibiotics. Nature. 509(7498): S16-17.

Dahal RH and Chaudhary DK. 2018. Microbial infections and antimicrobial resistance in Nepal: current trends and recommendations. Open Microbiol J. 12: 230-242.

De Briyne N, Atkinson J, Pokludová L and Borriello SP. 2014. Antibiotics used most commonly to treat animals in Europe. Vet Rec. 175(13): 325.

Dhakal S and Gompo TR. 2022. Assessment of farmer's knowledge of antimicrobial resistance, their practice of antimicrobial usage and biosecurity status of poultry farms in Kathmandu valley and Chitwan district, Nepal. Int J Appl Sci Biotechnol. 10(1): 50-59.

DLS. 2021. Livestock statistics. Department of Livestock Services, Lalitpur, Nepal. 2021: 3-9.

DoHS. 2021. National antimicrobial resistance containment action plan. Department of Health Services, Kathmandu, Nepal. 2016:8-24.

EU. 2017. A European one health action plan against antimicrobial resistance. European Commission, Brussels, Belgium. 2017: 3-22.

FAO. 2022. "Subject: Antimicrobial resistance" (online). Available: https://www.fao.org/antimicrobial-resistance/background/what-is-it/en/. 22 January 2023.

Farrell S, McKernan C, Benson T, Elliott C and Dean M. 2021. Understanding farmers' and veterinarians' behavior in relation to antimicrobial use and resistance in dairy cattle: a systematic review. J Dairy Sci. 104(4): 4584-4603.

Giamarellou H. 2010. Multidrug-resistant gram-negative bacteria: how to treat and for how long. Int J Antimicrob Agents. 36 Suppl 2: S50-54.

Gibson JS, Wai H, Oo S, Hmwe EMM, Wai SS, Htun LL, Lim HP, Latt ZM and Henning J. 2020. Antimicrobials use and resistance on integrated poultry-fish farming systems in the Ayeyarwady Delta of Myanmar. Sci Rep. 10(1): 16149.

Gozdzielewska L, King C, Flowers P, Mellor D, Dunlop P and Price L. 2020. Scoping review of approaches for improving antimicrobial stewardship in livestock farmers and veterinarians. Prev Vet Med. 180: 105025.

Hassan MM, Kalam MA, Alim MA, Shano S, Nayem MRK, Badsha MR, Al Mamun MA, Hoque A, Tanzin AZ, Nath C, Khanom H, Khan SA, Islam MM, Uddin MB and Islam A. 2021. Knowledge, attitude, and practices on antimicrobial use and antimicrobial resistance among commercial poultry farmers in Bangladesh. Antibiotics. 10(7): 784.

Hedman HD, Vasco KA and Zhang L. 2020. A review of antimicrobial resistance in poultry farming within low-resource settings. Animals. 10(8): 1-39.

Hoffman SJ, Outterson K, Rottingen JA, Cars O, Clift C, Rizvi Z, Rotberg F, Tomson G and Zorzet A. 2015. An international legal framework to address antimicrobial resistance. Bull World Health Organ. 93(2): 66.

Holmes AH, Moore LS, Sundsfjord A, Steinbakk M, Regmi S, Karkey A, Guerin PJ and Piddock LJ. 2016. Understanding the mechanisms and drivers of antimicrobial resistance. Lancet. 387(10014): 176-187.

Hoque R, Ahmed SM, Naher N, Islam MA, Rousham EK, Islam BZ and Hassan S. 2020. Tackling antimicrobial resistance in Bangladesh: a scoping review of policy and practice in human, animal and environment sectors. PLoS One. 15(1): e0227947.

Imam T, Gibson JS, Foysal M, Das SB, Gupta SD, Fournie G, Hoque MA and Henning J. 2020. A cross-sectional study of antimicrobial usage on commercial broiler and layer chicken farms in Bangladesh. Front Vet Sci. 7: 576113.

Johnson TJ and Lang KS. 2012. IncA/C plasmids: an emerging threat to human and animal health. Mob Genet Elements. 2(1): 55-58.

Kalam MA, Alim MA, Shano S, Nayem MRK, Badsha MR, Mamun MAA, Hoque A, Tanzin

AZ, Khan SA, Islam A, Islam MM and Hassan MM. 2021. Knowledge, attitude, and practices on antimicrobial use and antimicrobial resistance among poultry drug and feed sellers in Bangladesh. Vet Sc. 8(6): 111.

Khan SA, Imtiaz MA, Sayeed MA, Shaikat AH and Hassan MM. 2020. Antimicrobial resistance pattern in domestic animal-wildlife-environmental niche via the food chain to humans with a Bangladesh perspective; a systematic review. BMC Vet Res. 16(1): 320.

Khouja T, Mitsantisuk K, Tadrous M and Suda KJ. 2022. Global consumption of antimicrobials: impact of the WHO global action plan on antimicrobial resistance and 2019 coronavirus pandemic (COVID-19). J Antimicrob Chemother. 77(5): 1491-1499.

Kim TR, John A. Ross and Smith DP. 1969. Korea: trends in four national KAP surveys, 1964-67. Stud Fam Plann. 1(43): 6-11.

Kimberly AE, Charles K. and M. J. 2017. "Subject: A global treaty to reduce antimicrobial use in livestock" (online). Available: https://policycommons.net/artifacts/3761075/a-global-treaty-to-reduce-antimicrobial-use-in-livestock-abstract/4566624. 12 December 2022.

Klein EY, Van Boeckel TP, Martinez EM, Pant S, Gandra S, Levin SA, Goossens H and Laxminarayan R. 2018. Global increase and geographic convergence in antibiotic consumption between 2000 and 2015. Proc Natl Acad Sci. 115(15): E3463-e3470.

Lai CC, Wang CY, Chu CC, Tan CK, Lu CL, Lee YC, Huang YT, Lee PI and Hsueh PR. 2011. Correlation between antibiotic consumption and resistance of Gram-negative bacteria causing healthcare-associated infections at a university hospital in Taiwan from 2000 to 2009. J Antimicrob Chemother. 66(6): 1374-1382.

Lambrou AS, Innes GK, O'Sullivan L, Luitel H, Bhattarai RK, Basnet HB and Heaney CD. 2021. Policy implications for awareness gaps in antimicrobial resistance (AMR) and antimicrobial use among commercial Nepalese poultry producers. Glob Health Res Policy. 6(1): 6.

Lekshmi M, Ammini P, Kumar S and Varela MF. 2017. The food production environment and the development of antimicrobial resistance in human pathogens of animal origin. Microorganisms. 5(1): 11.

Lindsey RL, Frye JG, Fedorka-Cray PJ and Meinersmann RJ. 2011. Microarray-based analysis of IncA/C plasmid-associated genes from multidrug-resistant *Salmonella enterica*. Appl Environ Microbiol. 77(19): 6991-6999.

Malla S, Dumre SP, Shakya G, Kansakar P, Rai B, Hossain A, Nair GB, Albert MJ, Sack D, Baker S and Rahman M. 2014. The challenges and successes of implementing a sustainable antimicrobial resistance surveillance programme in Nepal. BMC Public Health. 14(1): 269.

Martin LC, Weir EK, Poppe C, Reid-Smith RJ and Boerlin P. 2012. Characterization of blaCMY-2 plasmids in *Salmonella* and *Escherichia coli* isolates from food animals in Canada. Appl Environ Microbiol. 78(4): 1285-1287.

Masud AA, Rousham EK, Islam MA, Alam MU, Rahman M, Mamun AA, Sarker S, Asaduzzaman M and Unicomb L. 2020. Drivers of antibiotic use in poultry production in Bangladesh: dependencies and dynamics of a patron-client relationship. Front Vet Sci. 7: 78.

MoALD. 2019. One health strategy 2019. Ministry of Agriculture and Livestock Development, Nepal. 2019:1-6.

Moffo F, Mouliom Mouiche MM, Kochivi FL, Dongmo JB, Djomgang HK, Tombe P, Mbah CK, Mapiefou NP, Mingoas JK and Awah-Ndukum J. 2020. Knowledge, attitudes, practices and risk perception of rural poultry farmers in Cameroon to antimicrobial use and resistance. Prev Vet Med. 182: 105087.

Murray CJL, Ikuta KS, Sharara F, Swetschinski L, Robles Aguilar G, Gray A, Han C, Bisignano C, Rao P, Wool E, Johnson SC, Browne AJ, Chipeta MG, Fell F, Hackett S, Berkley JA, Bethou A, Bielicki J, Boonkasidecha S, Bukosia J, Carvalheiro C, Castañeda-Orjuela C, Chansamouth V, Chaurasia S, Dokova K, Dramowski A, Dunachie SJ, Duong Bich T, Eckmanns T, Eibach D, Emami A, Feasey N, Fisher-Pearson N, Forrest K, Holm M, Hopkins S, Hsia Y, Iregbu KC, Jacobs J, Jarovsky D, Javanmardi F, Jenney AWJ, Khorana M, Khusuwan S, Kissoon N, Kobeissi E, Kostyanev T, Krapp F, Krumkamp R, Kumar A, Kyu HH, Lim C, Lim K, Limmathurotsakul D, Loftus MJ, Lunn M, Ma J, Manoharan A, Marks F, May J, Mayxay M, Mturi N, Musicha P, Olliaro P, Ooko E, Ortiz-Brizuela E, Ounchanum P, Pak GD, Paredes JL, Phommasone K, Plakkal N, Ponce-De-Leon A, Raad M, Riddell A, Roberts T, Thwaites G, Tigoi C, Turner C, Turner P, Van Doorn HR, Velaphi S, Vongpradith A, Vongsouvath M, Vu H, Walsh T, Wannapinij P, Wozniak T, Young Sharma TEMW, Yu KC, Zheng P, Sartorius B, Lopez AD, Stergachis A, Moore C, Dolecek C and Naghavi M. 2022. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. The Lancet. 399(10325): 629-655.

Nepal A, Hendrie D, Robinson S and Selvey LA. 2019. Knowledge, attitudes and practices relating to antibiotic use among community members of the Rupandehi district in Nepal. BMC Public Health. 19(1): 1-9.

Nhung NT, Chansiripornchai N and Carrique-Mas JJ. 2017. Antimicrobial resistance in bacterial poultry pathogens: a review. Front Vet Sci. 4: 126.

NPHL. 2018. Summery report on antimicrobial resistance. National Public Health Laboratory, Kathmandu, Nepal. 2018: 33.

NSO. 2023. National census: a preliminary result. National Statistical Office, Kathmandu, Nepal. 2023: 33-98.

NVC. 2020. Annual progress report. Nepal Veterinary Council, Kathmandu, Nepal. 2020: 1-5.

O'Neill J. 2016. Tackling drug-resistant infection globally: an overview of our work. The review on the antimicrobial resistance, London. 2014: 10-74.

Obimakinde S, Fatoki O, Opeolu B and Olatunji O. 2017. Veterinary pharmaceuticals in aqueous systems and associated effects: an update. Environ Sci Pollut Res Int. 24(4): 3274-3297.

Odoi A, Samuels R, Carter CN and Smith J. 2021. Antibiotic prescription practices and opinions regarding antimicrobial resistance among veterinarians in Kentucky, USA. PLoS ONE. 16(4): e0249653.

Okeke IN, Laxminarayan R, Bhutta ZA, Duse AG, Jenkins P, O'Brien TF, Pablos-Mendez A and Klugman KP. 2005. Antimicrobial resistance in developing countries. Part I: recent trends and current status. Lancet Infect Dis. 5(8): 481-493.

Osman AY, Elmi SA, Simons D, Elton L, Haider N, Khan MA, Othman I, Zumla A, McCoy D and Kock R. 2021. Antimicrobial resistance patterns and risk factors associated with *Salmonella* spp. isolates from poultry farms in the East Coast of Peninsular

Malaysia: a cross-sectional study. Pathogens. 10(9): 1160.

Ozturk Y, Celik S, Sahin E, Acik MN and Cetinkaya B. 2019. Assessment of farmers' knowledge, attitudes and practices on antibiotics and antimicrobial resistance. Animals (Basel). 9(9): 653.

Pokharel S, Raut S and Adhikari B. 2019. Tackling antimicrobial resistance in low-income and middle-income countries. BMJ Glob Health. 4(6): e002104.

Poole T and Sheffield C. 2013. Use and misuse of antimicrobial drugs in poultry and livestock: mechanisms of antimicrobial resistance. Pak Vet J. 33: 266–271.

Pradhanang U, Pradhanang S, Sthapit A, Krakauer N, Jha A and Lakhankar T. 2015. National livestock policy of Nepal: needs and opportunities. Agriculture. 5(1): 103-131.

Rahman MK, Islam A, Samad MA, Islam S, Uddin MH, Rumi MA, Rostal M, Hagan E, Epistein JH, Flora MS and Hassan MM. 2020. Epidemiological assessment of antimicrobial resistance of *Salmonella* species from wildlife at human-animal interface in Bangladesh. J Infect Dis. 101(1): 70.

Roth N, Käsbohrer A, Mayrhofer S, Zitz U, Hofacre C and Domig KJ. 2019. The application of antibiotics in broiler production and the resulting antibiotic resistance in *Escherichia coli*: a global overview. Poult Sci. 98(4): 1791-1804.

Samuels R, Qekwana DN, Oguttu JW and Odoi A. 2021. Antibiotic prescription practices and attitudes towards the use of antimicrobials among veterinarians in the city of Tshwane, South Africa. PeerJ. 9: e10144.

Sarker MS, Ahmed I, Siddiky NA, Islam S, Begum R, Ahmed A, Mahua FA, Kabir ME and Samad MA. 2022. Knowledge, attitude and practice towards antibiotic use and resistance among the veterinarians in Bangladesh. medRxiv. 2021.2006.2003.21258263.

Sarwar MR, Saqib A, Iftikhar S and Sadiq T. 2018. Knowledge of community pharmacists about antibiotics, and their perceptions and practices regarding antimicrobial stewardship: a cross-sectional study in Punjab, Pakistan. Infect Drug Resist. 11: 133-145.

Saud B, Paudel G, Khichaju S, Bajracharya D, Dhungana G, Awasthi MS and Shrestha V. 2019. Multidrug-resistant bacteria from raw meat of buffalo and chicken, Nepal.

Vet Med Int. 2019: 7960268.

Schokker D, Jansman AJ, Veninga G, de Bruin N, Vastenhouw SA, de Bree FM, Bossers A, Rebel JM and Smits MA. 2017. Perturbation of microbiota in one-day old broiler chickens with antibiotic for 24 hours negatively affects intestinal immune development. BMC Genomics. 18(1): 241.

Shrestha A, Bajracharya AM, Subedi H, Turha RS, Kafle S, Sharma S, Neupane S and Chaudhary DK. 2017. Multi-drug resistance and extended spectrum beta lactamase producing gram negative bacteria from chicken meat in Bharatpur Metropolitan, Nepal. BMC Res Notes. 10(1): 574.

Speksnijder DC, Jaarsma AD, van der Gugten AC, Verheij TJ and Wagenaar JA. 2015. Determinants associated with veterinary antimicrobial prescribing in farm animals in the Netherlands: a qualitative study. Zoonoses Public Health. 62(1): 39-51.

Subedi D, Kandel M, Khanal S, Mahato PL and Acharya R. 2020. Prevalence of diseases in broilers age group 1-14 days at Chitwan district, Nepal. Int J Appl Sci Biotechnol. 8(1): 102-107.

Subedi M, Luitel H, Devkota B, Bhattarai RK, Phuyal S, Panthi P, Shrestha A and Chaudhary DK. 2018. Antibiotic resistance pattern and virulence genes content in avian pathogenic *Escherichia coli* (APEC) from broiler chickens in Chitwan, Nepal. BMC Vet Res. 14(1): 113.

Ul Haq N, Hassali MA, Shafie AA, Saleem F, Farooqui M and Aljadhey H. 2012. A cross sectional assessment of knowledge, attitude and practice towards Hepatitis B among healthy population of Quetta, Pakistan. BMC Public Health. 12(1): 692.

Upadhyaya N, Karki S, Oli M and Tiwari RN. 2020. Status of antimicrobial use in livestock sector in Nepal. Veterinary Standard and Drug Regulation Laboratory, Kathmandu, Nepal. 2020: 1-2.

Van Boeckel TP, Brower C, Gilbert M, Grenfell BT, Levin SA, Robinson TP, Teillant A and Laxminarayan R. 2015. Global trends in antimicrobial use in food animals. Proc Natl Acad Sci. 112(18): 5649-5654.

Van Boeckel TP, Pires J, Silvester R, Zhao C, Song J, Criscuolo NG, Gilbert M, Bonhoeffer S and Laxminarayan R. 2019. Global trends in antimicrobial resistance in animals in low- and middle-income countries. Int J Infect Dis. 110: 8-19.

Vijay D, Bedi JS, Dhaka P, Singh R, Singh J, Arora AK and Gill JPS. 2021. Knowledge, attitude, and practices (KAP) survey among veterinarians, and risk factors relating to antimicrobial use and treatment failure in dairy herds of India. Antibiotics. 10(2): 1-16.

Wangmo K, Dorji T, Pokhrel N, Dorji T, Dorji J and Tenzin T. 2021. Knowledge, attitude, and practice on antibiotic use and antibiotic resistance among the veterinarians and para-veterinarians in Bhutan. PLoS One. 16(5): e0251327.

Weldon I, Rogers Van Katwyk S, Burci GL, Giur D, de Campos TC, Eccleston-Turner M, Fryer HR, Giubilini A, Hale T, Harrison M, Johnson S, Kirchhelle C, Lee K, Liddell K, Mendelson M, Ooms G, Orbinski J, Piddock LJV, Rottingen JA, Savulescu J, Singer AC, Viens AM, Wenham C, Wiktorowicz ME, Zaidi S and Hoffman SJ. 2022. Governing global antimicrobial resistance: 6 key lessons from the Paris climate agreement. Am J Public Health. 112(4): 553-557.

WHO. 2008. "Subject: Advocacy, communication, and social mobilization for TB control: a guide to developing knowledge, attitude and practice surveys" (online). Available: https://apps.who.int/iris/bitstream/handle/10665/43790/9789241596176_eng.pdf;jsessionid=59BA73B40E70E69B8FCC30A674DA8B85?sequence=1. 3 November 2022.

WHO. 2015. "Subject: Antimicrobial resistance–SEA/RC68/R3" (online). Available: https://apps.who.int/iris/handle/10665/190978. 11 March 2022.

WHO. 2021. "Subject: Monitoring global progress on antimicrobial resistance: tripartite AMR country self-assessment survey (TrACSS) 2019-2020" (online). Available: https://www.who.int/publications/i/item/monitoring-global-progress-on-antimicrobial-resistance-tripartite-amr-country-self-assessment-survey-(tracss)-2019-2020. 11 March 2022.

WOAH. 2016. "Subject: Strategy on antimicrobial resistance and the prudent use of antimicrobials" (online). Available: https://www.woah.org/app/uploads/2021/03/en-oie-amrstrategy.pdf. 11 March 2022.

WOAH. 2022. "Subject: Antimicrobial resistance" (online). Available: https://www.woah.org/en/what-we-do/global-initiatives/antimicrobial-resistance/. 11 March 2022.

Woolhouse M, Ward M, van Bunnik B and Farrar J. 2015. Antimicrobial resistance in humans, livestock and the wider environment. Philos Trans R Soc Lond B Biol Sci. 370(1670): 20140083.

Xiong W, Sun Y and Zeng Z. 2018. Antimicrobial use and antimicrobial resistance in food animals. Environ Sci Pollut Res Int. 25(19): 18377-18384.

APPENDICES

Annex I: Questionnaire for poultry practitioner veterinarian

Situation analysis and KAP on antimicrobial use and resistance among veterinarians and broiler poultry farmers of Nepal

Questionnaire code: ______ Date: _______

Section I: General Information
Q1: Name of veterinarian: Dr.________________ Age: ____ years Gender: M/F
Q2: Name of organization: ____________________________ Position: ______________
Q3: Working address: Province: _________ District: _________ Municipality: _________
Q4: Contact: Mobile/phone: ____________________ E-mail: ____________________
Q5: Educational level: (a) Bachelor (b) Master or above (c) Specify specialization_____ (d) Graduation year of bachelor's degree: ______
Q6: Veterinary practice: (a) Poultry practice (b) Mixed practice (c) Others (specify) __

Q7: Type of Services:

(a) Government

(b) Private

(c) I/NGOs

(d) Other (please specify)

Section II: Knowledge

Q8: AMR is a public health issue in Nepal.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q9: Inappropriate use of antimicrobials in animals leads to AMR in humans.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q10: AMR is a natural as well as an anthropogenic phenomenon.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q11: Antibiotics are used when animals have a disease diagnosed by a veterinarian.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q12: Inappropriate of antimicrobials without prescription are major factors of AMR.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q13: Antimicrobial residues can lead to the emergence of antimicrobial resistance.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q14: Ciprofloxacin is an effective drug for salmonellosis.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q15: Enrofloxacin is the choice of drug for Chronic Respiratory Disease in poultry.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q16: The National Action Plan on AMR is needed to combat AMR.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q17: Lack of control in the sale of antibiotics contributes to antimicrobial resistance.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q18: What is a critically important antimicrobial specified by WHO?

(a) Colistin

(b) Chloramphenicol

(c) Sulfamethoxazole

(d) Metronidazole

Q19: What antimicrobial is prohibited in food-producing animals?

(a) Colistin

(b) Chlortetracycline

(c) Sulfamethoxazole

(d) Furazolidone

Section III: Attitude

Q20: Antimicrobials are safe, so they are commonly used in animals.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q21: Vaccination can reduce the use of antimicrobials in poultry farms.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q22: Broad-spectrum antimicrobial is better, even narrow-spectrum drugs available.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q23: Sales of non-prescribed antimicrobials should be prohibited.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q24: A significant reason for AMR is (tick one most important):

(a) Irrational use

(b) Over the counter sell

(c) Low dose administration

(d) Low quality antimicrobials

Q25: An appropriate withdrawal period is needed before selling poultry.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q26: National guideline on the rational use of antimicrobials is necessary for veterinary Practice.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q27: Prescribing antimicrobials to a healthy animal for prophylaxis may harm the health of the animal.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q28: Priority antimicrobials must be restricted for human use only.

(a) Completely agree (b) Agree (c) Disagree d) Completely disagree

Q29: Important strategies to combat AMR are (Tick one most important strategy): (a) Educational campaigns (b) Use of appropriate treatment guidelines (c) Control of antimicrobial sells (d) Reduce AMU in animals (e) Improve biosecurity and hygiene of farm/hospital (f) Vaccination campaigns
Section IV: Practice
Q30: I use antimicrobials for growth promoters. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree
Q31: I do not prescribe the antibiotics upon the farmer's request. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree
Q32: The farmer pressure me for an antimicrobial's prescription. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree
Q33: I strictly follow the National AMR Plan on Antimicrobial Resistance. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree
Q34: Skipping 1 or 2 doses during the antimicrobials course is not acceptable. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree
Q35: I calculate the dose of antimicrobials before using. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree
Q36: I have changed my prescription due to the AMR issue in poultry. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree
Q37: Familiar with a critically important list of antimicrobials specified by WHO. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree
Q38: I have attended training to update my knowledge of AMU and AMR. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree
Q39: I have conducted a training program to improve farmers' knowledge of AMR. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree
Q40: I used to combine antibiotics to ensure therapeutic success. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q41: Please list down your most prescribed antibiotics last six months in poultry: ____

Q42: Did you give the following advice to the farmers after the antimicrobial prescription?

(a) Use complete dosages of antimicrobials as prescribed:

(i) Always (ii) Sometimes (iii) Never (iv) Do not perform

(b) Dispose of the unused or wasted antimicrobials:

(i) Always (ii) Sometimes (iii) Never (iv) Do not perform

(c) Do not stop treatment even if there is improvement after a few days of treatment in poultry:

(i) Always (ii) Sometimes (iii) Never (iv) Do not perform

(d) Do not sell the poultry within the recommended withdrawal period of antimicrobial:

(i) Always (ii) Sometimes (iii) Never (iv) Do not perform

(e) Keep drug register in the farm:

(i) Always (ii) Sometimes (iii) Never (iv) Do not perform

Q43: I prescribe antimicrobials over the phone or without examination of birds.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q44: I feel that poor clinical response to the antimicrobial used.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q45: What proportion of your prescription has antimicrobials?

(a) <20% (b) 20-40% (c) 40-60% (d) >60%

Q46: How often have you changed an antimicrobial agent because of resistance confirmed on AST?

(a) Always (b) Sometimes (c) Never/rarely (d) Don’t remember.

Q47: How frequently do you prescribe the antimicrobials for therapeutic purposes?

(a) Everyday (b) 1-2 times a week (c) 3-5 times a week d) Never

Thank you very much for your cooperation and support!

Annex II: Questionnaire for broiler poultry farmers

Situation analysis and KAP on antimicrobial use and resistance among veterinarians and broiler poultry farmers of Nepal

Questionnaire code: ______ Date: _____________

Section I: Demographic information
Q1: Farm name: _________________________
Q2: Farm address: District: ___________ Municipality: ________________ Ward___
Q4: GIS point: Latitude: ___________________ Longitude: _________________
Q5: Contact Mobile: ___________________ E-mail: __________________
Q6: Name of Respondent: ____________ Age: ___ Sex: __ M/F Position ____________
Q7: Education level of respondent: (a) Illiterate (b) Primary school (c) High school (d) Graduate
Q8: Poultry farming experience: ___________year(s)
Q9: Income from the previous batch of broiler poultry: ________________
Q10: Flock Size: ___________

Section II: Farm Security and poultry health
Q11: Age of flock (days): ___ Number of poultry house: ___ Bird per house[1]: _________
Q12: Number of batch production per year: ________
Q13: Current batch bird sick and death birds: (a) Number of sick: _________ (b) Number of dead: ___
Q14: Source of water: (a) Municipality (b) Ground (c) Deep well (d) Other (please specify) _______
Q15: Source of feed: (a) commercial (please specify ___________) (b) Homemade
Q16: Who can enter the farm? (a) Only staff (b) All family members (c) All visitors (d) Other (please specify) _______
Q17: How often do you disinfect vehicles before entering farm premises? (a) Every time (b) Sometimes (c) Never (d) Other (please specify) ___________
Section III: Situation analysis of AMU (Collect the information just previous batch of broiler poultry)

[1] If more than one house, specify birds per house separately.

Q18: Have you heard about AMR and AMU issues in animals and humans? (a) Yes (b) No (c) Don’t know
Q19: Have you had experience in training on antimicrobial resistance? (a) Yes (b) No (c) Don’t know
Q20: What is the common source of advice on using antibiotics on the farm? (a) Veterinarian (b) Para-veterinarian (c) Feed /chicks/drug suppliers (d) Yourself (e) Other
Q21: What is the common source of antimicrobials? (a) Veterinarian (b) Feed seller (c) Drug seller (d) Freely purchase from drug store (e) Other____
Q22: What is the purpose of antimicrobial use? (a) Treatment (b) Disease prevention (c) Growth promotion (d) All of the above (e) Don’t know
Q23: How to select antimicrobials in farms? (a) Laboratory results (b) Previous symptoms (c) Follow veterinarian (d) Based on neighboring farms practice (e) Other (please specify) ____________ (e) As per the drug seller's opinion

Q24: What is your cost of medicine per batch/cycle (NRS):

(a) First batch _____

(b) Second batch _________

(c) Third batch_____________

(d) Another batch_______

Q25: Where do you store the antibiotics?

(a) In the farm

(b) (b) In the house

(c) Medical cabinet

(d) Other (please specify) _____

Q26: What about your access to a source of antimicrobials?

(a) Very easy

(b) Easy

(c) Difficult

(d) Very difficult

Q27: What antimicrobials did you use on the following clinical Sign that appeared in your birds of this batch?

S.N.	Antibiotic Used (trade name, concentration, duration, and quantity)	Clinical Sign (s) circle one or more)	Source of antimicrobials	Route of application	Age of birds applied antimicrobials	Advisor of AMU	Tentative Diagnosis
1		RS/CNS/DS/ Immune/SI/other[2]					

[2] RS= respiratory like coughing, nasal secretion, difficulty in breathing; CNS=nervous like paralysis, torticollis, etc., DS=Digestive like diarrhea; SI=skin and integument problem

Section IV: Knowledge
Q28: Antimicrobial resistance is a serious national public health problem. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don’t Know
Q29: The government of Nepal has a policy for antimicrobial use in animals. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don’t Know
Q30: Antimicrobials can be passed to humans through poultry meat and egg consumption. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don’t Know
Q31: Antimicrobials cannot be used to treat all types of poultry diseases. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don’t Know
Q32: Inappropriate use of antibiotics can develop AMR. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don’t Know
Q33: Poultry should sell after the withdrawal period of antimicrobials. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don't Know
Q34: Treatment is preferred when one/few birds are sick in a poultry farm. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don’t Know
Q35: All antimicrobials do not have the same curative effect on all poultry diseases. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don't Know.
Q36: Antibiotic residue in poultry meat could be hazardous to public health. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don’t Know
Q37: The antimicrobial-free production cycle is possible in poultry farm. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don’t Know
Q38: The use of antimicrobials in feed formulation is inappropriate. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don’t Know
Q39: Lack of control in the sales of antimicrobials contributes to AMR. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don't know

Q40: Who has the right to prescribe antibiotics to animals?

(a) Veterinarian

(b) Para-veterinarian

(c) Drug/feed seller

(d) No need for any prescription

(e) Don’t Know

Q41: Who is the important stakeholder in monitoring the responsibility of AMU in farms?

(a) Farmers

(b) Veterinarian

(c) Drug seller

(d) Government

(e) All are correct

(f) Don’t Know

Section V: Attitude

Q42: Antimicrobials are safe, so they are commonly used in humans and animals.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don’t Know

Q43: Antimicrobials are needed to treat any illness in animals.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don't Know

Q44: It is better to ensure that broad spectrum antimicrobials cure animals.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don't Know

Q45: Antimicrobials are needed to prevent only serious illnesses.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don’t Know

Q46: Non-prescribed antimicrobials sale should be prohibited.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don’t Know

Q47: When the season changes, antimicrobials are needed for birds.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don’t Know

Q48: When you have a fever/cold, antimicrobials are needed.

(a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don’t Know

Q49: Missing a dose of antimicrobials might contribute to antimicrobial resistance. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don't Know
Q50: Vaccination can reduce the use of antimicrobials in poultry farms. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don't Know
Q51: Antimicrobials can be added to poultry feed to prevent from becoming sick. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don't Know
Q52: Expired antimicrobials can feed to the birds rather than be disposed of it. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree (e) Don't Know
Section VI: Practice
Q53: Whom do you consult for the selection of antimicrobials and their dosage? (a) Veterinarian (b) Para-Veterinarian (c) Sale representative (d) Personal experience (e) Other (please specify)________
Q54: Whom do you consult for the preparation and administration of antimicrobials? (a) Veterinarian (b) Para-Veterinarian (c) Sale representative (d) Personal experience (e) Other (please specify)____
Q55: Complete the entire course of antimicrobials as prescribed by a veterinarian. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree
Q56: Give antimicrobials to day-old chicks to prevent disease. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree
Q57: Skipping 1 or 2 doses of antimicrobials in the course is not acceptable. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree
Q58: Withdraw the antimicrobials when animal symptoms disappear. (a) Completely agree (b) Agree (c) Disagree (d) Completely disagree

Q59: I check the expiry date of the antimicrobials before use.			
(a) Completely agree	(b) Agree	(c) Disagree	(d) Completely disagree
Q60: Increase the dose of antimicrobials when there are clinical symptoms.			
(a) Completely agree	(b) Agree	(c) Disagree	(d) Completely disagree
Q61: Whom do you consult when poultry are sick? (a) Veterinarian (b) Drug seller (c) Self-treatment (d) Other (please specify) _______			

Thank you very much for your cooperation and support!

Annex III Research information sheet

This questionnaire is carried out for the thesis on the topic of situation analysis and KAP on antimicrobial use and resistance among veterinarians and broiler poultry farmers of Nepal for a master's degree. The major objective of this research is to define the situation, knowledge, attitude, and practise of AMR and AMU in broiler farmers and veterinarians. This study assists to create plan for AMR policy and to make awareness of AMR and AMU in public. The concern for the safety of the participants is that there is no risk-taking part in the questionnaire. Nevertheless, if anyone feels uncomfortable sharing their information, they can always say avoid any questions of their choice. If the participants need further information, the participant can always contact the principal researcher.

अनुसन्धानको सूचना पाना (Research information sheet in Nepali)

यो प्रश्नावली मास्टर डिग्रीको लागि नेपालको ब्रोइलर कुखुरा पाल्ने किसान र पशु चिकित्सकमा एन्टीवायोटिक प्रयोग र प्रतिरोधको अवस्था, ज्ञान, मनोवृत्ति र अभ्यास आँकलन तथा अध्ययनका लागि गरिदैछ। थेसिसको मुख्य उद्देश्य भनेको किसान र पशु चिकित्सकहरुमा एन्टीवायोटिक प्रतिरोध ज्ञानको स्तर पत्ता लगाउनु हो। यस अध्ययनले एन्टीवायोटिक प्रतिरोध बारेमा थप योजना बनाउन मद्दत गर्दछ। यसको व्यवस्थापनको बारेमा मानिसहरूलाई सचेत गराउँदछ। प्रश्नावलीमा भाग लिन कुनै जोखिम छैन। तर कुनै जानकारी भन्न असहज महसुस गर्नु हुन्छ वा भन्न सक्दिँन भन्ने लाग्छ भने बीचमा प्रश्नवलीको उत्तर दिन छोड्न सक्नुहुन्छ। यदि सहभागीलाई कुनै थप जानकारी आवश्यक भए सहभागीले सीधै शोधकर्तालाई सम्पर्क गर्न सक्नु हुनेछ।

मनोज कुमार शाही
९८५११९५८२१

Annex IV Consent form for questionnaire

Project Title: Situation analysis and KAP on antimicrobial use and resistance among veterinarians and broiler poultry farmers of Nepal

Researcher: Manoj Kumar Shahi, MVPH student, Chulalongkorn University, Thailand

PURPOSE OF THE FORM

You are requested to give your consent to answer the questionnaire questions. You may ask any question about the research, such as the possible risks and benefits, rights as a volunteer participant, and anything else that needs to be clarified. When all your doubts have been cleared, you can decide whether you will participate in this study.

Procedure: Questions will be asked from the questionnaire.

Risk of the procedure: No risk

Compensation for participation: No compensation for participation

COSTS FOR PARTICIPATION: No cost is involved.

Consent for procedure

Participation in this research is voluntary, and you can deny your involvement. Your consent on this form indicates that the research procedure has been explained, questions/queries have been answered to your satisfaction, and you agree to allow your animal to participate in this study.

Investigator

Name: Manoj Kumar Shahi

Phone number: 9851195821

Signature:

प्रश्नावलीको लागि सहमति फारम

(Consent form for questionnaire in Nepali)

परियोजना शीर्षकः नेपालको ब्रोइलर किसान र पशु चिकित्सकमा एण्टीवायोटिक प्रयोग र प्रतिरोध सम्बन्धी अवश्था, ज्ञान, मनोवृत्ति र अभ्यास आकलन।

अनुसन्धानकर्ताः मनोज कुमार शाही, मास्टर अफ साइन्स इन भेटेरिनरी पव्लिक हेल्थ, विद्यार्थी, चुलालङ्गकोर्न विश्वविद्यालय, थाइलेण्ड।

फारमको उद्देश्य

तपाईँलाई प्रश्नावलीका प्रश्नहरूको उत्तर दिन तपाईंको सहमति दिन अनुरोध गरिएको छ। तपाईले अनुसन्धानको बारेमा कुनै प्रश्न सोध्न सक्नुहुन्छ, जस्तै सम्भावित जोखिम र सुविधाहरू, इत्यादी। तपाईँका सबै शंकाहरू हटाइएको छ, तपाईँले निर्णय गर्न सक्नुहुन्छ कि तपाईँ यस अध्ययनमा भाग लिनुहुनेछ वा छैन।

प्रक्रियाः प्रश्नावलीबाट प्रश्नहरू सोधिनेछ।

प्रक्रियाको जोखिमः कुनै जोखिम छैन।

सहभागिको लागि क्षतिपूर्तिः सहभागिताको लागि क्षतिपूर्ति हुने छैन।

सहभागिको लागि वजेटः यसमा कुनै मूल्य छैन।

प्रक्रियाको लागि सहमति

यस अध्ययनमा तपाईंको सहभागिता पूर्ण रूपमा स्वैच्छिक हो। तपाईं आफ्नो संलग्नतालाई इन्कार पनि गर्न सक्नुहुन्छ। यस फारममा तपाईंको हस्ताक्षरले संकेत गर्दछ कि अनुसन्धान प्रक्रिया तपाईंलाई राम्रोसँग सम्झाइएको छ। तपाईंको प्रश्न/प्रश्नहरूको जवाफ तपाईंको सन्तुष्टिको अनुरूप दिइएको छ। तपाईं आफ्नो जनावरका विषयमा यस अध्ययनमा भाग लिन अनुमति दिन सहमत हुनुहुन्छ।

नामः	नामः मनोज कुमार शाही
हस्ताक्षरः	हस्ताक्षरः

Annex V Ethical clearance from National Health Research Council, Nepal

Government of Nepal

Nepal Health Research Council (NHRC)

Estd. 1991

Ref. No.: 3029

15 May 2022

Assist. Prof. Sharutai Jemsripong

Dr. Manoj Kumar Shahi

Principal Investigators

Chulalongkorn University

Thailand

Ref: Approval of thesis proposal

Dear Assist. Prof. Jemsripong and Dr. Shashi,

This is to certify that the following protocol and related documents have been reviewed and granted approval through the expedite review process by the Expedited Review Sub-Committee meeting for it's implementation.

Protocol Registration No/ Submitted Date	162/2022 MT 1 April 2022	**Sponsor Protocol No**	NA
Principal Investigator/s	Assist. Prof. Sharutai Jemsripong Dr. Manoj Kumar Shahi	**Sponsor Institution**	NA
Title	The situation on antimicrobial use and knowledge, attitude, and practice on antimicrobial use and resistance among veterinarians and farmers in poultry farms in Nepal		
Protocol Version No	NA	**Version Date**	NA
Other Documents	1. Data collection tools 2. Informed consent form	**Risk Category**	Minimal risk
Co-Investigator/s	NA		
Study Site	31 district of the Nepal		
Type of Review	[√] **Expedited** [ ] Full Board **Meeting Date:** 22 April 2022	**Timeline of Study** 15 May 2022 to May 2023 **Duration of Approval**	**Frequency of continuing review** NA

Tel: +977 1 4254220, Fax: +977 1 4262469, Ramshah Path, PO Box: 7626, Kathmandu, Nepal
Website: http://www.nhrc.gov.np, E-mail: nhrc@nhrc.gov.np

Annex V Ethical clearance from National Health Research Council, Nepal (Continue)

Government of Nepal
Nepal Health Research Council (NHRC)
Estd. 1991

Ref. No.: 3029

		15 May 2022 to 15 May 2023 **This approval will be valid one year**	
Total budget of research	**NRs 2,50,000.00**		
Ethical review processing fee	**NRs 10,000.00**		

Investigator Responsibilities

- Any amendments shall be approved from the ERB before implementing them
- Submit progress report every 3 months
- Submit final report after completion of protocol procedures at the study site
- Report protocol deviation / violation within 7 days
- Comply with all relevant international and NHRC guidelines
- Abide by the principles of Good Clinical Practice and ethical conduct of the research

If you have any questions, please contact the Ethical Review M & E Section at NHRC.

Thanking you,

Dr. Pradip Gyanwali
Member Secretary

Tel: +977 1 4254220, Fax: +977 1 4262469, Ramshah Path, PO Box: 7626, Kathmandu, Nepal
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Annex VI Classes of antimicrobials used in PPV

Class of antimicrobials (n=730) *	N (%)
Quinolones	
Enrofloxacin	88 (12.1)
Ciprofloxacin	57 (7.8)
Levofloxacin	50 (6.8)
Flumequine	5 (0.7)
Tetracyclines	
Doxycycline	79 (10.8)
Tetracycline	68 (9.3)
Chlortetracycline	12 (1.6)
Aminoglycosides	
Neomycin	56 (7.7)
Gentamycin	49 (6.7)
Amikacin	5 (0.7)
Macrolides	
Tylosin tartrate	48 (6.6)
Azithromycin	6 (0.8)
Erythromycin	2 (0.3)
Glycopeptides	
Colistin Sulfate	45 (6.2)
Bacitracin	2 (0.3)
Penicillins	
Amoxicillin	43 (5.9)
Cloxacillin	2 (0.3)
Sulfonamides	
Sulfamethoxazole	32 (4.4)
Sulfadiazine	9 (1.2)

Note: *Multiple answers allowed

Annex VI Classes of antimicrobials used in PPV (Continue)

Class of antimicrobials (n=730) *	**N (%)**
Cephalosporins	
Cephalosporin**	16 (2.2)
Cephalexin	10 (1.4)
Ceftiofur	4 (0.5)
Diaminopyrimidines	
Trimethoprim	13 (1.8)
Phenicols	
Florfenicol	11 (1.5)
Nitrofurans	
Furaltadone	9 (1.2)
Chloramphenicol	5 (0.7)
Lincosamides	
Lincomycin	4 (0.5)

Note: *Multiple answers allowed; **Response with class of antimicrobials

VITA

NAME	Manoj Kumar Shahi
DATE OF BIRTH	5 December 1986
PLACE OF BIRTH	Jukot-1, Bajura, Nepal
INSTITUTIONS ATTENDED	Nepal Veterinary Council
HOME ADDRESS	Jukot-1, Bajura, Nepal
PUBLICATION	Shahi MK. 2020. Situation of animal rabies in Nepal from 2013 to 2017. Nep Vet J. 3:112–119. Shahi MK, Boonyo K, Wongphruksasoong V, Upadhya M, Rana S, Karki S, Kafle SK and Kafle S. 2021. Investigation of Foot and Mouth Disease outbreaks in dairy cattle of Kageshwari and Shankharapur Municipalities, Kathmandu, Nepal, and associated risk factors from March to April 2020. OSIR Journal. 14 (2): 52-57. Shahi MK and Gairhe KP. 2019. Prevalence of helminths in wild Asian elephants and Indian rhinoceros in Chitwan and Bardia National Park, Nepal. Nep Vet J. 36:60–74. Shahi MK and Jeamsripong S. 2023. Knowledge, attitude, and practice on AMU and AMR among broiler poultry farms of Nepal. Thai J Vet Med. 53(Suppl.):439-441. Shahi MK and Jeamsripong S. 2023. Knowledge, attitude, and practice on AMU and AMR among poultry practitioner veterinarians of Nepal. AMRU Asia Pacific-2023. 1:100-101. Sharma S, Dhital K, Puri D, Pradhan S, Rajbhandari U, Basnet A, Ghaju S, Manandhar P, Ghimire NU and Shahi MK. 2022. Screening avian pathogens in eggs from commercial hatcheries in Nepal: an effective poultry disease surveillance tool. bioRxiv:2022.08.11.503567.