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Research Article

Assessment of Mongolia's Status on Antimicrobial Use and Antimicrobial Resistance in the Agrifood Sectors

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Abstract

The public health threat of antimicrobial resistance (AMR) is viewed as a problem requiring multidisciplinary or One Health approaches to resolve. This study took different approaches to identify the issues that needed to be addressed before developing the National Action Plan (NAP) on AMR 2022-2025. First, we documented the regulations on AMR and antimicrobial use (AMU) that had been enacted by the Mongolian government. Secondly, the knowledge, attitude, and practices (KAP) of agrifood AMU/AMR stakeholders were determined using surveys. Lastly, the laboratory capacity to test for drug and pesticide residues in food products was assessed. Briefly, the limited number of legislative actions on AMU/AMR identified in this study were poorly enforced. Moreover, herders, dairy farmers, and veterinary professionals administered antimicrobials with little awareness about the risks of AMR and antimicrobial residues in meat and milk products. AMR stakeholders in Mongolia could benefit from a multipronged approach to improve awareness, surveillance, and governance.

Keywords: AMR stakeholders; National Action Plan to control AMR; Knowledge Attitude and Practices (KAP) survey.

Introduction

Antimicrobial resistance (AMR) is one of the top global challenges of the 21st century. An estimated 4.95 million (95% uncertainty interval: 3.62–6.57 million) deaths associated with bacterial AMR, including 1.27 million (95% uncertainty interval 0.911–1.71 million) deaths were attributed to bacterial AMR in 2019. At the regional level, the estimated all-age death rate attributable to AMR was highest in western sub-Saharan Africa (27.3 deaths per 100,000) and lowest in Australasia (6.5 deaths per 100,000). Infections of the lower respiratory tract accounted for more than 1.5 million deaths associated with resistance in 2019, making it one of the most burdensome infectious syndromes in the world. The six leading bacterial pathogens associated with resistance (*Escherichia coli*, followed by *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Streptococcus pneumoniae*, *Acinetobacter baumannii*, and *Pseudomonas aeruginosa*) were responsible for 929,000 deaths attributable to AMR and 3.57 million deaths associated with AMR in 2019 [1].

Although the AMR burden was largely unknown in Mongolia, a World Health Organization (WHO) study from 2018 found that Mongolians were among the world's most prolific users of antibiotics, consuming an average of 64.4 defined daily dose (DDD) per 1,000 individuals [2]. A more recent study from 2021 showed that Mongolians had reduced their antimicrobial use by 21.3% to 50.7 DDD [3]. The decreased AMU may have reflected the government's nationwide "antibiotics only by prescription" campaign. Despite this encouraging trend, the

decrease in antimicrobial use (AMU) represented a minor change in the overall picture. Mongolia still ranks at the top of the list of countries included in an AMU survey [4]. At the time of this review, more than 800 veterinary drugs and vaccines were registered for use in the livestock sector [5]. Unlike the AMU data on human consumption, information about AMU in the food and agriculture sectors was lacking. Moreover, the AMR data in these sectors in Mongolia was scarce [6]. That was aggravated as the understanding of scientists and policymakers on AMR was often confused with presence of antimicrobial residues.

Various legal acts covering different sectors have been adopted to promote the proper use of antimicrobials and to prevent AMR in Mongolia. These policies were reflected in the National Multi-Sectoral Action Plan (NAP) for Combating Antimicrobial Resistance 2017-2020 [7]. AMR is not limited to treated patients (human and animal) because resistant microbes can spread between animals and humans by various routes, including direct contact, food and feed consumption, and environmental exposure. Therefore, it is vital to limit antimicrobial residues and resistant microbes wherever possible, including in food.

This study had three main objectives: addressing the issues of unclarity about the extent to which existing legal acts aim to mitigate AMR in the agrifood sectors, the lack of information on the use of antimicrobials and the ability to test for drug and pesticide residues in food products. The first objective was to determine the scope of national legislation related to AMR mitigation activities in Mongolia. This analysis examined ongoing AMR activities and relevant regulations. The second objective was to understand he current knowledge, attitudes, and practices regarding the use of antimicrobials by herders, private and public veterinarians, dairy farmers, and pharmacists. The third objective was to compile information on testing capability for antimicrobial residues in food products.

Materials and Methods

Analysis of national legislation

To analyze the scope of national legislation related to AMR mitigation activities, we used the AMR Situation Analysis checklist developed by the Food and Agriculture Organization (FAO) [8]. This tool incorporated AMR/AMU data collected from international and national legal documents including the NAP 2017-2020, reports, and surveillance materials. The findings from the participatory approaches (i.e. surveys, interviews, focal groups) were also considered.

Survey Design

We developed and conducted surveys designed to determine the knowledge, attitudes, and practices (KAP) of different antimicrobial users in the livestock sector (Table 1). These surveys were adapted to the specific concerns of each target group: herders, private and public veterinarians working in the field, dairy farmers, and pharmacists. As a result, the surveys varied according to the number and content of the questions. All surveys contained sections on understanding the purpose of antimicrobials and the meaning of AMR. The surveys explored attitudes towards medications in general and antimicrobials in particular. The surveys also included questions on how medications were selected, stored, administered, and recorded (the surveys can be requested from the first author).

The different surveys were pre-tested with three persons representing the intended target groups. Upon finalization of the survey, three veterinary researchers from the Institute of Veterinary Medicine (IVM) and ten final-year students from the School of Veterinary Medicine of the Mongolian University of Life Science (MULS) were trained to conduct these surveys by the first author. The KAP surveys were conducted by phone due to the limitations imposed during the COVID-19 pandemic during the period of April to July 2022. The responses were recorded in the Google Form program.

The herders and veterinary professionals were selected from three aimags (provinces): Khovd in the western region (mountainous), Uvurkhangai in the central region (steppe) and Sukhbaatar (desert) in the eastern region. These aimags were chosen to assure that different livestock management practices were considered. Eight to ten herders were randomly selected from each district in the aimag based on a list provided by the veterinary departments in the aimag. All private and public veterinarians working in the districts were approached to participate. The dairy farmers and pharmacists were selected from the provincial municipality of Ulaanbaatar because this was where the majority of these professionals resided. The survey responses were analyzed by downloading the Google Form data into Excel and Stata (version 11)® for descriptive statistics including Chi-square testing for comparison between groups (female versus male, category of working experience, veterinary professionals versus veterinary para-professionals).

Aimags/city	District	Herders	Private and public veterinarians	Dairy farmers	Veterinary pharmacists	**Total**
Khovd	17	150	34		4	**188**
Uvurkhangai	19	175	43		3	**221**
Sukhbaatar	13	111	61		3	**175**
Ulaanbaatar	2	0	0	25	20	**45**
Grand total		**436**	**138**	**25**	**30**	**629**

Table 1: Number of participants in the KAP survey.

Laboratory Surveillance for Veterinary Drug Residues

The first author assessed the reported ability of the State Central Veterinary Laboratory (SCVL) to detect drug and pesticide residues. SCVL is the principal laboratory in the agrifood sector for testing drug and pesticide residues in food products. It used 4 different types of assays to detect residues: enzyme-linked immunosorbent assays (ELISA), radio-receptor assays, gas chromatography/mass spectrometry (GC/MS), and liquid chromatography (LC-DAD/FLD). The laboratory claimed to have the capacity to detect 37 types of drug residues in agricultural raw materials and products, including 2 types of group A substances and 35 types of group B substances as defined by Annex 1 of the European Commission Directive 96/23. Substances classified into group A include pharmaceuticals prohibited for use in food animals (e.g., chloramphenicol, nitrofuran, nitroimidazole), while substances classified into group B include medicines with pharmacologically active compounds that can be used in animals with approval.

Results

Governance

A review of the "National Multi-sectoral Action Plan on Combatting Antimicrobial Resistance (2017-2020)" indicated that many activities had not been planned or implemented in the livestock sector. For example, no action was taken to adopt a process for requiring veterinary pharmaceutical prescriptions or to develop an AMR surveillance system. In addition, policies addressing the development of training programs on the proper use of veterinary drugs and antimicrobial resistance were not in place. It was argued that there was insufficient budget allocated to implement the planned activities of the National Action Plan.

By contrast, Mongolia had adopted the Livestock and Animal Health Law in 2017, which aimed to encourage the rational use of antimicrobials in livestock. The law provided for the introduction and control of veterinary drugs by requiring prescriptions and by registering veterinary drugs and animal feed additives in a single database. In accordance with these provisions, a new electronic database for veterinary drugs and feed additives was created and launched in May 2021. The same month, the government implementing agency, the General Authority for Veterinary Services (GAVS), provided training on how to use the e-database for veterinary drug suppliers, veterinary drug manufacturers, and veterinary pharmacists. In 2021, there were 324 drugs and vaccines registered in the online database. It should be noted that the database does not record feed additives.

In 2017, the Ministry of Food, Agriculture and Light Industry (MoFALI) issued Order A-50 under the Law on Medicine and Medical Devices. This order listed the essential veterinary drugs and medical devices including antimicrobials, common drugs, vaccines, and disinfectants. According to this order, veterinary medicines were separated into 3 classifications: prescription drugs, over-the-counter drugs, and drugs that are under special control.

However, the procedure for prescribing different classifications of veterinary drugs have not been developed yet. This absence has led to continued unregulated use of antibiotics and antiparasitic drugs by herders, dairy farmers, and other livestock owners. In addition, the standards established by the Mongolian Agency for Standards and Metrology on General Requirements for Veterinary Pharmacies (MASM) [8] and the General Requirements for Veterinary Medicines and Medical Devices Suppliers did not contain specific provisions to properly register the sales of antimicrobials to end-users [9]. As a result, and as noted by the veterinary pharmacists in the KAP survey, veterinary prescription drugs were often sold without a prescription.

KAP Surveys

Herders

The KAP survey engaged a total of 436 herders from 3 geographically distinct aimags (Table 1). Of the interviewed herders, 19% were female and all herders except two were married. Just over 30% had 6 or more family members. The number of years' experience rearing livestock was mostly 21 to 30 years (39%) whereas 32% of herders indicated to have more than 30 years' experience. The pastoral herders typically maintained mixed herds of cattle (15%), small ruminants (sheep and goats, 75%), and horses (10%), ranging in size from 250 to 2,500 animals. According to the re-

sults of the survey, 32% (n=139) of the herders regularly registered the use of antimicrobial drugs in their animal health records, 13% (n=57) registered occasionally, and 55% (n=240) did not register this information at all. By contrast, 46% (n=201) of the herders recorded vaccinations only.

Additional findings of the KAP survey for herders were that most herders (67%) typically administered antimicrobials themselves without a prescription or veterinary consultation, even though the drugs were purchased from a local veterinarian. Herders routinely (41%) treated the entire herd in spring (April, May, June). Of these herd treatments, 68% were aimed at treatment against internal and external parasites. Only 55-60% of the herders adhered to antimicrobial withdrawal times for meat and milk. Herders mentioned that they needed proper training on the use of antimicrobials and other related issues such as the appropriate use of syringes and needles, as well as the storage of veterinary drugs. In addition, the herders indicated a need to improve the quality of veterinary services, including increasing the availability of vaccinations against endemic infectious diseases.

Dairy Farmers

The survey used for the herders was also delivered to 25 dairy farmers of which 7 were females. The dairy farmers were in business for more than 10 and up to 30 years. Although dairy farmers consulted veterinarians when animals were first identified as being sick, the veterinarians typically did not conduct on-site physical examinations or laboratory tests. Consequently, the farmers were accustomed to diagnosing health problems and treating their animals based on their personal experiences. At the same time, dairy farmers were generally unfamiliar with how antimicrobials work. Eighty percent of farmers indicated that antimicrobials could be used for any kind of clinical signs. Forty-four percent agreed that the use of antimicrobials in livestock is safe and harmless.

Veterinarians

A total of 138 veterinarians responded to the KAP survey, of which 83% were private veterinarians and 17% veterinarians were working as soum public veterinarians. Of the private veterinarians, 84 (74%) were trained as veterinarians (School of Veterinary Medicine) while the remaining 30 were trained as veterinary para-professionals. Of the 24 veterinarians working as soum public veterinarians, all were trained as veterinarians. Fifty-four percent of veterinarians were males whereas of veterinary para-professionals only 33% were males. Female private veterinarians (combination of veterinarians and veterinary para-professionals) had on average more years of working experience compared to their males colleagues. There was no difference in years of working experience between males and females working for as soum public veterinarians.

One third of the respondents (n=45) stated that they organize trainings and advertisements on the proper use of veterinary drugs in their local areas. However, there were no reports documenting when or where these trainings took place. One third of veterinarians suspected that more than 10 percent of the antimicrobials sold were of poor quality, unregistered, substandard, and/or falsified. Only 22% of veterinarians had a good understanding of the difference between antimicrobial resistance and antimicrobial residues in meat and milk. The five most common antibiotics used by veterinarians to treat animal diseases were oxytetracycline, penicillin-G, amoxicillin, tylosin, and penicillin-streptomycin. Only 6% veterinarians prescribed antimicrobials. The majority of the veterinarians typically recommended treatments to livestock owners who were able to purchase medicines at veterinary pharmacies without a prescription. The veterinarians noted that there was a need for regulations on antimicrobial prescriptions and that these regulations needed to be enforced by the authorities. In the view of the veterinarians, herders overused veterinary drugs, especially ivermectin, which is used to treat internal and external parasites including worms, sucking lice, and ticks.

Veterinary Pharmacists

A total of 30 veterinary pharmacists (of which 19 females) responded to the KAP survey designed specifically for this group. Except for two, all had a degree from the Veterinary Faculty. The main findings of this survey indicated that veterinary pharmacists (90%) were aware of the risks of AMR and antimicrobial residues in meat and milk when antimicrobials were used inappropriately. Nonetheless, the veterinary pharmacists sold antimicrobials to anyone, even when a customer did not present a prescription or provide relevant information. Moreover, the pharmacists did not routinely record these sales. At the same time, the majority (75%) of the veterinary pharmacists indicated that they wanted to have more education and training on the use of antimicrobials to better regulate antimicrobial sales and use.

At the national level, the SCVL tested for veterinary drug residues in imported and exported food products including milk, eggs, meat and meat products, honey, and fish. The laboratory conducted a study between 2017-2020 that looked for antimicrobial residues in food products. Of the 7,336 samples evaluated, 154 (2.10%) were positive for residues (Table 2). The following types of drug residues were detected: ivermectin, clenbuterol, penicillin, streptomycin, sulfonamides, tetracyclines, chloramphenicol, and nitrofurazone [10].

Year	Residue detected	Samples tested	Percent residue positive
2017	32	1,944	1.65%
2018	62	2,336	2.65%
2019	36	2,355	1.53%
2020	24	701	3.42%
Total	154	7,336	2.10%

Table 2: Summary of veterinary drug residues in food samples (2017-2020).

The findings of this study contributed to defining the short- and mid-term priorities for the GAVS and to establishing an AMR working group. The AMR working group developed recommendations for follow-up actions, which were discussed with AMR stakeholders.

Discussion

Collectively, these studies provide valuable information on the status of AMR regulation in Mongolia and the knowledge, attitudes, and practices of various AMR stakeholders in the agrifood system in Mongolia.

Governance

The relevant ministries (Ministry of Health and MoFALI) have supported the adoption of several regulations aimed at controlling the use of antimicrobials. Although these regulations were important unto themselves, no coordinated effort linked these regulations into a cohesive message that was fully recognized by antimicrobial users (herders and farmers) and suppliers (veterinarians and pharmacists). Moreover, the agencies (GAVS and GASI) have not been able to develop the necessary procedures and to build the capacity to enforce these regulations.

The implementation of a coordinated plan that incorporates awareness, surveillance, and governance has been hampered by competing issues that are prioritized over AMR because of their persistence and their conspicuous impact. Indeed, although AMR could spread pervasively to humans, animals, food, and the environment, it is not easily recognized without a thorough surveillance system that tests samples from various sources. As with many health initiatives, the implementation of a national action plan on AMR had been relegated to a lower priority due to the COVID-19 pandemic.

KAP Studies

Veterinary drugs were widely used in practice as livestock owners, predominantly nomadic herders, were not restricted from purchasing and administering these drugs. Consequently, no information on the quantities of antimicrobials used in the food and agricultural sectors was available. The KAP survey findings demonstrated that antimicrobial users had limited awareness of the implications of their practices. The veterinarians rarely prescribed antimicrobials. Furthermore, veterinary pharmacists did not require prescriptions to sell antimicrobials and did not record these sales.

Moreover, the quality the drugs available in the open market was in question. This finding was concerning because poor quality drugs that are only partially effective in killing infectious agents are known to contribute to the development of AMR [11]. To guard against this problem, regulations regarding the oversight of drug quality and sales should be strengthened and enforced.

Because herders and farmers administered antimicrobials with little guidance and with limited knowledge, the injudicious use of antimicrobials could increase the risk of residues in milk and meat. These practices can also lead to the development and spread of AMR to consumers and to people in contact with treated livestock and their environment.

Anecdotally, the primary concern at the time of the surveys focused more on antiparasitic drugs (e.g. ivermectin) rather than antibiotics. Several factors may account for this concern including the fact that many parasites can be detected without laboratory testing, successful treatments are easily noted, and the widespread availability of an effective drug. The emergence of resistance among parasites of veterinary importance presents an animal health challenge that potentially impacts productivity, revenue, livelihoods, and food security issues [12].

Surveillance

The testing conducted at the SCVL over a 4-year period provided evidence that antimicrobial residues were present in livestock intended for human consumption. Additional details on the kinds and types of residues identified can be helpful in developing targeted information for education and enforcement. The presence of antimicrobial residues exceeding acceptable limits in the samples indicated that antimicrobial use was inconsistent with the recommendations contained in the Codex Alimentarius [13]. However, no conclusions can be drawn about the status of antimicrobial resistant bacteria in food of animal origin. The microbiology laboratories will need training and supplies to conduct antimicrobial susceptibility tests (AST) and minimum inhibitory concentration tests (MIC) to evaluate the actual prevalence of AMR in the food supply. The veterinary and food safety laboratories will be especially vital for detecting AMR at the farm level where the uncontrolled use of antimicrobials is prevalent.

The effort to contain the development and spread of AMR in Mongolia is in its infancy. Although initial steps have been taken, such as the adoption of some regulations, these steps have not exerted a broad impact yet. A coordinated effort should be undertaken to address these limitations. In the 12 months following this study,

FAO organized the Progressive Management Pathway for AMR (PMP-AMR) [14] workshop, supported the second Multi-sectoral National Action Plan (NAP) on AMR 2022-2025, and initiated the Quadripartite National Bridging Workshop [15] to develop the Roadmap for One Health in Mongolia. The roadmap included a specific chapter on AMR/AMU. The combination of these activities formed the basis for the development of a Multi-sectoral National Action Plan on AMR 2022-2025 (MNAP-AMR). This new MNAP also integrated the recommendations contained in the action plans on AMR developed by the WHO [16], the FAO [17], and the World Organization for Animal Health (WOAH) [18]. The MNAP-AMR considered 3 interrelated areas aimed at increasing awareness, expanding surveillance, and enhancing enforcement. Of course, the ministries tasked with implementing these changes will require adequate budgets to implement the provisions in the MNAP-AMR.

In addition, the results of this investigation formed the basis for identifying activities for two new projects: 1) the Action to support implementation of Codex AMR Texts (ACT) project (ACT 20212026) funded by the Republic of Korea and 2) the One Health approach to manage AMR and AMU in Mongolia, which was financed by the Multi-partner Trust Fund for AMR 2023-2025. Furthermore, the first author presented the results of this assessment and its conclusions to a multitude of seminars, postgraduate training courses and workshops, with the aim of putting AMR/AMU on the agendas of the food and agriculture sectors.

Conclusions

The two issues of the responsible and prudent use of antimicrobials and the control of AMR were new to Mongolia. This study provided some insights on the status of AMR/AMU from different perspectives including governance, surveillance, and awareness, especially as they relate to the agrifood sector. The findings reported here were a reminder that effective containment of AMR requires the engagement of a constellation of stakeholders from government officials, to livestock producers, to consumers. The KAP study demonstrated that the stakeholders who are likely to have the greatest influence on the control of AMR will need additional resources to implement a nationwide effort to reduce the spread of antimicrobial resistance in humans, in animals, in the environment, and in food. It is anticipated that the two new projects (ACT and MPTF) will support the implementation of the Mongolian MNAP-AMR with their focus on governance, AMR surveillance, and prudent use of AMs.

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- State Central Veterinary Laboratory (SCVL)
- Institute of Veterinary Medicine (IVM)

- State Veterinary Drug Testing and Certification Laboratory (SVDTCL)
- Mongolian University for Life Sciences (MULS)
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