

Evaluation of the Antimicrobial Resistance Surveillance System in Zambian Poultry: Performance, Gaps, and One Health Policy Implications

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Abstract

Background: Surveillance of antimicrobial resistance (AMR) is a critical component of antimicrobial stewardship. Zambia recently developed and implemented AMR surveillance in layer and broiler poultry sectors. This study evaluated the AMR surveillance system used in poultry production in Zambia. **Methods:** This cross-sectional study employed qualitative methods and was conducted from September 2020 to April 2022. The evaluation was done using the Centres for Disease Control (CDC) guidelines. All responses from participants were categorised into themes. Thematic analysis was used to analyse the data that were collected from key informants. **Results:** This study found that the AMR surveillance used in poultry in Zambia is efficient and effective in monitoring the resistance profiles of specified microorganisms. The initial financing of surveillance activities was done by the Government of the Republic of Zambia through the Ministry of Livestock and Fisheries, the Flemming Fund, UK Programme and other key stakeholders. The study found that the

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AMR surveillance strategy was simple and partially flexible. However, it was not representative of the entire country as it was being conducted in five provinces out of the ten. Additionally, the data quality was affected by a lack of human and financial resources, using paper-based methods, data sharing challenges, and a lack of integration between epidemiological and laboratory data. Furthermore, AMR surveillance was not consistently implemented due to a lack of human resources and an inconsistent supply of reagents in most surveillance sites and laboratories. **Conclusion:** The AMR surveillance system used in poultry in Zambia faces challenges such as a lack of human and financial resources, inadequate data management and sharing software, and a lack of integration of the poultry surveillance system into the human health surveillance system. Therefore, there is a need to strengthen the AMR surveillance system in the poultry sector in Zambia to mitigate antimicrobial-resistant infections.

Keywords

Antimicrobial Resistance, Layer Poultry Farms, Surveillance, Zambia

1. Introduction

Antimicrobial resistance (AMR) is a global public health issue that has been worsened due to the inappropriate use of antimicrobials [1]-[3]. AMR may cause devastating effects, including negative impacts on the global economy, increased morbidity and mortality [3]-[5]. The World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) have provided guidelines for monitoring AMR in food-producing animals as a means of food security [6]. The surveillance of AMR is critical in addressing this public health problem [7]-[9]. The monitoring of AMR should encompass the entire food chain, starting from the farm, abattoir and retail level [10].

Many drivers have been reported to be responsible for the development of AMR across the One Health sectors [11]-[15]. The misuse and overuse of antimicrobials across human and animal populations have been identified as contributing factors [16]-[20]. In poultry, most antimicrobials have been used for growth promotion, improving production, disease prophylaxis, and treatment [21]-[25]. This has continued to expose gut and environmental microorganisms to antimicrobials, thereby promoting the development and spread of AMR [23] [26]. The surveillance of AMR in low-and middle income countries (LMICs) such as in most African settings, has been reported to be affected by many challenges which include limited resources, inappropriate use of antimicrobials, lack of diagnostic services, increased empiric use of antimicrobials, shortage of staff, weak enforcement of regulations on antimicrobial usage, and lack of awareness of AMU and AMR [27]-[32].

Tackling AMR requires a “One Health” approach because there is an interac-

tion between animals, humans, and the environment [33]-[36]. Due to the AMR challenge, the WHO recommended that all member countries develop and implement National Action Plans (NAPs) on AMR in line with the Global Action Plan (GAP) on AMR [34]. Additionally, WHO member countries were encouraged to reinforce the surveillance of AMR by establishing integrated AMR Surveillance systems [37]-[39]. This would ensure the integration of tackling AMR in humans, animals, and the environment [40]-[43].

The Zambian Government, through the Zambia National Public Health Institute (ZNPPI), with support from various partners, developed the Multisectoral National Action Plan (NAP) on AMR [44]. The NAP was developed as a tool to monitor AMR in humans, animals, plants, and the environment [44]. Zambia continues to face drug-resistant pathogens across the One Health continuum, as evidenced by many studies [45]-[49]. Zambia developed and implemented the AMR poultry surveillance system in 2020. However, there is little information on the efficiency and effectiveness of the surveillance system used for monitoring AMR in the poultry production in Zambia. Consequently, there has never been an evaluation of the AMR surveillance system used in poultry populations in Zambia. Therefore, this study evaluated the AMR surveillance system used in the poultry sector in Zambia.

2. Materials and Methods

2.1. Study Design, Site and Population

This cross-sectional study was conducted among key informants involved in the development and implementation of the AMR surveillance system used in poultry populations in Zambia. This study employed qualitative methods and was conducted from September 2020 to April 2022. To be eligible, a participant should have participated in the development and implementation of the AMS surveillance system. At the time of evaluation, surveillance activities were implemented in five provinces (Lusaka, Southern, Eastern, Copperbelt, and Western), with plans for national scale-up

2.2. Sample Size and Sampling Criteria

This study used a sample size of twelve (12) key informants who were involved in the development and implementation of the AMR surveillance system used in poultry populations in Zambia. The participants were selected using purposive sampling method including those that were from the University of Zambia (involved in the development of the tool and its implementation; involved in processing sample collection, processing, analysis, and data entry), the Centre for Infectious Disease Research in Zambia (CIDRZ) (providing resources and monitoring the surveillance system), The Food and Agriculture Organization of the United Nations (FAO), Antimicrobial Resistance Coordinating Committee (AMRCC), the Ministry of Fisheries and Livestock (representing the government), and one from the Central Veterinary Research Institute (CVRI).

2.3. Data Collection

Data were collected using semi-structured interviews guided by the CDC surveillance evaluation framework. Interviews lasted 45 - 60 minutes and were conducted by the principal investigator. Responses were recorded through detailed note-taking and subsequently transcribed verbatim. The evaluation of the surveillance system used to monitor AMR in poultry was accomplished using the CDC guidelines [50]. The interviews were structured as follows: 1) Public health importance of AMR; 2) Purpose and operation of the surveillance system; 3) Resources needed to operate the surveillance system; 4) Credible evidence of the surveillance system used to monitor: usefulness of surveillance; Simplicity; Flexibility; Data quality; Acceptability; Sensitivity; Positive predictive value; Representativeness; Timeliness; Stability; and Lessons Learnt. The interviews took approximately one hour per participant.

2.4. Data Analysis

Thematic analysis was used to analyse the data following an inductive approach. Firstly, the principal investigator went through all the responses (reviewed repeatedly) that were provided by the key informants and made corrections within 24 hours of collection. This was done for familiarisation with the submitted responses. Secondly, the principal investigator read through all the responses carefully and analysed them to make meaningful statements. This was followed by aggregating the meanings of the responses into themes. Codes were generated and grouped into themes aligned with CDC surveillance attributes. To enhance rigour, themes were reviewed iteratively for consistency and coherence. Given the small number of expert participants, thematic saturation was considered achieved when no new themes emerged. Eventually, the developed themes were checked and connected to the interview to obtain a complete description.

The next step involved the identification of the fundamental structure in which two pathways were identified to give a description of the AMR surveillance system in layer poultry production in Zambia: *i.e.*, the performance of the AMR surveillance system and the needed interventions to improve the surveillance of AMR in layer poultry production in Zambia.

Lastly, the principal investigator went through the responses for validation and cleaning. This involved verification and revisions, if necessary, of the responses.

2.5. Evaluation Framework

The evaluation followed CDC guidelines for surveillance system assessment. Each attribute (usefulness, simplicity, flexibility, data quality, acceptability, representativeness, timeliness, and stability) was assessed based on qualitative evidence from key informants, supported by examples from system operations. Attributes such as sensitivity and positive predictive value could not be quantitatively assessed due to the absence of numerical surveillance data and were therefore interpreted cautiously based on qualitative insights.

3. Results

The following results were obtained from the evaluation of the surveillance system used in poultry in Zambia based on the CDC evaluation guidelines.

3.1. Stakeholders

According to the current Zambian Protocol for surveillance of AMR in poultry populations, the stakeholders include poultry farmers, the general public, the United Kingdom through the Fleming fund grant, Africa Center of Excellence for Infectious Diseases of Human and Animals (ACEIDHA), AMRCC of the Zambia National Public Health Institute (ZNPPI), Ministry of Fisheries and Livestock, Ministry of Health, Government Animal Health (Veterinary Services), Department of Veterinary Services (DVS), Zambia Medicines Regulatory Authority (ZAMRA), FAO, WHO, Civil Society Organizations, and implementers of the surveillance programme in poultry, the University of Zambia - School of Agricultural Sciences, and the University of Zambia - School of Veterinary Medicine.

3.2. System Description

1) *Public Health Importance of AMR*

Poultry production is very important to the Zambian population as a source of income and nutrition in the form of proteins. Most Zambian poultry farmers rear broiler chickens, and a few of them keep layer chickens, which are sources of meat and eggs. However, the overuse and misuse of antimicrobials in poultry production and the evolution of resistant genes in bacteria have contributed to the development of AMR [51]-[56]. The consequences of AMR include a burden on the economy, a negative impact on food security and livelihood, difficulties or impossibilities in treating infectious diseases, and increased morbidity and mortality in humans [3]. It has been estimated that there will be approximately 10 million human deaths globally by 2050 if AMR is not addressed soon [57]. The sub-Saharan African region, where Zambia belongs, reported 235,000 human deaths attributed to AMR in 2019 [28]. According to the Zambia Poultry AMR Surveillance Protocol of 2020, an estimated 80% of Zambian poultry farmers do not have access to the District Veterinary Services, which may promote personal and peer experiences in accessing and administering poultry antibiotics. Besides, the high demand for chickens and their products (meat and eggs) may promote an increase in the use of antibiotics, some of which are of concern to human health. There were also concerns about the potential risks of chickens, compared to other livestock species, being a significant contributor to AMR in humans.

2) *Purpose and Operation of the Surveillance System*

In 2015, the WHO developed the GAP on AMR in collaboration with FAO and WOAHA [34]. The purpose of the GAP on AMR was to tackle the ever-growing problem of AMR. The tripartite organisations recommended that all nations develop and implement their NAPs in line with the GAP on AMR [34]. Additionally, there was a need for the fight against AMR using a One Health approach to be

well coordinated and complementary [37].

The Zambian Government developed and implemented the NAP on AMR in 2017 to address AMR using a One Health approach [44]. This was followed by developing and implementing the Integrated Antimicrobial Resistance Surveillance Framework in 2020 to strengthen the fight against AMR using a One Health approach [58].

In 2020, the Zambian government developed a protocol for surveillance of AMR in poultry populations in Zambia for the period 2020-2027. The protocol was developed in line with the Zambian NAP on AMR 2017-2027. The protocol focused on randomly sampling broiler and layer poultry farms across the country using active and passive surveillance, and samples processed from the Central Veterinary Research Institute (CVRI) in Chilanga for all samples collected from the Southern region of Lusaka province. Other laboratories included the Eastern Regional Veterinary Laboratory in Chipata, the Western Regional Veterinary Laboratory in Mongu, the Southern Regional Veterinary Laboratory in Choma, the Northern Regional Veterinary Laboratory in Kasama, and the University of Zambia - School of Veterinary Medicine, Public Health and Microbiology laboratories. With CVRI serving as a reference laboratory for AMR in animal health, the data collected from all the satellite laboratories were to be aggregated by CVRI to make decisions and interventions to reduce AMR.

The purpose of the surveillance system in poultry is to provide actionable information on AMR in Zambia that informs policy direction and contributes to understanding the risks to human health associated with using antimicrobials in poultry. The objectives of the protocol on surveillance of AMR in poultry populations in Zambia, 2020-2027, include:

- 1) To estimate prevalence, assess trends and sources of resistance to targeted antibiotics amongst priority zoonotic bacteria in market-ready broilers and layers sold for meat;
- 2) To identify possible risk factors driving AMR in poultry that may influence the transmission of AMR bacteria to humans.
- 3) To generate the data necessary for conducting risk analyses as relevant to animal and human health;
- 4) To detect the emergence of new AMR mechanisms;
- 5) To provide information for evaluating antimicrobial prescribing practices and for prudent use recommendations;
- 6) To assess and determine the effects of actions to combat AMR, and
- 7) To share AMR surveillance data through the “One Health” approach.

With these set objectives, the surveillance system aims to monitor AMR across the country, but in a phased manner, starting with poultry-rich provinces. The rationale for this was that there was more usage of antimicrobials in the poultry sector compared to other sectors.

The protocol emphasises the use of both active and passive surveillance strategies, though initially only active surveillance was implemented. The protocol rec-

ommends the probabilistic method of sampling broilers and layers in active surveillance. This is done through farm visits by the surveillance team and the district veterinary assistants. However, a shortage of human and financial resources affects this surveillance mode (Key informant #1). Additionally, there has been a disconnect between the poultry farmers and district veterinary personnel, forcing the farmers to hesitate to participate in the surveillance programme (Key informant #1). Unfortunately, passive surveillance has usually not been helpful because very few farmers visited veterinary offices or clinics to take their sick chickens for disease diagnosis or consult on antibiotic use for their chickens (Key informant #2).

Objective five (5) emphasises evaluating the prescribing practices and prudent use of antimicrobials. However, there are no standard treatment guidelines (STGs) to standardise the prescribing of antimicrobials in poultry and promote their prudent use (Key informant #1).

To achieve the objectives of the surveillance system, there was a need to do further analysis of the collected data to make it adequate and meaningful (Key informants #2 and #3).

3) Resources Needed to Operate the AMR Surveillance System used in poultry

The Fleming country grant on surveillance of AMR in poultry in Zambia was being managed by a consortium including the Centre for Infectious Disease Research in Zambia (CIDRZ), Program for Appropriate Technology in Health (PATH), and the University of Zambia - School of Veterinary Medicine. Additionally, some resources come from other stakeholders such as the FAO, Ministry of Health, Ministry of Fisheries and Livestock, Zambia Medicines Regulatory Authority (ZAMRA), and Department of Veterinary Services (DVS). The Ministry of Fisheries and Livestock, the Ministry of Health, CIDRZ, DVS and the University of Zambia/ACEIDHA were the significant contributors of personnel involved in data collection, processing, and analysis.

3.3. Evaluation Design of the AMR Surveillance System in Poultry Populations in Zambia

The purpose of this evaluation was to evaluate the performance of the AMR surveillance system in poultry populations in Zambia.

1) Credible Evidence

a) The Usefulness of Information Collected by the Surveillance System

The surveillance system on AMR in poultry in Zambia is very useful and provides information on the resistance patterns of priority pathogens such as *E. coli*, *Enterococcus* spp, *Campylobacter* spp, and *Salmonella* spp. Additionally, the surveillance protocol provides procedures for collecting epidemiological data that can be used to map farmers and identify the risk factors associated with AMR in poultry. By doing so, the AMR surveillance system in poultry contributes to achieving the objective of the Zambian NAP on AMR objectives, in particular the

objective “to strengthen knowledge through surveillance and research”.

2) Surveillance System Attributes

The evaluation of the Antimicrobial Resistance Surveillance System in Poultry in Zambia is crucial for understanding its effectiveness in addressing the growing challenge of AMR. Given the significance of poultry as a key component of the country’s food security and economic development, this assessment will focus on the system’s attributes as follows:

b) Simplicity:

The surveillance system of AMR in poultry was simple, as the procedures were outlined in the protocol (Key informant #1).

I would say the AMR surveillance system was simple, as the survey focused on the broiler and layer poultries (Key informant #2). We concentrated very much on active surveillance, but we needed to consider improving the awareness of farmers so that they could increase reporting and take their sick chickens to the veterinary clinics or authorities, thereby promoting passive surveillance (Key informant #2).

The surveillance system used for monitoring AMR in poultry was quite simple since it is a national surveillance; people have always been assigned to monitor all the activities (Key informant #3).

The surveillance system to monitor AMR in broiler and layer poultries was simple because we were trained before beginning the program (Key informant #4). The data collection process, reporting, and analysis were simple to do. Once we collected the samples, laboratory analysis was done using standard operating procedures that were simple to follow. In addition, the obtained results were entered in WHONET for analysis and later shared with CIDRZ and ZNPHI (Key informant #4).

c) Flexibility:

The surveillance system has been flexible because the different surveillance sites can operate without supervision (Key informant #1, 5 and 6).

The initial plan was to work with a paper-based system, which proved to be challenging in some situations (Key informant #2). We planned to change to digital data collection and reporting and piloted the Epicollect5 (<https://five.epi-collect.net/>) software for data collection, which we shall try to implement in the next phase of the surveillance project (Key informant #2).

As it stands, the surveillance system of AMR in poultry in Zambia was conducted manually using a paper questionnaire (Key informants #3, 4, and 12). This makes adding new information or questions to the surveillance data collection tools difficult. However, we planned to conduct surveillance twice a month at two seasons of the year and amend the protocols and SOPs when necessary (Key informant #3).

The surveillance system was flexible in that we could even add other microbes to the list of the initially targeted microbes for surveillance (Key informant #4). This is also true for the listed diseases in the data collection tool, in which the

farmers could report any other diseases they experienced in their poultry farming (Key informant #4).

d) Data quality:

We were doing our very best to ensure that we collected, analysed, reported, and shared good-quality data, but sometimes, the data quality was affected by challenges we faced regarding human and financial resources (Key informant #1).

Data quality was affected by factors such as a lack of registers with lists of poultry farmers, no proper structure to identify poultry farmers, and fewer farmers on the ground than what was estimated (Key informant #2).

Our data quality was fair. We needed much improvement in the next phase of the surveillance programme (Key informant #3). Sometimes, there were discrepancies in the results because, in some surveillance sites, antibiotics from those listed on the panels to use were missing, affecting the standardisation of the results (Key informant #3). Sometimes we ran out of key antibiotics discs to complete the panel, leading to incomplete data for some isolates (Key informant #4).

Since the inception of the AMR surveillance system used in broiler and layer poultry farming, we were using paper-based data collection and reporting, which usually delayed the entire process and affected the quality of the collected data (Key informants #4, 7, and 8). Due to the challenges associated with paper-based questionnaires, our laboratory data were not integrated with the epidemiological data (Key informant #4).

e) Acceptability:

Regarding acceptability, the AMR surveillance system in poultry populations was owned by the Government of the Republic of Zambia. Some stakeholders, such as CIDRZ and UNZA, had high acceptability of the surveillance system and were doing much work to see that the programme succeeded (Key informant #1).

Most farmers were willing to work with and allow epidemiological data and sample collection without challenges. However, some farmers did not cooperate with the surveillance team as they never received feedback from the surveillance team (Key informants #2, 3, 4, and 12).

So far, our stakeholders have received excellent feedback, with many of them who accepted and were willing to support the surveillance of AMR in poultry (Key informants #3 and #4).

Therefore, there was variability regarding the acceptability of the AMR surveillance system used in the poultry production in Zambia.

f) Sensitivity:

The AMR surveillance data were not adequate to give insights into sensitivity. Therefore, further analysis and collection of more data in the second phase of the implementation of the surveillance programme would be required to determine the sensitivity of the AMR surveillance system used in poultry production (Key informants #1, #2 and #3). Despite this limitation, the robustness of the AMR surveillance system is able to identify changes in AMR trends at the data collection point, like poultry farms (Key informant #3).

The AMR surveillance system was established in 2020 and implemented towards the end of 2020 (Key informant #4). It has been difficult to monitor trends in AMR over time until we complete the second phase of the project and use the results to compare with the findings of the first phase of implementation (Key informant #4).

g) Positive Predictive Value:

The predictive value of the current surveillance system was difficult to determine based on the collected data, which required further analysis. Hence, the participants recommended further investigations in the future (Key informant #1, #2, #3 and #4).

h) Representativeness:

The AMR surveillance system was established to monitor AMR in all poultry populations across all ten (10) provinces of Zambia (Key informant #1-12). However, the Fleming grant at the time of the evaluation only supported the monitoring of AMR in poultry in five provinces, namely, Lusaka, Southern, Eastern, Cop-perbelt and Western (Key informant #1-12). Therefore, the current surveillance system was not implemented across the country.

In poultry, we collected data from more broiler farmers compared to layer farmers from the five (5) provinces so far (Key informant #3). Therefore, we planned to expand the scope and recruit more layer farmers nationwide.

The representativeness of the poultry birds was limited to broiler and layer chickens (Key informants #4, 7, 8, 9).

i) Timeliness:

The timeliness of our AMR surveillance system was slow due to the use of paper-based methods in data collection (Key informants #1 and #2).

The paper-based method of data collection sometimes caused the loss of some epidemiological data, leading to a disconnection between the epidemiological data and laboratory findings or a delay in linking epidemiological data and laboratory data (Key informant #1, #2, #3 and #4).

j) Stability:

All in all, the stability of the AMR surveillance system used in poultry was affected by a lack of trained human resources and transfers of the few available staff (Key informants #1, #2, #3, and #4). This is because we needed adequately trained human resources for data collection, reporting, and analysis. However, most sites had few data collectors and usually one or two staff working on all laboratory samples (Key informant #1).

3.4. Summary of the Findings of the AMR Surveillance System Attributes in Zambia

Table 1 provides a consolidated assessment of the key attributes of the antimicrobial resistance (AMR) surveillance system in poultry in Zambia, based on CDC evaluation criteria. Overall, the findings indicate that while the system demonstrates strong foundational value, its effectiveness is constrained by operational

and structural limitations.

1) Usefulness - High

The surveillance system is highly useful as it generates critical data on AMR patterns in priority pathogens such as *E. coli*, *Salmonella*, and *Campylobacter*. This supports:

- Evidence-based policymaking
- Monitoring of resistance trends
- Contributions to the national AMR action plan

Interpretation: The system fulfils its core purpose and is valuable for public health decision-making.

2) Simplicity - Moderate

Although standard operating procedures (SOPs) exist and the system is relatively easy to implement, resource constraints (human and financial) reduce operational simplicity.

Interpretation: The system is conceptually simple but practically constrained.

3) Flexibility - Limited

Flexibility is restricted mainly due to reliance on paper-based data collection tools, which:

- Make it difficult to modify data collection forms
- Slow adaptation to new surveillance needs

Interpretation: The system cannot easily evolve in response to emerging AMR priorities.

4) Data Quality - Moderate

Data quality is affected by:

- Reagent shortages (incomplete laboratory testing)
- Paper-based systems (errors, delays, data loss)

Interpretation: While usable, the data are not consistently reliable or complete.

5) Representativeness - Low

Surveillance is conducted in only five out of 10 provinces, with:

- Overrepresentation of broiler farms
- Limited inclusion of other poultry types

Interpretation: Findings cannot be generalised to the entire country.

6) Timeliness - Low

The use of paper-based systems leads to:

- Delayed data reporting
- Poor linkage between epidemiological and laboratory data

Interpretation: The system is slow, reducing its usefulness for real-time decision-making.

7) Stability - Low

System stability is compromised by:

- Staff shortages
- Frequent reagent stock-outs
- Dependence on external funding

Interpretation: The system is vulnerable to interruptions and not sustainably robust.

The AMR surveillance system in poultry in Zambia is functionally valuable but operationally fragile. While it successfully generates important AMR data (high usefulness), its performance is undermined by limited geographic coverage, weak data systems (paper-based), resource constraints (staff and reagents), and poor system integration.

Notably, the system provides a strong foundation for AMR surveillance, but requires significant strengthening in infrastructure, digitalisation, workforce capacity, and national coverage to achieve full effectiveness.

Table 1. Summary of surveillance system attributes.

Attribute	Assessment	Key Evidence
Usefulness	High	Generates AMR data for priority pathogens
Simplicity	Moderate	SOPs exist, but resource constraints
Flexibility	Limited	Difficult to modify paper tools
Data Quality	Moderate	Affected by missing reagents, the paper system
Representativeness	Low	Only 5 provinces
Timeliness	Low	Delays from paper-based reporting
Stability	Low	Staff shortages, reagent stock-outs

3.5. Lessons Learned

- 1) Active AMR surveillance is costly to implement and can pose a challenge in resource-limited countries.
- 2) Inadequate use of the ITC tool, such as an electronic questionnaire, affected data quality and efficiency.
- 3) Frequent transfer of laboratory staff mentored in AMR surveillance affected the sustainability of the surveillance programme.
- 4) Providing feedback to the poultry farmers regarding the AMR results would increase their confidence and participation in surveillance activities.

4. Discussion

This study aimed to evaluate the AMR surveillance system used in poultry populations in Zambia. The objective of this study was in line with the GAP on AMR objective number two (2), which aims to strengthen the knowledge and evidence base through surveillance and research, and objective number four (4), which aims to promote the use of antimicrobials in human and animal health [34]. Evaluating AMR surveillance systems frequently is important so that their performance is known, monitor the quality of data and information collected, and help with efficient allocation of surveillance resources [59]. Further, adequate surveillance provides a basis for evidence-based antimicrobial stewardship programs and interventions.

This was the first evaluation of the AMR surveillance system used in Zambia's broiler and layer poultry production. The current evaluation found that the AMR surveillance system used in poultry was owned and implemented by the Government of the Republic of Zambia and supported by many stakeholders that included poultry farmers, the general public, the United Kingdom through the Fleming fund grant, ACEIDHA, ZNPHI, Ministry of Fisheries and Livestock, Ministry of Health, Government Animal Health (Veterinary Services), Department of Veterinary Services (DVS), Zambia Medicines Regulatory Authority (ZAMRA), FAO, WHO, Civil Society Organizations, and implementers of the surveillance programme in poultry, the University of Zambia - School of Agricultural Sciences, and the University of Zambia - School of Veterinary Medicine. Additionally, the study found that the surveillance system was very useful and provided vital information on the resistance patterns of priority pathogens such as *E. coli*, *Enterococcus* spp, *Campylobacter* spp, and *Salmonella* spp. Additionally, the surveillance protocol provided procedures for collecting epidemiological data that can be used to map farmers and identify the risk factors associated with AMR in poultry. Further, developing standard treatment guidelines for poultry use would be essential in curbing AMR. Furthermore, the findings of the current evaluation suggest that there is a need for urgent improvement in human resources, funding, interval data collection, data quality, and frequent review of the protocol on AMR surveillance used in poultry populations in Zambia, 2020-2027. This is consistent with findings by Caudell et al, who stated that the realities of underfunded veterinary healthcare systems constrain efforts to promote prudent antimicrobial use and AMR control [60].

The findings of this study demonstrate the importance of stakeholders as collaborators in the success of a surveillance system. Similar findings were reported in other studies, which showed that stakeholders might contribute to the success of a surveillance system [61] [62]. Additionally, the present study showed that the AMR surveillance system comprises a multi-disciplinary team with personnel from different sectors. This aligns with the GAP on AMR, which recommends a holistic multi-disciplinary approach in the fight against AMR [34]. Moreover, the multi-disciplinary approach may promote the integration of animal health AMR surveillance into human health AMR surveillance, promoting the One Health approach.

Our study demonstrated that the surveillance system is useful in monitoring the AMR patterns of pathogens isolated from poultry populations such as broiler and layer chickens. In Colombia, establishing the Colombia Integrated Program for AMR Surveillance in poultry farms, slaughterhouses, and retail markets was critical in identifying pathogens found in poultry products and characterising their resistance patterns [61]. Additionally, AMR surveillance in food-producing animals is critical and promotes the analysis of AST data to monitor trends in resistance patterns of microorganisms to antimicrobials used in human and animal health [62]. In addition, point-prevalence surveys can also be beneficial in

monitoring and documenting AMR trends in poultry and other livestock animals [63]. This is important in decision-making to derive appropriate measures that reduce the development of AMR.

This study found gaps in the attributes of the surveillance system used in Zambia's broiler and layer poultry production. Despite being reported to be simple, the inadequacy of human resources, funding, being paper-based and a lack of harmonisation in the participating laboratories may impair the simplicity of the surveillance system. In Zambia, it has been established that there is a lack of human resources required to achieve the needed workforce in animal health [44]. This can affect disease diagnosis, veterinary extension services in poultry farms, and AMR surveillance [44]. Establishing AMR surveillance programmes in poultry requires adequate financial and human resources [61]. A study conducted in Tanzania found that the AMR surveillance system used in poultry was not simple regarding manual data collection and reporting, which was worsened by inadequate resources required to simplify these data management [64]. A European survey including 27 countries also reported that most participating countries lacked dedicated resources for surveillance and no harmonisation between laboratories [62]. Another study across six countries reported a lack of standardisation and harmonisation with the AMU data sources, laboratory methods used, interpretation of AMU and AMR data, and evaluation methods adopted [65]. This may affect the surveillance system in achieving the set objectives [62]. Lack of standardisation and harmonisation may provide misleading results and affect surveillance evaluations and decision-making [66].

This study also found that the current AMR surveillance system used in poultry was not very flexible because, since its implementation, all procedures have been based on the protocol developed in 2020 and have not been reviewed. Alongside this, it was difficult to add new information to the protocol, epidemiological data collection tools, and laboratory SOPs. Further, since the current AMR surveillance system is inclined more toward broiler chickens and, to a lesser extent, to layer chickens, it is not as flexible as the other poultry populations, like geese, turkeys, village chickens, and pigeons, have been left out. Furthermore, the few targeted microbes (*E. coli*, enterococci, *Salmonella* spp, and *Campylobacter* spp) leave out other potential pathogens that can cause severe infections and increase morbidity and mortality in poultry and humans. This study's findings are similar to those reported in Tanzania, where animal surveillance was observed not to be flexible and had various versions of reporting data [64].

The present study also found that the data quality was fair but required improvement to produce and share good data. The data quality was affected by inadequate resources, a lack of farmer registers for easy identification of poultry farmers, and the paper-based system, which delays data collection and reporting. A lack of databases has also been identified as a challenge that affects data quality. Similar findings have been reported in which data management and analysis appear to be a weakness in most AMR surveillance systems in some countries [62].

This is because some countries do not have efficient data management tools, such as data extraction and cleaning tools, invalid or incomplete metadata, and cannot store collected isolates in the monitoring system [62]. The data quality is further weakened by poor information sharing and communication mechanisms among collaborators [67].

The AMR surveillance system has been well accepted among implementers and all stakeholders. The study found that stakeholders were willing to support the AMR surveillance system in poultry production. However, the government should lead in promoting and supporting the system. A study reported that a surveillance system's success depends on the political will of the government [62]. The high acceptance of a surveillance system occurs when stakeholders know its usefulness [64]. In Tanzania, despite the partially acceptable animal surveillance system, stakeholders realised its usefulness in collecting data that informed national authorities on disease magnitudes in the animal sector [64].

The current study also found that the AMR surveillance system in broiler and layer poultry production was only being done in five (5) provinces of Zambia, with plans of rolling it out to the rest of the country. Therefore, AMR surveillance in poultry production in Zambia was not country-representative at the time of the study and evaluation. Similarly, a lack of country representation has been reported to be a significant weakness of AMR surveillance in food-producing animals [62]. On the contrary, a study in Tanzania reported that the surveillance system covered the whole country geographically and represented the entire animal population [64].

The current study found that the timeliness of the AMR surveillance system used in poultry production was slow because of delays in paper-based methods used in data collection, analysis and incomplete data sets. Delays in data reporting have also been reported to be a challenge that affects many countries [62]. The paper-based methods affected timeliness because it usually leads to incomplete data sets, which may affect a surveillance system [64].

This study has shown that the stability of the AMR surveillance system used in broiler and layer chickens is affected by inadequate human resources for data collection, reporting, and analysis. Many sites have few human resources handling huge samples, which is likely to affect data quality. Similarly, the animal health surveillance system was reported not to be stable in Tanzania due to the transfer of data breakdown and the system being manual [64].

Developing and implementing standard treatment guidelines in poultry would improve the treatment outcomes of various diseases. This would promote food security and prevent further occurrences of AMR. Recently, Zambia developed STGs for the animal sector, indicating progress in the right direction to promote the rational use of antimicrobials and address AMR [68]. Like in human health, standard treatment guidelines are very important in disease diagnosis, drug selection, dosage and duration of treatment. This means that all professionals involved in the prescribing of medicines follow a particular standard (evidence-based pre-

scribing) which prevents deviation from the recommended practices and meets the fourth (4th) objective of the GAP and NAP on AMR [34] [44]. A study in Australia reported on the importance and need for treatment guidelines in poultry and their benefits in ensuring that if antimicrobials are needed, then the right drug should be prescribed, right done, right duration, right time, and right route [69]. Alongside this, the guidelines may help in prescribing lower-rating or narrow-spectrum antimicrobials [69]. Alongside this, the treatment guidelines are also critical in recommending the use of vaccinations rather than administering antimicrobials [69].

Study Limitations and Strengths

This study had several limitations. First, the sample size was small and limited to 12 key informants involved in the development and implementation of the AMR surveillance system, which may not fully capture all perspectives across institutions. The purposive sampling approach may introduce selection bias. Additionally, findings were based on self-reported experiences, which may be subject to recall bias. The qualitative design limits quantification of surveillance performance metrics. Furthermore, the absence of triangulation with quantitative surveillance data constrained the validation of some findings. This study provides in-depth insights into the performance of the AMR surveillance system in poultry in Zambia from the perspective of key stakeholders involved in its design and implementation. The use of qualitative methods enabled detailed exploration of system attributes, operational challenges, and policy implications. The study contributes valuable evidence to inform the strengthening of AMR surveillance systems within a One Health framework.

The policy recommendations and practice implications are shown in **Table 2**. The study identifies key policy actions needed to improve poultry health and antimicrobial practices in Zambia. Strengthening veterinary extension services and developing poultry-specific treatment guidelines will reduce farmer reliance on self-medication and promote rational antimicrobial use. Regulating over-the-counter antibiotic sales and enhancing AMR/AMU surveillance systems are essential for controlling misuse and improving data quality. Regular farmer training, improved feedback from researchers, and investment in biosecurity infrastructure will support better disease prevention and safer antimicrobial practices. Integrating One Health principles across policies will further enhance coordinated AMR control efforts in the poultry sector.

The identified operational gaps have important implications for surveillance effectiveness. Paper-based reporting contributes to delays in data capture, analysis, and dissemination, thereby limiting timely decision-making. Reagent shortages result in incomplete laboratory testing, reducing data completeness and comparability across sites. Limited human resources constrain both field data collection and laboratory processing capacity, affecting coverage and consistency. Furthermore, weak integration between epidemiological and laboratory data limits

the ability to link resistance patterns with risk factors, thereby reducing the usefulness of surveillance outputs for targeted interventions and policy formulation. These challenges collectively reduce the system's ability to generate actionable evidence for antimicrobial stewardship and One Health decision-making.

Table 2. Policy recommendations, practice implications, and key stakeholders.

Policy Recommendation	Rationale/Problem Addressed	Practice Implications	Key Stakeholders
1. Strengthen nationwide veterinary extension services	Limited or no access to veterinary personnel; farmers rely on self-medication	Improved disease diagnosis, proper antimicrobial use, and reduced misuse	Ministry of Fisheries & Livestock (MFL); District Veterinary Offices; Veterinary Associations MFL; Zambia
2. Develop poultry-specific antimicrobial treatment guidelines	Lack of standardised treatment protocols; inconsistent dosing	More rational antimicrobial use; better management of poultry diseases	Medicines Regulatory Authority (ZAMRA); Veterinary Schools/Training Institutions
3. Regulate and monitor the over-the-counter sale of antimicrobials	Easy access to antimicrobials without a prescription leads to misuse	Ensures responsible access; reduces self-medication and inappropriate dosing	ZAMRA; Veterinary Drug Outlets; Agrovet Retailers
4. Strengthen AMR and AMU surveillance systems in poultry farms	Weak reporting systems; inadequate sample feedback to farmers	More accurate data for policy; improved farm-level AMR awareness	Zambia National Public Health Institute (ZNPHI); MFL; Research Institutions
5. Establish routine farmer training and capacity-building programs	Farmers lack knowledge of dosing, withdrawal periods, and biosecurity	Increased adherence to good practices; reduced antibiotic residues and resistance	Extension Officers; NGOs; Farmer Cooperatives; Training Providers
6. Improve communication and feedback mechanisms between researchers and farmers	Farmers report a lack of feedback on surveillance results	Enhances trust, awareness, and collaboration in surveillance programs	Research Institutions; Universities; ZNPHI; MFL
7. Promote biosecurity infrastructure support for small and medium poultry farms	Poor biosecurity practices contribute to the disease burden and AMR	Reduced disease outbreaks; decreased antimicrobial use	Local Governments; NGOs; Farmer Associations
8. Integrate One Health principles into poultry production policies	Human-animal-environment interactions accelerate AMR	Holistic AMR mitigation; coordinated surveillance across sectors	MFL; Ministry of Health; Ministry of Environment; One Health Committees

5. Conclusion

This study identified key strengths and gaps in the AMR surveillance system in the poultry sector in Zambia. While the system is useful and relatively simple, it is constrained by limited geographic coverage, inadequate resources, and weak data integration. Strengthening surveillance capacity, improving data systems, and enhancing One Health coordination are essential to improve the effectiveness of AMR surveillance and inform policy and practice.

Ethical Consideration

We obtained ethical approval from the ERES Converge of Zambia (approval ID of Ref No. 2019-Dec-004). Furthermore, regulatory approval was obtained from the National Health Research Authority (NHRA). All participants were informed about the purpose of the study and provided informed and written consent to be part of the study.

Recommendations

1) Enhance Government Commitment and Funding: The Government should fully support and fund the national AMR surveillance system in broiler and layer poultry production. Relevant departments should integrate AMR activities into annual plans to reduce reliance on external funding.

2) Expand Surveillance Coverage: Broaden the scope of AMR surveillance to include more geographical areas, poultry value chains, and production systems to obtain comprehensive national data.

3) Strengthen Laboratory and Human Resource Capacity: Establish provincial veterinary laboratories and recruit additional trained animal health personnel to improve sample processing, data quality, and overall surveillance efficiency.

4) Build Technical Capacity and Retain Skilled Staff: Provide continuous training in data collection, analysis, and reporting, while minimising staff transfers to maintain expertise in AMR surveillance activities.

5) Improve Data Management and Communication: Develop robust digital systems for data collection and sharing, conduct in-depth (including molecular-level) analyses, and regularly disseminate resistance trends and risk factors to farmers and stakeholders.

6) Develop and Update Poultry Treatment Guidelines: ZAMRA, the Veterinary Council of Zambia, the AMRCC, and the Ministry of Fisheries and Livestock should collaborate to develop and periodically review standardised treatment guidelines for poultry use, ensuring they reflect current resistance patterns and production dynamics.

Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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