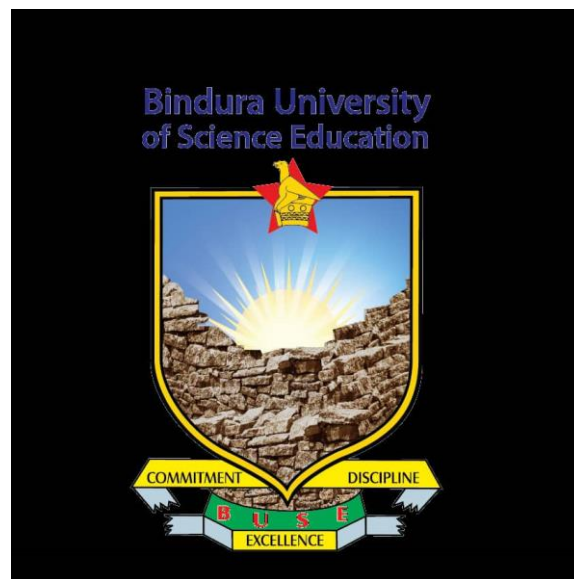


Antibiotic residues in milk, poultry and beef from informal traders and implications on food security: A case of Mutare and Mutasa Districts of Manicaland Zimbabwe

A dissertation submitted in partial fulfilment of the requirements for the Master of Science Degree in Food Security and Sustainable Agriculture (Production)

BINDURA UNIVERSITY OF SCIENCE EDUCATION



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Declaration

I hereby declare that the research project entitled “**Antibiotic residues in milk, poultry and beef from informal traders and implications on food security: A case of Mutare and Mutasa Districts of Manicaland Zimbabwe**” submitted to Bindura University of Science Education, Department of Agricultural Economics, Education and Extension is a record of an original work done by me under the guidance and supervision of **Dr. A.C. Mujeyi** and this work is submitted in partial fulfilment of the requirements for the award of a Master of Science Degree in Food Security and Sustainable Agriculture. The results embodied in this thesis have not been submitted to any University or Institute for the award of any degree or diploma.

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Dedication

Dedicated to the Almighty God.

Acknowledgements

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Abstract

Food security has been compromised due to the presence of antibiotic residues in food of animal origin. Antibiotic residues are directly harmful to those that consume antibiotic contaminated food, and cause antibiotic resistance in both people and animals. The problem of antibiotic residues in food is very serious but yet is poorly studied and its magnitude is not objectively outlined in Zimbabwe. A cross-sectional study was done in Manicaland Province of Zimbabwe in 2024 on beef, milk and poultry meat sold informally, to determine prevalence of antibiotic residues and antibiotic residues were found to contaminate 62% (104, n=168) of the samples tested. Tetracyclines were the most common antibiotic residues affecting 79/168 samples, followed by penicillins at 53/168 samples and then other antibiotics at 30/168 samples. The most common antibiotic in beef and poultry was tetracycline (49% and 53% respectively). For milk penicillins were the most common antibiotic residues (45%). Antibiotic access system was found to be compromised at the level of antibiotic retail outlets, antibiotic regulation and poor farmer antibiotic use practises and attitudes. Drug retail outlets are operated mostly by unqualified persons and the acquisition of prescription items is almost free, whilst the veterinarians are not well capacitated to provide the best antibiotic stewardship and management practises to farmers. Farmer antibiotic practises were found to be unguided, antibiotic misuse, overuse or irrational use was common. More education is required to promote practices that promote biosecurity practises on farms which should lead to reduced need to use antibiotics and therefore reduction of antibiotic residues. The findings in this study form one of the earliest pieces of knowledge to better understand the impact of antibiotic residues on food security and the link for animal production to One health family in tackling animal health and public health challenges involving zoonotic pathogens in Zimbabwe.

Keywords: (antibiotic residues, antibiotic resistance, prevalence of antibiotic residues, most common antibiotic residue, food security, Mutasa, Mutare)

List Of Acronyms and Abbreviations

AMR	Antibiotic resistance
AMU	Antimicrobial use
AMC	Antimicrobial consumption
CVSZ	Council of Veterinary Surgeons of Zimbabwe
MCAZ	Medicines Control Authority of Zimbabwe
DVS	Department of Veterinary Services
SADC	Southern Africa Development Community
FAO	Food and Agriculture Organization
ILRI	International Livestock Research Institute

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CHAPTER 1: INTRODUCTION

1.1 Background

The livestock farming industry plays an important role in food security by providing products like poultry, milk and beef which are important in meeting the protein needs of the increasing world population (Priyanka., et al, 2017) and is particularly very important in developing countries (Said, 2021). Livestock products account for 40% of total agricultural output in developed countries and about 20% in developing ones, supporting the livelihoods of at least 1.3 billion people worldwide and providing about 34% of global food protein (Santos, 2023).

The demand for livestock products is increasing at a very high rate both in developed and developing countries (Herrero et al., 2012), (Van Boeckel et al., 2015). Intensified livestock production globally is caused by increased demand for livestock products and is coupled to increased antibiotic use in animals. Antibiotics are the mainstay for treatment of diseases in livestock (Van Boeckel et al., 2015, Hosain et al., 2021). Additionally, some stock feeds and supplements contain antibiotics, as constituents for prophylaxis against infections and in some instances believed to be growth promotants (National Research Council, 1980)

Approximately 20% of the protein consumed in developing countries originates from poultry (Perdersen, 1998). Zimbabwe's livestock production system is dominated by small-scale subsistence farming (International Livestock Research Institute, 2022). 65% of rural households own poultry. Household dietary diversity studies have shown increasing trends of meat and milk consumption in Zimbabwe.

The average milk volume per capita in Zimbabwe has been on the rise from 9.1 kg in 2018 to 10.6kg in 2023 and is projected to rise to 11.7 by 2028 (Statistica, 2023)

Most livestock owners in Zimbabwe are communal smallholder farmers who keep about 90% of the national cattle herd (Nyika, 2021). They face challenges in participating in livestock value chains, as they lack access to well-functioning markets, information, and support services. (Homann-Kee Tui, et al, 2022). The national herd is estimated to be about 5,6 million cattle (The Herald, 2023). Manicaland Province in Zimbabwe has a herd size of 626055 cattle in the communal sector. Mutare has a cattle census of 108746 and Mutasa has 32145 (Department of Veterinary Services Records, 2023). 37% of rural livestock farmers own cattle and 9.5% of their total earnings is derived from livestock production or livestock sales. 1.3% of urban population practise some livestock production (ZimVac, 2023). Poultry meat consumption per capita was 7.33kg in Zimbabwe in 2021. Beef consumption was

120000mt in 2021 and projected to reach 123400mt by 2026. Zimbabwe is ranked 88th on 158 countries in terms of milk consumption. In 2013 Zimbabweans consumed 369757 kilotons of milk (HelgiLibrary, 2023).

Rural and urban consumers consumed livestock-based products such as meat, eggs, milk on a weekly basis. (Homann-Kee Tui., et al, 2022). Rural households consume dairy products on average on 1.1 days per week and meat on 2.5 days per week (ZimVac, 2023). About 4% of households in Zimbabwe slaughtered a sick animal for consumption or sale which predisposes the households to possibly consuming food contaminated from antibiotic residues (ZimVac, 2023).

Increased livestock production has pushed antibiotic usage upwards in livestock and may result in antibiotic residues tainting foodstuffs such as milk, eggs and meat (Bor, 2023). Consequently, there is a danger of anti-microbial residues in livestock products reaching the food chain (Merve Bacanl, Nurşen Başaran, 2019). 65% of cattle mortality is due to tick-borne disease, whose treatment options are based on tetracyclines, an antibiotic. This underscores the demand for antibiotics in Zimbabwe (World Organization for Animal Health, 2022)

Antibiotic residues are bactericidal drugs or their metabolites that accumulate as traces in tissues before they are completely metabolized or excreted from the body. They can be found in food of animal origin such as milk, eggs or meat, and represent a potential health risk to both humans and animals that consume them. Bacteria and other pathogens are treated and controlled by use of antibiotics. However, pathogens frequently escape the lethal effect of antibiotics and learn or evolve genetically to resist antimicrobials. Thus, antimicrobial resistance (Antibiotic Resistance) occurs when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines making infections harder to treat and increasing the risk of disease spread, severe illness and death (WHO, 2021).

Antibiotic residues in food products are a growing concern worldwide, as they can pose a risk to human health and contribute to the development of Antibiotic Resistance. Antibiotic Resistance results in a serious condition in which the usual antibiotics for treatment of ailments are no longer effective at usual drug strengths, leading to the requirement of a new line of antibiotics or higher strength formulations (Sun et al., 2022). The antibiotic pipeline is limited and running dry and medical management of bacterial infections becomes more

complicated, futile or very expensive. This results in deaths or disability in patients infected by drug resistant infections. Apart from causing Antibiotic Resistance, antibiotic residues consumed in food can cause anaplastic anaemia, organ toxicities and can be carcinogenic (Okocha et al., 2018). The causes of Antibiotic Resistance are many, involving multi-sectoral cross linkages as drivers, and include improper antibiotic prescribing practices, livestock owner behaviours in use of antibiotics, inadequate farmer education, the unauthorized acquisition and sale of antimicrobials, the lack of drug regulatory mechanisms, failure to observe antibiotic withdrawal periods for meat and milk and indiscriminate, overuse or irrational use of antimicrobials in animal production. The misuse of antibiotics often has more impact in less developed countries. Accordingly, the brunt of Antibiotic Resistance is borne and felt more severely in less developed countries (Wu-Wu et al., 2023)

Antibiotic Resistance affects the food security pillar of utilization in which both the ability to utilize food in the affected people is reduced and the food itself contaminated by antibiotics cannot be used as safe food. Antibiotic residues also reduce food availability since food found contaminated by antibiotics is rejected and discarded. Antibiotics residue free food is required in both local and international markets, hence contaminated food results in loss of trade and trade opportunities (Okocha et al., 2018)

In developing countries like Zimbabwe, the sale of food products through informal channels, such as roadside vendors, has become a common and convenient way for people to access food. Road side trading is vital contributor to rural and urban economies (Kiran and Babu, 2019). However, the lack of regulations and oversight for these informal food vendors may lead to a higher risk of antibiotic residues in the food they sell. There is no empirical evidence on the status of antibiotic residues in such foods and their implications on food security. This study thus aims to fulfil that gap by investigating the prevalence of antibiotic residues in milk, poultry, and beef sold by informal traders in Zimbabwe. The study seeks to unravel some factors that may contribute to the presence of antibiotic residues in meat produced by informal meat producers.

Previous studies have shown that antibiotic residues are present in a significant proportion of food products around the world, with levels exceeding safety standards in some cases. For example, a study in China found that over 40% of milk samples tested positive for antibiotic residues, and a study in Spain found that over 20% of chicken meat samples tested positive

for these residues. These high levels of antibiotic residues in food products are a concern, as they can lead to Antibiotic Resistance in humans and animals.

In 2020, approximately 90% of Zimbabwe's small holder farmers sold their produce in informal markets (UNDP, 2020). Zimbabwe has the second largest informal sector in the world (UNDP, 2021). Small scale or informal meat and milk producers occur in both Mutare and Mutasa districts in Zimbabwe. It is common to encounter roadside vendors selling milk in plastic bottles usually reused from original use. Several informal persons advertise on social media platforms like WhatsApp or Facebook about milk, chickens or beef that there have on offer for sale. It is therefore almost obvious to assume that such milk or meat products are not subject to food safety tests, regulations and controls and thus represent an important avenue through which food contaminated with the undesirable antibiotic residues finds its way into the food chain.

Regulation and control of antibiotics in food produced from the formal sector is regulated well in Zimbabwe. The Department of Veterinary Services (DVS) is the regulatory body in terms of monitoring and testing antibiotics residues at production level through the Dairy Services section and Veterinary Public Health Section. Authorised officers from DVS use the Animal Health Act Cap14:01, the Dairy Act and the Public Health Act to carry out their mandates of ensuring that food of animal origin pose no risk to public health. The country also has a One Health, National Action Plan on Antimicrobial Resistance lead by Focal Persons selected from Animal Health Services, Human Health Services, the Environmental Management Authority and Plant Health Services. This core group coordinates and promotes prudent use of antibiotics and ways of reducing the burden of Antibiotic Resistance in both animals and people. The Medicines Control Authority (MCAZ) of Zimbabwe is also a regulator that prescribes the manner, the persons, circumstances and premises for antibiotics and other drugs use through the Medicines and Allied Substances Act.

The Council of Veterinary Surgeons of Zimbabwe is a statutory body in Zimbabwe which governs the conduct of animal health practitioners, responsible for use and persons authorised to administer antibiotics being one of their mandates as laid out in the Veterinary Surgeons Act of Zimbabwe.

The Ministry of Health in Zimbabwe and many studies have reported increased incidences of drug resistant bacteria isolated from human patients. The Central Veterinary Laboratory in

Zimbabwe has also reported many cases of samples with common bacteria that affect both people and animals.

The Dairy Services Unit in the Veterinary Public Health section routinely tests milk and milk products for antibiotics for the formal sectors and hundreds of thousands of litres of milk are discarded every year throughout the country due to antibiotic residues. (Appendix 6.7.9)

The January Disease problem in Zimbabwe has also seen desperate farmers administering all sorts of concoctions involving undisclosed or disclosed types and amounts of antibiotics to their cattle. The cattle often die and desperate farmers consume or sell the antibiotic-residue-laced meat to informal butchers or community markets. There is no regulatory control, yet Antibiotic Resistance is such a serious emerging situation which requires risk assessment and evaluation. This January Disease case scenario mirrors the magnitude of the problem in as far as all antibiotic use and practice is concerned in animals and also applies to other animal species like chickens.

The consumption levels of beef, milk and chicken meat by Zimbabweans indicates that this as a hazard to potentially consume food contaminated by antibiotic residues. Milk and milk products and meat are valuable sources of protein for people (Priyanka, et al, 2017). Poultry meat consumption per capita was 7.33kg in Zimbabwe in 2021. Beef consumption was 120000mt in 2021 and projected to reach 123400mt by 2026. Zimbabwe is ranked 88th on 158 countries in terms of milk consumption. In 2013 Zimbabweans consumed 369757 kilotons of milk (HelgiLibrary, 2023). If a significant fraction of any of these foods becomes contaminated with antibiotic residues, then the population will be at risk of developing Antibiotic Resistance. In the formal sector like at Dairiboard of Zimbabwe, contaminated food is rejected and represents significant food unavailability.

1.2 Problem Statement

The problem of antibiotic residues in food products is particularly concerning in developing countries like Zimbabwe, where regulations are often poorly enforced and food safety systems are inadequate. This can lead to a high risk of Antibiotic Resistance and serious health consequences for the population. It has become increasingly very costly to treat certain bacterial infections because costly alternatives have to be resorted to or require research whose solutions are not immediately within reach. Antibiotic Resistance burden has also resulted in deaths, disability and loss of production. About 4.95 million people who died in 2019 worldwide suffered from drug-resistant infections. Antibiotic Resistance directly caused

1.27 million of those deaths and 1 in 5 of those deaths occurred among children under 5 years old. In Zimbabwe in 2019, there were 3,900 deaths attributable to Antibiotic Resistance and 15,800 deaths associated with Antibiotic Resistance. There is a rise in Antibiotic Resistance causing more morbidity and mortality (WHO, 2020, Chimbwanda, 2022). Antibiotic Resistance (AMR) is indicated by the number of infections that become complicated because of resistance to traditional or common drugs (Drug resistant or multi-drug resistant infections). It can also be objectively measured by number of human or animal patients that died or became disabled as a result of Antibiotic Resistance. The presence of antibiotic residues in food samples is an important premonitory indicator that estimates the risk and cause of Antibiotic Resistance in human and animal patients (Murray et al., 2022)

Some bacteria are environmental commensals but under favourable conditions become pathogenic. Harmless bacteria also interact with pathogenic bacteria, sharing genetic resistance factors produced as a result of non-lethal exposure to antibiotics. This means public health risk is a result of exposure to greater than maximum tolerable antibiotics residues in food. Therefore, antibiotics in food makes it unsafe and un-utilisable reducing food security. The other problem is that food that had taken time and resources is rejected if it is subjected to regulatory testing, for example on 25 August 2023, a total of 12279 litres of milk was discarded due to presence of antibiotics when DVS conducted routine regulatory checks. Rejection of antibiotic contaminated food reduces food availability.

1.3 Objectives

1.3.1 Main Objective

To determine the prevalence of antibiotic residues in milk and poultry and poultry and beef food in informal traders in Mutare and Mutasa districts and assess possible drivers to antibiotic use by informal sector farmers in Mutare and Mutasa districts.

Specific objectives

1.3.2.1 To identify and profile the antibiotic types available and accessible for use by farmers in Mutare and Mutasa

1.3.2.2 To estimate the prevalence of antibiotic residues in milk, poultry, and beef sold by informal traders in Mutare and Mutasa, Zimbabwe.

1.3.2.3 To analyse the determinants of antibiotic use in livestock rearing

1.3.2.4 To identify the main factors contributing to the presence of antibiotics in beef, milk and chicken meat produced in the informal sector in Mutare and Mutasa, Zimbabwe.

- 1.3.2.5 To outline the effect of antibiotic residues in human patients in Mutare and Mutasa and relate the prevalence of antibiotic residues to effect of antibiotic residues on people and food security
- 1.3.2.6 To recommend interventions to improve compliance with regulations and reduce the risk of Antibiotic Resistance.

1.4 Research questions

- 1.4.1 Which antibiotics are used in the production of milk, poultry and beef?
- 1.4.2 Which general class of antibiotics are available and accessible for farmers?
- 1.4.3 What are determinants of antibiotics use in livestock production?
- 1.4.4 What is the prevalence of antibiotic residues in milk, poultry, and beef sold by informal traders in Mutare and Mutasa, Zimbabwe?
- 1.4.5 What is the impact of antibiotic residues on people and food security in Mutare and Mutasa?
- 1.4.6 What are the possible interventions that can be implemented to reduce the presence of antibiotic residues?

1.5 SIGNIFICANCE OF THE STUDY

An understanding of the prevalence of antibiotic residues in food together with drivers that contribute to antibiotic use in food animals and products produced in the informal sector gives an estimation of the contribution of antibiotic residues to antimicrobial resistance in the unregulated informal meat and milk production sector. This will enable development of appropriate measures to reduce the levels of antibiotic residues in food that potentially cause development of Antibiotic Resistance, harmful effects to people and animals and indirect food losses. The results of the study will quantify the magnitude of the risk to Antibiotic Resistance caused by antibiotic residues. This will help determine priority level to development of adequate regulatory framework inclusive of the informal sector. Informal traders make use of e-marketing, yet regulatory controls are unmatched in terms of technological development. Gaining an understanding of knowledge, attitudes and perceptions by farmers on rationale use of antibiotics enables application of complete cross cutting socio-cultural and economic measures that lead to a reduction in the antibiotic residue level in food.

The study will also be able to complete narratives and ideas developed from other previous studies, for example, the adequacy of food policy law, as well as forming basis for future studies, for example, relative contribution to Antibiotic Resistance from the environment.

This study will emphasise on the importance that animal and animal products production systems play in contributing to the relative Antibiotic Resistance burden to humans and animals.

Furthermore, whilst many developed countries have made strides in understanding the extent of the prevalence of antibiotic residues and the risk there pose to food safety and food availability, in Africa, there is dearth of information on antimicrobial use in agriculture and food production systems and its consequential resistance in pathogens that affect animal, human and environmental health (Mshana et al., 2021) (Pokharel et al., 2020). Zimbabwe has unexplored, unreported and undiscovered areas in terms of antibiotic residues in food. Information on the exact impact of antibiotic residues on food security and Antibiotic Resistance burden in Zimbabwe is limited and this study will add to the body of knowledge. As an increasing number of countries report antimicrobial sales data

An increasing number of countries are reporting antibiotic use information (through antimicrobial sales data). There were only 5 countries reporting in 2000, 39 in 2015, and 41 in 2017), and so this study offers the opportunity to make statistical inferences on the global trends in veterinary antimicrobial use. This study therefore adds to this body of knowledge through reporting patterns of antibiotic use in the informal environment in Zimbabwe (Tiseo et al., 2020). Furthermore, countries that have low animal based foods exports tend to report less on antibiotic use data than those that do export (Tiseo et al., 2020). Zimbabwe beef exports are low and the reporting on antimicrobial use will be one of the first steps towards good antibiotic use and stewardship as well as preparing to open up access to lucrative international trade markets in animal-based foods.

1.6 LIMITATIONS OF THE STUDY

The study was limited to Mutasa and Mutare districts of Zimbabwe. The study was also limited to antibiotic residues as related to informal sector and covered poultry, beef and milk production. This study focused on qualitative data for antibiotic residues in food in order to determine effects on food security.

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CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Poultry, milk, and beef are three of the most widely consumed animal-source foods globally, playing a critical role in ensuring food security and nutrition for billions of people. These products are rich in protein, micronutrients, and other essential nutrients, making them a vital component of a healthy and balanced diet. Moreover, they are important sources of income and livelihoods for millions of smallholder farmers and pastoralists, particularly in low- and middle-income countries. The national cattle herd was about 5.6 million cattle in 2022, 2% up from 5.5 million in 2021. (Nyika, 2022). Zimbabwe targeted 6 million cattle by 2023 and 8 million by 2025 (Directorate of Veterinary Services 2022 Annual Report). Zimbabwe's raw milk production rose by 15 percent to 91.31 million litres in 2022, compared to 79.6 million litres realised in 2021 (Dairy services 2022 Annual Report). Ensuring the availability, access, and utilization of safe and nutritious poultry, milk, and beef products is therefore crucial for achieving food security and improving public health. However, the production and consumption of these products are facing numerous challenges, including antibiotic residues, animal diseases, and environmental degradation, which can compromise their safety and sustainability. This literature review chapter explores the issues associated with antibiotic use in poultry, milk, and beef.

2.2 Antibiotic Residues in people and animals.

Antibiotic residues have a direct effect on the quality of food or affect further processing such as with milk where bacterial cultures are used for fermentation in yoghurt, cheese and sour milk production. Antibiotic residues of certain antibiotics have direct adverse effects on the body as well such as causing allergies, organ toxicities or causing cancers and cause development of antibiotic resistance. Antibiotic Resistance occurs when bacteria develop the ability to defeat and resist the lethal bactericidal or bacteriostatic effect of medicines designed to eliminate infections. Antibiotic Resistance is a top risk to the public health all over the world. Antibiotic Resistance threatens progress in assuring health, and food production, and ultimately has the negative effect of reducing life expectancy. Not any one region throughout the world is spared of Antibiotic Resistance. (Centres for Disease Control and Prevention, 2023). The World Bank estimates that Antibiotic Resistance could result in US\$ 1 trillion in additional healthcare costs by 2050, and US\$ 1 trillion to US\$ 3.4 trillion in gross domestic

product (GDP) losses per year by 2030. People living in low-resource settings and vulnerable populations are especially impacted by both drivers of Antibiotic Resistance (antibiotic residues) and the consequences of antibiotic residues. Incidence rates of Antibiotic Resistance in 76 countries of 42% for third-generation cephalosporin-resistant *E. coli* and 35% for methicillin-resistant *Staphylococcus aureus* have been reported and are a major concern, calling for action to reduce antibiotic residues in food. Increased levels of antibiotic resistance potentially leads to heightened utilization of last-resort drugs like carbapenems, for which resistance is in turn being observed across multiple regions. As the effectiveness of these last-resort drugs is compromised, the risks to increased number of infections that cannot be treated is seen. Projections by the Organization for Economic Cooperation and Development (OECD) indicate an anticipated twofold surge in resistance to last-resort antibiotics by 2035, compared to 2005 levels, underscoring the urgent need for robust antimicrobial stewardship practices and enhanced antibiotic residue surveillance coverage worldwide. (WHO, 2023).

2.3 Drivers to antibiotic residues in food

Over-prescription by veterinarians of antimicrobials, particularly antibiotics, even in the absence of appropriate indications is one way of unnecessary exposure of antibiotics to bacteria. Diagnostic uncertainty, lack of opportunity for patient follow-up, lack of knowledge regarding optimal therapies, farmer demand for antibiotics, self-medication and noncompliance with recommended treatments are some of the practices that give rise to the presence of antibiotic residues in food of animal origin. Only 16% of farmers observed withdrawal periods for antibiotics in a study done in Ghana in 2020 (Phares et al., 2020).

Noncompliance occurs when individual farmers forget to administer medication, prematurely discontinue the medication as they begin to see their animals feel better, or cannot afford a full course of therapy. In some cases, available antimicrobials are poorly manufactured, counterfeit, or have exceeded their effective lifetimes.

Non-adherence to public health meat inspection of animals before and after slaughter results in the consumption of food potentially from diseased animals treated with antibiotics.

Poor biosecurity and sanitation practices around animals for food production result in the entry and establishment of bacterial infections which puts pressure to summon the use of antibiotics. Vaccination, segregation, cleaning and disinfection reduce the pressure for antibiotic use and the chance of any antibiotic residues present in food. In cattle and goats,

dipping results in reduced tick infestation which results in reduced tickborne disease burden. Tick borne diseases are commonly treated by tetracycline antibiotics. Tetracycline overuse and consequently reduced chance of tetracycline antibiotic residues is reduced through effective dipping programs as well as strict animal movement controls that prevent mixing and spread of rickettsial infections among cattle.

Setup and human resource establishment of animal health officers have an influence on antibiotic use and the eventual presence of antibiotic residues in food sourced from animals. Untrained officers occupying the position of animal health care providers will likely be uneducated and perform poorly as antibiotic stewards exacerbating the presence of antibiotic residues in food or failing to prevent avoidable antibiotic use (Anderson et al., 2020).

Failure to observe withdrawal periods as indicated for animals which had been treated with antibiotics will result in use of products from animals still incubating traces of antibiotics. Animals that die of disease pose another way in which withdrawal periods are not observed. About 4% of households in Zimbabwe slaughtered a sick animal for consumption or sale which predisposes the households to possibly consuming food contaminated by antibiotic residues (ZimVac, 2023).

Availability and access to veterinary drug centres can force farmers who stay far from such centres to pre-stock antibiotics in bulk to prepare for emergencies. However as soon as the drug is in the hands of a nonprofessional, its use, underuse or overuse will be something which cannot be controlled and chances of irrational use will be quite high in such cases (Anderson et al., 2020).

At the farmer level, lack of knowledge, awareness stereotyped approaches also result in irrational use of antibiotics resulting in antibiotic residues in food. In 2020 in Ghana 74% of farmers never had education on antibiotics (Phares et al., 2020).

Legislation, policy, strategies and action plans at the governance level also play a crucial role in controlling the acquisition, quality control, monitoring and use of antibiotics. Transboundary controls are also important in controlling and monitoring the traffic of drugs across borders. If prescribers and users are not controlled there will be rampant unmonitored and irrational use of antibiotics which will in turn cause a high prevalence of antibiotics in the food produced by animals. In some countries, there are weak or no controls for the sale of

drugs and one can even find drugs being sold from road pavements, with people having complete unrestricted access to the drugs as long as they can purchase them(Anderson et al., 2020).

2.4 Antibiotic consumption and use in animals

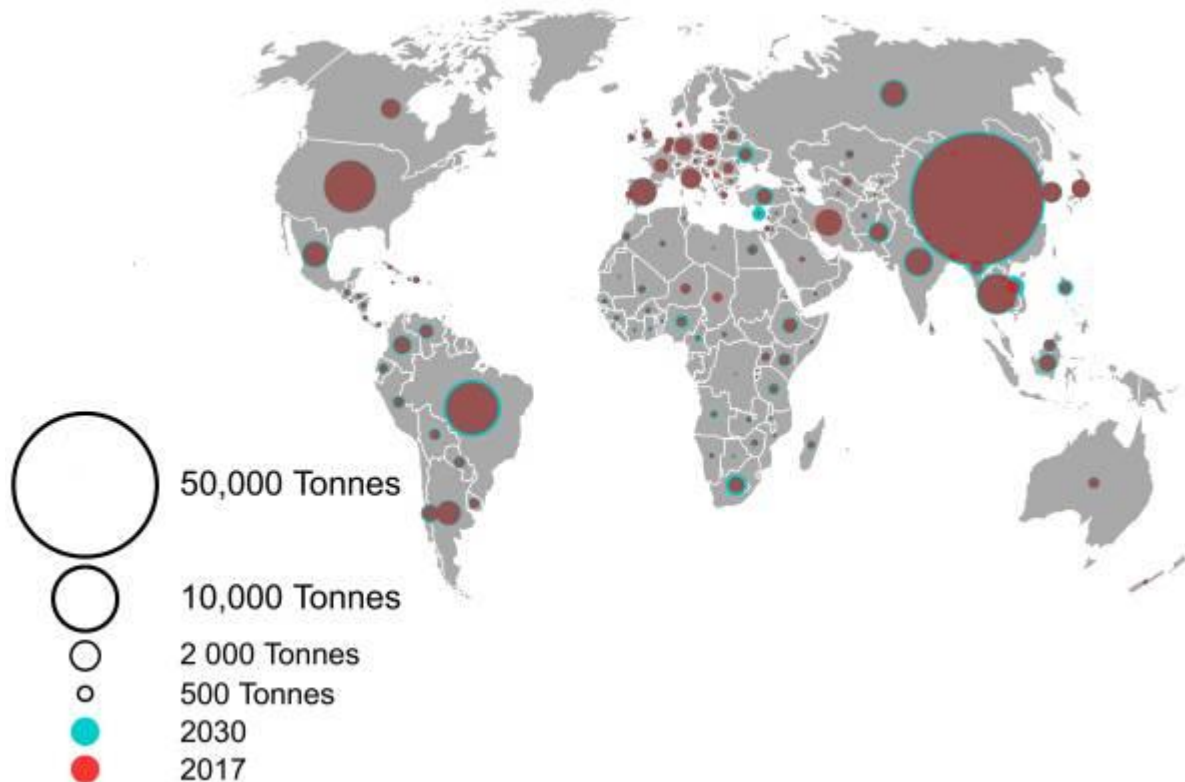


Figure 2.2: Relative antibiotic consumption levels for all species of domesticated animals in Africa, (Kimera et al., 2020)

Antibiotic consumption is highest in Asia, which is the most populated continent. In Africa, South Africa has the highest antibiotic consumption data. Antibiotic in usage in Zimbabwe is poorly studied.

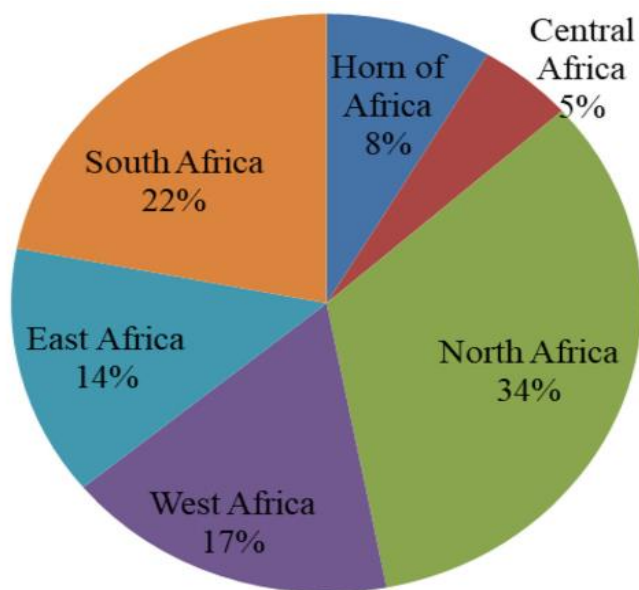


Figure 1 above shows that antibiotic consumption was highest in North Africa and lowest in Central Africa.

Table 1: Antibiotic use trends

Global trends of antibiotic use in animals (Tiseo et al., 2020)

Region/Country	Prevalence of antibiotic use in farms	Prevalence of antibiotic residues in food	Type of food	Conclusion	Reference
AFRICA	>50% use general antibiotics 63% use Tetracyclines	No data	Beef, poultry	Data limiting Huge potential risk to the public of antibiotic residues	(Mshana et al., 2021)
Worldwide	80% of animals receive antibiotics			Huge potential risk to the public of antibiotic residues	(Kebede, 2021)
Northwest Ethiopia	97% use tetracyclines 49% used β -lactams	76%	Beef	Serious public health risk of antibiotic residues	(Agmas and Adugna, 2018)
Iran		22.8%	beef	Moderate risk	(Soepranianondo et al., 2019)
Ghana		30.8%	beef	High risk	(Soepranianondo et al., 2019)

					et al., 2019)
Pakistan		38.33%	Beef	High risk	(Soepranianondo et al., 2019)
Nigeria		44%	Beef	High risk	(Soepranianondo et al., 2019)
Turkey		57.7%	beef	High risk	(Soepranianondo et al., 2019)
Indonesia		14%	beef	Low risk	(Soepranianondo et al., 2019)
Vietnam		7.4%	beef	Low risk	(Soepranianondo et al., 2019)
Sindh Province, Pakistan	38.29% β -lactams 21.14% Tetracyclines 40.57% other types	49.75%	milk	High risk	(Mangsi et al., 2014)
Kenya		41.26%			
Zimbabwe	No data	No data			

Table 1 Percentage of farms using antimicrobials by country, type of animal and class of antimicrobials, (Kimera et al., 2020)

Country	Food animal	% AMU	Class of antimicrobial
Ghana	Poultry	98	Tetracyclines, Aminoglycosides, Penicillins, Quinolones
Ghana	Cattle, goat, sheep, pig, poultry	98	Tetracyclines, Penicillins, Macrolides, Aminoglycosides, Sulphonamides, Benzimidazoles
Tanzania	Cattle, chickens, pigs	100	Tetracyclines, Sulphonamides, Penicillins, Aminoglycosides
Cameroon	Poultry	100	Aminoglycosides, Sulphonamides, Quinolones, Macrolides, Tetracyclines, Penicillin
Sudan	Poultry	92	Tetracyclines
Nigeria	Cattle, sheep, goats	77.5	Tetracyclines, Quinolones, Penicillins, Aminoglycosides
Zambia	Cattle		Aminoglycosides, Sulphonamides, Macrolides, Penicillins, Polypeptides, Tetracyclines
Zambia	Cattle	100	Tetracyclines, Penicillins,
Tanzania	Cattle, goat, sheep, pigs, poultry	74	Tetracyclines, Penicillins, Macrolides, Aminoglycosides, Sulphonamides
Ghana	Pigs	100	Tetracyclines, Sulphonamides, Penicillins, Quinolones, Macrolides, Aminoglycoside
Tanzania	Cattle	85	Tetracyclines
Tanzania	Poultry	90	Tetracyclines, Sulphonamides, Dihydrofolate, Aminoglycosides, Quinolones
Sudan	Poultry, cattle, sheep, goats	95	Tetracyclines, Penicillins, Macrolides, Sulphonamides, Aminoglycosides, Lincosamides, Streptogramins, Quinolones
Ethiopia	Cattle, poultry	80	Tetracyclines, Penicillins, Sulphonamides
Nigeria	Poultry	88.5	Tetracyclines, Aminoglycosides, Macrolides, Quinolones, Penicillins, Sulphonamides, Furanes, Polypeptides
Uganda	Pigs	40.6	Dihydrofolate, Tetracyclines, Aminoglycosides,
Cameroon	Poultry	80	Tetracyclines, Macrolides, Phenocols, Aminoglycosides
Egypt	Poultry	100	Tetracyclines, Quinolones
Uganda	Poultry	96.7	Sulphonamides
Nigeria	Cattle	77.6	Tetracyclines, Macrolides, Penicillins, Aminoglycosides, Sulphonamides, Quinolones

These studies show that there is a very high level of antibiotic use in Africa in general for all species of livestock kept but data from Zimbabwe is not included. This in general means that the countries are at risk of detecting antibiotic residues in their food and further assessment will be revealed by analysis of the behaviour and manner of antibiotic use and effectiveness of antimicrobial use and stewardship programs and regulations.

Table 2 *Qualitative detection of antibiotics in chicken meat from different countries (Muaz et al., 2018)*

Country	Sample	Positive samples (%)
Egypt	Fresh	90
	Imported (frozen)	72
	Local (frozen)	88
Sudan	Muscle	29.2
	Liver	28.3
	Kidney	21.4
Egypt	Frozen	8
	Fresh	34
Tanzania	Liver	50
Iraq	Stored	51

Studies of antibiotic residue prevalence in poultry in several African countries generally indicate a high incidence of antibiotic residues in poultry meat, which obviously poses a public health risk to Antibiotic Resistance and probably highlights the need to recruit antibiotic residue-minimizing strategies in all countries.

2.5 Prevalence of Antibiotic Resistance in People and Other Antibiotic Residue-Related Effects

In this section we look at global, regional and incidence of events or situations due to the impact of antibiotic residues. Toxicological and public health hazards of consuming food contaminated with antibiotic residues include development of antibiotic resistance, drug hypersensitivity reactions (allergies), carcinogenesis, teratogenesis and disruption of normal gut bacterial biome (Kebede, 2021).

2.5.1 Antibiotic Resistance

A study in Harare in 2017 from samples from a private laboratory showed that there was a high burden of drug resistance to common antibiotics in Harare and alarming levels of resistance of bacteria to the last line of antibiotic therapy. Between 70 to 100% of the samples examined showed resistance to ampicillin and penicillin. The study also revealed that *E. coli*, *Staphylococcus*, *Salmonella* and *Actinobacter*, bacterial organisms common to both people

and animals, showed resistance to penicillin, fluoroquinolones and cephalosporins which last line antibiotics also used both in people and animals (Mhondoro et al., 2019)

In African studies, an incidence of Antibiotic Resistance to penicillin of 26.7% was found and common type of resistant bacteria included *Streptococcus pneumoniae* and *Haemophilus influenzae*. Both isolated organisms cause pneumonia in both poultry and people, and infectious coryza in poultry and pneumonia in people respectively (Tadesse et al., 2017)

2.5.2 Allergies

About public health risk, in general exposure to certain antibiotics for certain individuals that were pre-exposed to antibiotics can elicit allergic reactions or hypersensitivity in those individuals. Antibiotics are the most common cause of life-threatening immune-mediated drug reactions (Blumenthal et al., 2019). Whilst specific data correlating to antibiotic residues and incidence of antibiotic allergies are rare, a study in China found that 18.6% of patients sampled had a history of multiple use of antibiotics (MUA). Multiuse of antibiotics was more common in patients with allergic rhinitis (23.7% vs 16.2% in non-MUA patients, $P < 0.001$), conjunctivitis (22.5% vs 17.1% in non-MUA patients, $P < 0.001$), asthma (31.8% vs 17.7% non-MUA patients, $P < 0.001$), and Chronic Urticaria (25.9% vs 18.3%, $P < 0.01$) (Chen et al., 2019). In the USA antibiotic exposure was significantly associated with faster development of food allergy. There was a significant association between antibiotic exposure and faster development of food allergy and this was the case in 17 of 28 states studied in USA (Li et al., 2019). These studies confirm that exposure to antibiotic residues in food contributes in a similar way that people with multiuse of antibiotics end up with hypersensitive reactions to antibiotics. Therefore, food containing antibiotic residues can potentially affect the utilisability of food.

2.5.3 Carcinogenesis

The risk of developing prostate, breast, lung, and colon cancer rises with use of antibiotics, a large observational study has found (*International Journal of Cancer*). The study shows that the risk of being diagnosed with non-melanoma skin, duodenum, pancreas, kidney, bladder, male genitals (excluding prostate), and thyroid cancers as well as myeloma and leukaemia, was more than 1.5 times more among participants with six or more antibiotic prescriptions, compared with the group with lowest exposure.

The use of antibiotics predisposes people to the risk of developing cancers such as colon, thyroid, myeloma, leukaemia, kidney, duodenum and pancreatic cancers up to one and half

times more than people with lower antibiotic exposure (Roger, 2008). Antibiotic residues in food are a way of chronic exposure to antibiotics putting people at increased risk of developing cancer (Petrelli et al., 2019).

2.5.4 Teratogenesis

Teratogenesis refers to congenital malformations. A study in Hungary in 2004 sought to find any associations between sulphur-based antibiotics taken during pregnancy and cases of congenital malformations. The analysis of the cases and matched controls indicated a higher rate of cardiovascular malformation and clubfoot in babies born to mothers with sulphonamide treatment in the second and third months of pregnancy (Czeizel et al., 2004). Therefore, in the case of chronic exposure of antibiotics present as residues in food produced from animals will likely add on to or cause teratogenesis on their own in babies born to mothers exposed to such.

2.5.5 Availability and access of antibiotics by farmers

There is a paucity of information on antibiotic utilization by small-scale farmers and factors associated with the administration of antibiotics and farmers' knowledge of the effects of antibiotics are not well documented in Zimbabwe (Anderson et al., 2020). Insufficient attention has been paid to access and availability of antibiotics to farmers (MacPherson et al., 2022). In Ghana, in a cross-sectional study of farmers, 95% of farmers in the sample used antibiotics and 84% accessed antibiotics easily over the counter without prescription (Phares et al., 2020). The Veterinary Medical Dealers (veterinary drugs outlets) and pharmacies registered by the Medicines Control Authority of Zimbabwe are the primary source of antibiotics for most farmers. Some informal traffic of veterinary drugs also exists from middlemen and smuggled across borders. Some farmers obtain antibiotics from their consulting veterinarians and veterinary paraprofessionals. Antibiotics can be sourced secondarily from colleague farmers. In general, official drugs outlets are concentrated in city and town centers and of late are beginning to redistribute to growth points. However access for farmers in remote areas is limited and these rely on stocking, colleague farmers or have to wait several hours to days before the required antibiotic is delivered from town or growth points (Anderson et al., 2020).

2.6 Interventions to reduce antibiotic residues in food animals

2.6.1 Antibiotic Supply-Import controls

The Medicines Control Authority of Zimbabwe (MCAZ) issued some guidelines are meant to outline the responsibilities of the stakeholders involved in the import and export of

medicines., identify the persons who can import or export medicines into or out of Zimbabwe, to state the ports through which medicines can be imported into Zimbabwe, to define the minimum requirements for a complete application for a medicine import or export permit, to explain the criterion for submitting an application for an import or export permit for medicines and to outline the process of consignment verification and clearance. These guidelines seek to account for drugs that enter into the country and form part of the means of tracking antibiotic patterns in the country (MCAZ, 2017). Regulation and control of antibiotics at point of entry enables government and authorities to account for, perform surveillance of antibiotic use or sales.

In Zambia, the Medicines and Allied Substances Act provides for the registration and regulation of pharmacies, health shops and agro-veterinary shops; provide for the registration and regulation of medicines and allied substances; provide for the regulation of the manufacture, importation, exportation, possession, storage, distribution, supply, promotion, advertising, sale and use of medicines and allied substances; provide for the regulation and control of clinical trials; repeal and replace the Pharmaceutical Act, 2004; and provide for matters connected with, or incidental to, the foregoing (Medicines and Allied Substances Act of Zambia No. 3 of 2013). The Medicines and Allied Substances Control Act (MASCA) is a Zimbabwean law that establishes the Medicines Control Authority of Zimbabwe and confers functions on such Authority in relation to the registration of medicines. The Act also provides for the Zimbabwe Regional Medicines Control Laboratory and for its functions, the appointment of a Director-General of the Authority, and the keeping of a Medicines Register. The Act also provides for certain prohibitions, controls and restrictions relating to medicines and other substances. The Medicines and Allied Substances Control Regulations (MASCR) SI 150 of 1991 requires that all medicines be registered, after scientific scrutiny of quality, safety and efficacy data, before they are allowed to be used on the Zimbabwean public and/or animals.

At governance and policy level several stakeholders and government departments have established one health platforms that seek to coordinate information, action plans, people and implementation of approaches the aim to reduce the burden of Antibiotic Resistance through ameliorating factors that reduce antibiotic use and unnecessary exposure. The one health platform involves players from industry, health care, animal health, environment health and plant health. In Zimbabwe a National Action Plan on Antibiotic Resistance was established to promote rational use of antimicrobials in animals, plants and people (Makoni, 2017)

Contravening regulations for drug use attracts penalties for practices and practitioners, fines and custodial sentences for unauthorised acts and use. These prosecution measures serve to deter improper use as well conduct in as far as handling and administering antibiotics and other drugs.

2.6.2 Farmer Education and awareness

Public education imparts knowledge on antibiotic use and results in a positive impact on how farmers handle and administer antibiotics. Methods of public education include public health initiatives such as World Antibiotic Awareness Week, local public campaigns and educating young people in schools. Education can be held in the form of shows, quizzes and competitions on the theme of antibiotic residues (McNulty et al., 2020)

2.6.3 Farmer Field Schools

"These Farmer Field Schools participants are now experts themselves in the use of antimicrobials in poultry production. They no longer mix antibiotic capsules into poultry feed; they no longer give antibiotics to day-old chicks; they no longer give antibiotics to birds for the prevention of diseases, as growth promoters or as egg boosters. The chicken and table eggs they produce are therefore safe and healthy for all of us and free of drug residues," is a statement at the graduation of farmers that were trained to apply rationale use of antibiotics in Kenya and this underscores the value of such an intervention. (FAO, 2022). The Farmer Field School approach offers an intervention methodology that can reduce the emergence and spread of antimicrobial resistance in agricultural systems through targeting the variety of on-farm and off-farm factors that drive resistance. Participation in a layer poultry Farmer Field School in Ghana and Kenya is associated with self-reported reductions in antibiotic use, particularly for prevention, an increased investment in farm infection, prevention, and control practices and the same (Caudell et al., 2022). FAO worked closely with veterinary officers to assemble groups of farmers that take one model batches of broiler to experience first-hand from the start husbandry practises and poultry health practises which helps them discover and experience the feasibility of antibiotic residue free chickens. The farmer field schools have proved to be effective in reducing antimicrobials use in the broiler value chain (FAO, 2022)

2.6.4 Community vanguards/guardians

Understanding social hierarchy of rural communities and harnessing that to implementation of antibiotic stewardship and responsible use may prove to be effective in reducing presence of antibiotics in food. Rural Zimbabwean communities are governed by a complex system of local authorities, which includes traditional leaders, rural district councils, and district

administrators (Centre for Conflict Management and Transformation, https://africaportal.org/wp-content/uploads/2023/05/Roles_and_responsibilities_in_Rural_Local_Governance_in_Zimbabwe-1.pdf)

2.7 Food Security-Antibiotic Resistance Conceptual Framework

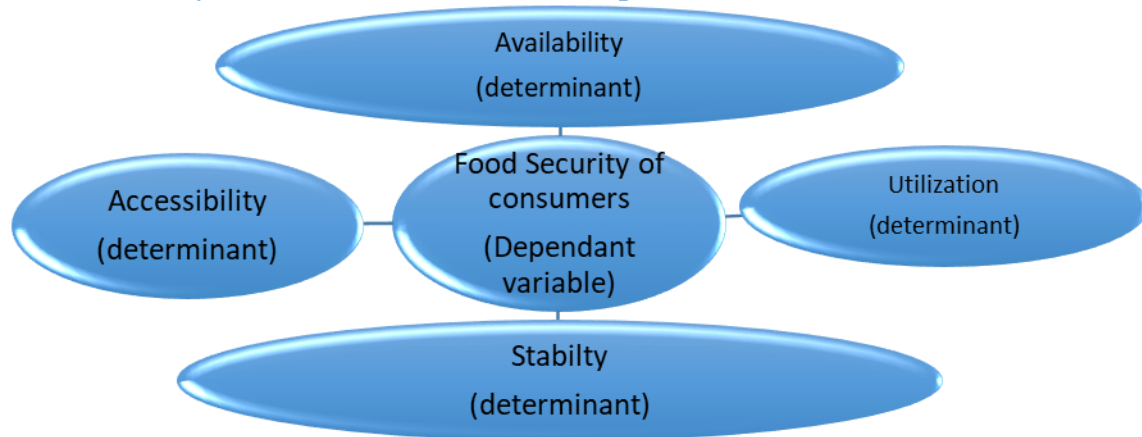


Figure 2: Conceptual framework: Food security pillars

Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (Peng and Berry, 2018). Food security can be considered as the dependent variable achieved through the 4 pillars of food security namely availability, accessibility, utilisation and stability.

This study focuses on and expands on utilization as a determinant of food security with a subcategory of food safety, as affected by the presence or absence of antibiotic residues.

Utilization is commonly understood as the way the body makes the most of various nutrients in the food. Sufficient energy and nutrient intake by individuals is the result of good care and feeding practices, food preparation, and diversity of the diet and intra-household distribution of food. Combined with good biological utilization of food consumed, this determines the nutritional status of individuals. Antibiotic residues reduce food safety and reduce the ability in the way the body to makes use of the nutrients. On the other hand, food found to be contaminated with antibiotic residues is rendered unfit for consumption and therefore discarded causing reduced availability which also affects overall food security. In terms of domestic and international trade antibiotic residue-contaminated food cannot penetrate the market and the resulting economic loss of trade also indirectly affects food security.

Furthermore, the cost of implementing controls and compliance to food safety standards both for the regulator and trader adds to the cost of food and thus reduces food access in that way.

Another concept in this study is the cause-effect of Antibiotic Resistance and antibiotics.

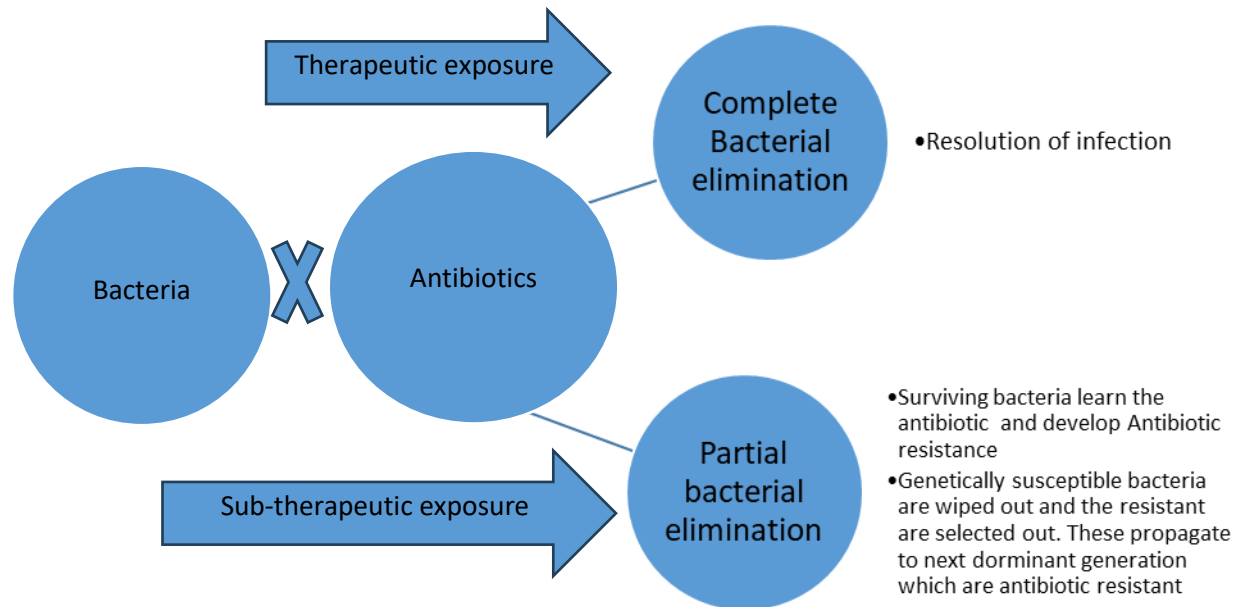


Figure 3: Conceptual framework: Results of bacteria antibiotic interactions

Antibiotics interact with antibiotics to produce mainly two outcomes; intended outcome where bacteria are destroyed or immobilised and infection is eliminated or resolved or the unintended partial or failure to eliminate all the bacteria. Subtherapeutic antibiotic exposure results in incomplete bacterial elimination of which the surviving bacteria usually develop antibiotic resistance factors. Subtherapeutic antibiotic exposure also eliminates the genetically weak and susceptible (less) resistant bacteria but the population of resistant bacteria is spared and survives to the next generation and propagates the selected resistant members.

2.8 Summary of Literature Review

Residues of antibiotics affect the quality of food in general as far as its acceptability (utilizability) for use along the food chain. From the onset, if antibiotics are detected in food, the whole affected consignment is discarded resulting in loss to the farmers who produced it and loss to consumers who find it unavailable. If antibiotic-contaminated food does enter the food chain, consumers are potentially likely to be affected in terms of their health and will be rendered unable to partake in economic activities or food-producing activities that ensure household food security. Furthermore, affected individuals will suffer physiologically when

their digestive systems are unable to uptake or utilise food due to direct and indirect harm from antibiotic residues.

Governments must put in place systems to control, survey and account for all antibiotics accessed in the country as a starting point, for example through vigilance and alertness at port of entry, illegal entry points into the country and internal sources of manufacturing and packaging. A dedicated inter-sectorial policing unit with clear terms of references should be in place, adequately funded and fully operational at all times to enforce, account and survey for antibiotic usage by farmers. It is also very important to train and register antibiotic use experts who must ensure professional and efficient antibiotic stewardship. Aggressive measures for control at dispensing outlets need to be implemented with follow ups, monitoring and prosecutions where necessary.

At farmer level, antibiotic residues can be controlled through education, awareness and recently through self-experiments in organised farmer field schools. The use of prosecution on repeat or un-repent offenders can also be an effective deterrent measure to reducing irrational use of antibiotics. It cannot also be left underscored that multi-stake holder approach and platforms on antibiotic use are very effective especially participatory bottom to top approaches. These afford potential perpetrators of antibiotic residues to discover and characterise the problem, come up with home grown strategies which are more often wholly implemented to yield positive results.

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CHAPTER 3: METHODOLOGY

3.1 Introduction

This study was a cross-sectional study. This type of study is of important particularly in this field since it seeks to establish preliminary evidence in planning for future and further studies. The study measured the prevalence of antibiotics, antibiotic residues in food samples and sought to understand their determinants, and described features of the study population. (Wang and Cheng, 2020).

3.2 Description of Study Sites

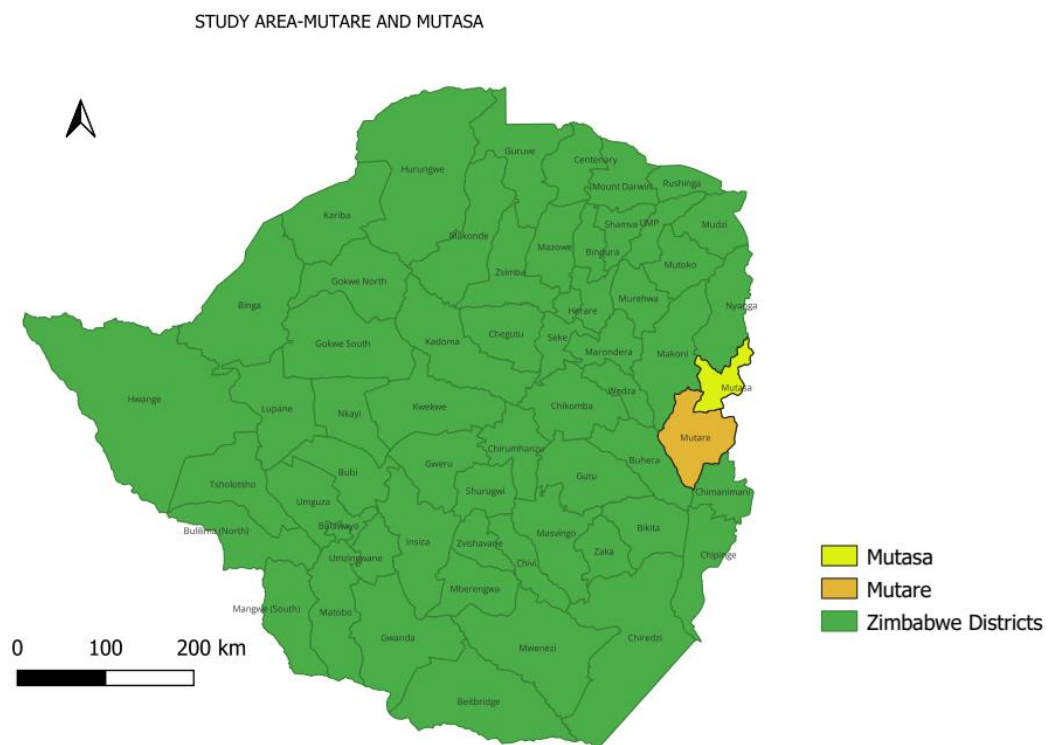


Figure 4 Zimbabwe map, highlighting the location of the study areas.

The study was conducted in Mutare and Mutasa, which are two adjacent districts located on the most eastern side of Zimbabwe in the Manicaland Province. Mutare District is the provincial capital whilst Mutasa is mostly rural or farming district. To access Nyanga further up north from Mutare, one has to pass through Mutasa. Mutasa is also located on the route to Harare from Mutare. Several people reside in Mutasa and commute to work or for markets to Mutare.

Geographical coordinates for Mutare are -18.976020, 32.669045 and Mutasa are -18.583331, 32.749997 (Sande, 2016).

3.3 Research Design

This research sought to discover evidence of the presence of antibiotic residues, the factors that cause their presence in food and their effects on food security.

In order to carry out this the design of the research is based on the following:

- i. Identifying the problem and coming up with a title of research
- ii. The research questions and objectives
- iii. Introduction, background information, justification or significance of the study, scope/delimitations and limitations of study
- iv. Literature review and searches
- v. Research approach: This research is a qualitative work (presence or absence of antibiotic residues, type of antibiotic), factors. Quantification of the findings was done by computing frequencies of occurrences of the factors
- vi. Sampling sites (study area): this was based on convenience and that the subjects are contiguous between Mutare and Mutasa.
- vii. Sample size was estimated using the Cochranes formula for sample size and the estimated number of people engaging in the informal trade of beef, poultry and milk.

Table 3: Determination of sample size, sampling procedures and medium used

Sample type	Determination of sample size	Sampling procedures	Medium
Food samples	Cochranes formula	Snowballing, stratified purposeful	Field collection of samples in sample bottles and placed on ice
Beef, poultry, dairy farmers	Cochranes formula	Stratified, random sampling, Close ended multiple choice questionnaire and open-ended questionnaire	The questionnaire, uploaded onto Kobocollect
Veterinarians	Cochranes formula. 52 veterinarians were sampled	Random sampling on WhatsApp groups, open-ended multiple choice and open-ended questionnaires,	WhatsApp group conferencing and poll administration, responses uploaded onto

			Kobo collect
Vendors for beef, poultry and milk	Cochranes formula	Snowballing, stratified purposeful	The questionnaire, uploaded onto Kobocollect
Farmers (Focus Group)	Convenience sampling	Focus group discussions on WhatsApp groups	WhatsApp group conferencing and poll administration, responses uploaded onto Kobo collect
Key informants	Purposeful	Focus group guide	Face to face Interview
Drug retailers	Purposeful (all 16 outlets in the study area were sampled)	Close-ended questionnaire	The questionnaire, uploaded onto Kobocollect

- viii. Uploaded documents were downloaded in MS Excel for Analysis and presentation
- ix. Data Analysis: Excel, MS Word, SPSS
- x. Presentation of Results
- xi. Discussion
- xii. Recommendations and Conclusions

3.4 Sampling

Convenient sampling and snow balling were used. This method was used for roadside vendors as well as informal trader advertising on social media platforms. The sampling frame was the Mutare and Mutasa districts. The sample size was determined from Secondary data in which the Local Authorities (Mutasa Rural District Council, City of Mutare, Mutare Rural District Council, Department of Agriculture Extension (AGRITEX) and Department of Veterinary Field Services provided household numbers per village or suburb together with type or number of livestock kept.

The following simple formula was used for calculating the adequate sample size in this study

$$n = \frac{Z^2 P(1-P)}{d^2}$$

Where n is the sample size, Z is the statistic corresponding to the level of confidence, P is expected prevalence (that can be obtained from the same studies or a pilot study conducted by the researchers), and d is precision (corresponding to effect size).

The level of confidence aimed for is 95%. A precision of 5% was selected if the prevalence of the disease was between 10% and 90%. However, when the assumed prevalence is too small (going to be below 10%), the precision would be one-fourth or one-fifth of prevalence as the amount of precision in the case of small P (Nanjundeswaraswamy and Divakar, 2021).

3.5 Data collection methods

3.5.1 Secondary Data Collection

Secondary data for total milk and meat consumed in Mutare and Mutasa was obtained from the Department of Veterinary Services and ZimVac Reports and Dairy Services Key Informants. The Ministry of Health Key Informants also provided human patient data related to antibiotic residues.

3.5.2 Primary Data Collection

Data was collected both on questionnaire forms and KoboCollect. Data was downloaded from kobo collected as excel sheets and imported into SPSS.

Primary data was collected from food vendors through a collection of food samples to be tested for the presence of antibiotic residues. Samples were tested for antibiotic residues using the Premi[®]Test kit (R-Biopharm AG, Germany). This kit is a micro-inhibition screening test containing *Bacillus stearothermophilus* spores in an agar medium and a bromocresol purple indicator. In the absence of inhibitory substances, antibiotics in this case, the spores germinate and multiply to form an acid. This causes the bromocresol indicator to change colour from purple to yellow. If antibiotics are present above the MRL, the colour of the indicator remains purple and was recorded as a positive result. Premi[®]Test is one of the most commonly used screening tests for β -lactams, macrolides, tetracyclines and sulphonamides in meat in the EU with confirmatory tests generally utilised to confirm positive samples (Widiasih, 2024)

Primary data on knowledge attitudes and perceptions on antibiotic use was collected via a combined structured and open-ended questionnaire interview (see annexures)

Key informant interviews were used to gather data about a number of livestock farmers and their livestock species and use. The main interviewees were the Department of Veterinary Field Services, Livestock Production Department, Veterinary Medical General Dealers and veterinary doctors. Hospital data on the incidence and occurrence of both Antibiotic

Resistance cases and antibiotic sensitivity tests was sourced from interviews with provincial medical epidemiologists and provincial medical laboratory.

3.5.3 Focus group discussions

The interviewer joined farmer and veterinary doctor WhatsApp groups and presented poll questions and gathered responses regarding antibiotic knowledge, attitudes and perceptions.

3.6 Data analysis methods

The prevalence of antibiotics was calculated in this cross-sectional study as a measure of frequency to describe how frequently antibiotic residues and Antibiotic Resistance cases occur in Mutare and Mutasa. Factors and determinants of antibiotic use and antibiotic residues were also coded and categorised for analysis of content and frequencies of responses/occurrences. The prevalence describes how frequently antibiotic residues are seen at a defined point in time. The significance of the study of Mutasa and Mutare was evaluated by calculating the confidence limits at 95%.

The data was analysed using the Statistical Package for the Social Sciences (SPSS), Microsoft Excel and Microsoft Word. Descriptive statistics, such as frequencies and percentages, were be used to describe the data. The qualitative data were analysed using content analysis and thematic using simple Microsoft Word “Find” features. The transcripts were read and coded, and themes were identified. The quantitative and qualitative data were be integrated to gain a holistic understanding of the research topic. The findings were presented in both narrative, histogram, pie charts and tabular form.

The chi-square analysis test for association and correlation shows the relationship strength. A two-tailed p-value of less than 0.05 was considered statistically significant.

Table 4 Data analysis Table

Research question	Data needed	Data collection	Data analysis	Data analysis Tool references	Relevant literature
What is the prevalence of antibiotic use among Informal vendors in Mutare and Mutasa?	Quantitative data	Digital Survey Questionnaire	Prevalences, Frequencies	SPSS, Spreadsheet	(Anderson., et al 2020)
What are the main sources of their supply	Qualitative	Digital Survey Questionnaire	Chi-square test for association	SPSS	(Anderson., et al 2020)
Common antibiotics used	Qualitative	Digital Survey Questionnaire	Chi-square test for association	SPSS	(Hossain, 2022)
What is their knowledge levels about the harm of antibiotics	Both quantitative and qualitative	Digital Survey Questionnaire	Pearson chi-square test	SPSS	(Hossain, 2022)
What motivates the producers to use antibiotics	qualitative	Digital Survey Questionnaire, KII	Thematic frequencies, Pearson chi-square test	SPSS, MS Word	(Anderson., et al 2020)
What alternatives do the producers have other than the use of antibiotics	qualitative	Digital Survey Questionnaire, KII	Thematic frequencies	SPSS, MS Word	(Anderson., et al 2020)

3.7 Pilot study

A pilot study of the proposed study was conducted in order to develop or refine the methodology (Dawson and Trapp 2004). This ensured that errors of whatever nature were rectified immediately at little cost. After the necessary modifications were made following the pilot study, the instrument was administered to the full sample. Actual data was collected during the pilot study and analysed carefully to ascertain whether the procedures and tools met the desired expectations. The result of the pilot study was used to refine the research instrument before using it in the actual study.

3.8 Ethical Considerations

- **Protecting the rights of the respondents.**
- **Informed consent**
Informed consent was obtained from the respondents.
- **Right to self-determination**

Right to self-determination (based on the ethical principle of respect for persons) All respondents were treated as autonomous agents by informing them about the proposed study and allowing them to voluntarily choose to participate or not. Coercion, convert data collection would be avoided.

- **Privacy**

Right to privacy: The opinions and other private information of respondents were protected.

- **Autonomy**

Right to autonomy and confidentiality: respondents' anonymity was ensured and the researchers' management of private information shared by the respondents was kept confidential.

- **Right to fair treatment**

Right to fair treatment (based on the ethical principle of justice): The selection and treatment of respondents was fair and devoid of bias. Gender selection was fair.

- **Protection from discomfort**

Right to protection from discomfort and harm (based on the ethical principle of beneficence): It holds that one should do well, and above all do no harm.

- **Integrity**

Scientific integrity is secured through honest conduct, reporting and publication of the study. Data would not be fabricated and the research materials/ processes not falsified. Appropriate credit to be given for the use of other person's ideas, processes, results and words.

3.9 Summary

A cross-sectional study was conducted in 2 districts of Manicaland Province Zimbabwe. Antibiotic sources, antibiotic prescribers, farmers, vendors of beef, milk and poultry, and key informants from DVS and the Ministry of Health provided primary and secondary data used in the study. Data was collected using structured close and semi-open questionnaires administered via physical forms, on Kobo-Collect and via WhatsApp-administered polls. Data was downloaded and collected on MS Excel, and MS Word and analysed on SPSS. Simple descriptive statistics, thematic trends and Chi-squared TEST were used for data analysis. Results were presented in tables, histograms, pie charts and narratives. Ethical considerations were strictly followed during the research.

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CHAPTER 4: RESULTS (Determinants of antibiotic use in livestock and prevalence of antibiotic residues)

ABSTRACT

This chapter investigated the use of antibiotics in livestock rearing and the prevalence of antibiotic residues in milk, poultry, and beef sold by informal traders in Mutare and Mutasa, Zimbabwe. Antibiotic types available and accessible to farmers were identified and profiled. The prevalence of antibiotic residues in livestock products sold by informal traders was also estimated. Sixteen drug retail outlets were visited and tetracycline was the most commonly sold antibiotic found at all outlets. Farmers used tetracyclines the most (70%) followed by other antibiotics (37%) and penicillins (22%). Tetracycline antibiotic residues ranked the most found for all samples at 47% followed by penicillins (32%) and other antibiotics (18%). Beef samples contained more tetracycline residues (49%) than penicillins (37%) than other antibiotics. Poultry samples also contained more tetracycline (78%) antibiotics than other antibiotics (21%) and penicillins (23%). Milk samples had more penicillins (45%) than tetracyclines (35%) and other antibiotics (4%). Farmers largely obtained their antibiotics for use on the farms without prescriptions from the veterinarian. Their use was not largely not guided by veterinarians (60% were not advised by veterinarians on diagnosis and type of antibiotic to use) and 44% sought advice from either a veterinarian or veterinary extension worker on the instructions on how to use antibiotics (68% are guided by product label instructions). 38% of farmers are not aware of the effects and dangers of antibiotic residues. 94% of the farmers were not aware that cleaning and disinfection are important biosecurity practices that reduce the burden of antibiotic use. Veterinarians believe that control for antibiotic use or consumption is not effective at the level antibiotic retail outlets (VMGDs) (41%) and Regulators (32) (Medicines Control Authority of Zimbabwe, Council of Veterinary Surgeons of Zimbabwe, Zimbabwe Republic Police, Department of Veterinary Services. Control of antibiotic use or consumption is lost at farmer level (20%) and some control is also lost during drug importation. None of the farmers interviewed indicated that any consumer preferred antibiotic-free food or was concerned with whether the product being sold contained any antibiotic and there are no mandatory requirements by food safety services to test for antibiotic residues whilst at the same time consumer organisations have no checklist for antibiotic residues. The study findings highlight the need for improved

regulation and monitoring of antibiotic use in livestock production and trade in Zimbabwe to ensure food safety and public health.

Keywords: *Antibiotic residues, veterinary prescriptions, drug retail outlets, farmer practises*

4.1 Introduction

Antibiotics have revolutionized the treatment of bacterial infections in humans and animals. However, the widespread use of antibiotics in livestock production has raised concerns about the potential risks to public health. The overuse and misuse of antibiotics in agriculture can lead to the development of antibiotic-resistant bacteria, which can spread to humans through the food chain. Moreover, antibiotic residues in food products can pose a risk to consumer health.

In Zimbabwe, livestock production is an essential sector of the agricultural industry, and antibiotics are widely used to promote growth and prevent disease in animals. However, there is limited information on the use of antibiotics in livestock rearing and the prevalence of antibiotic residues in livestock products sold by informal traders. This chapter presents the findings of a study that investigated the use of antibiotics in livestock rearing and the prevalence of antibiotic residues in milk, poultry, and beef sold by informal traders in Mutare and Mutasa, Zimbabwe. The study aimed to identify and profile the antibiotic types available and accessible to farmers, estimate the prevalence of antibiotic residues in livestock products and analyze the determinants of antibiotic use in livestock rearing.

4.2 Material and Methods

The study was a cross-sectional study of the prevalence of antibiotic residues in beef, milk and poultry sold informally in Mutare and Mutasa. Data was collected via questionnaires administered to farmers, drug retail outlets and samples of beef, poultry and milk in Mutare and Mutasa which are two districts in Manicaland Province Zimbabwe.

Secondary data was gathered and primary data was gathered through purposeful sampling and snowballing in combination with focus group discussions done on farmer WhatsApp groups as well as physical enumeration of close-ended questionnaires to farmers and drug retailers. Data was collected and uploaded onto Kobo and then downloaded on MS Excel, and analysed on SPSS, Excel and MS Word. Findings were presented as narratives, tables, graphs and pie charts. The sample size was determined from Secondary data in which the Local Authorities (Mutasa Rural District Council, City of Mutare, Mutare Rural District Council, Department of Agriculture Extension (AGRITEX) and Department of Veterinary Field Services provided household numbers per village or suburb together with type or number of

livestock kept. Excel and SPSS generated the descriptive statistics and also produced the tables graphs and pie charts, Themes were analysed using the find option in MS Word. The Chi-squared test was used to measure significance of the association between frequencies of occurrences measured between categories.

4.3 Challenges encountered during data collection

1. Participants not willing to disclose some personal details e.g., age
2. Some participants could not recall some information e.g. type of drug used; sales made
3. The survey followed in the wake of some operations by law enforcement agents e.g. crackdown on outlets selling illegally, and therefore not all information was freely shared
4. Some key informants had trouble retrieving information required because it is not routinely reported.

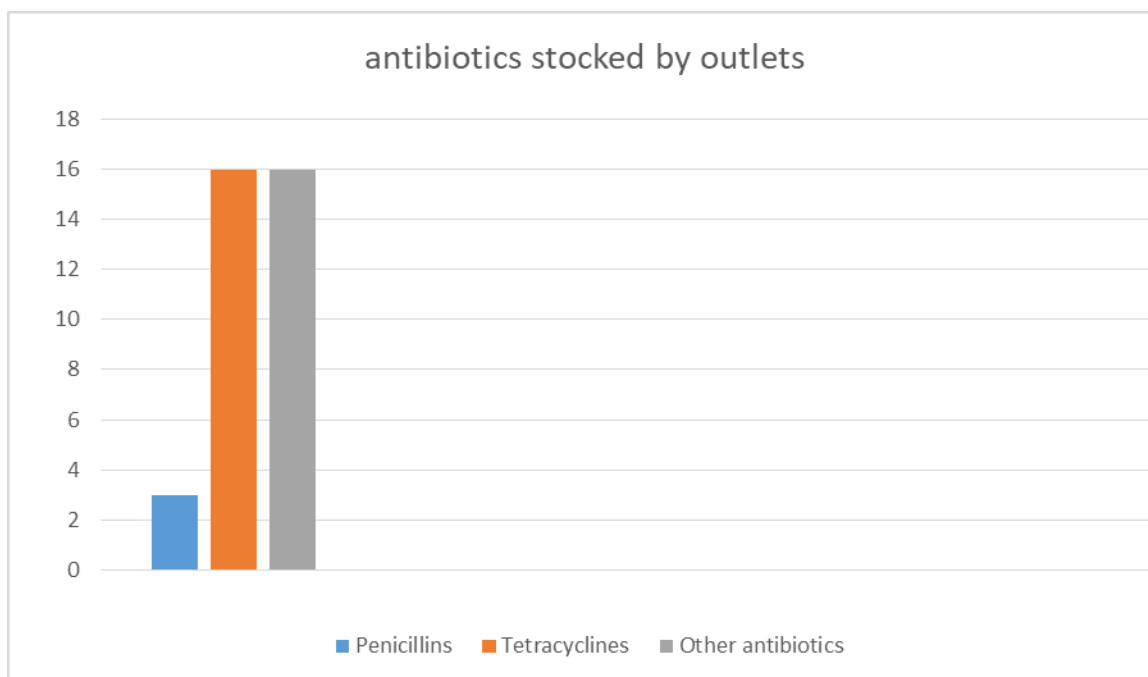
4.4 Results

This chapter looks at results for antibiotics that are available at veterinary drug retail shops, then systematically profiles what antibiotics eventually use on their animals before finally looking at the end of the chain by presenting prevalence of antibiotic residues in food. Results are presented in theme to the research objectives. Results generated in the study indicate prevalence of antibiotic residues in general for each class of the antibiotics tested, i.e., tetracyclines, penicillins and other antibiotics. Results are also presented according to prevalent antibiotic types in each of the products in the study, i.e., beef, milk and poultry. Results are also presented for antibiotic residues found in different production systems (subsistence, small scale commercial and large-scale commercial). Knowledge, attitudes and practises were also measured as frequencies and presented in short narratives, tables, graphs and pie charts.

4.4.1 Antibiotic supply

Table 5 Antibiotics that are supplied by veterinary shops

	Antibiotic type		
	Penicillins	Tetracyclines	Others
Number of outlets	3	16	16
Percentage	19	100	100



The most common antibiotic type sold from retail outlets (veterinary medicines general dealers) was tetracycline or its derivatives followed by penicillins. Tetracyclines were sold in their various forms (oral and injections) at all the outlets visited (16/16). Penicillins were sold at 3 of the 16 outlets visited. Other antibiotics (sulphonamides, cephalosporins, bacitracin, enrofloxacin, erythromycins) were sold at all the 16 outlets visited.

Table 6 Antibiotics that farmers have in stock or use

	Tetracyclines	Penicillins	Sulphonamides	Enrofloxacin	Terranox/Terramycin/ Aliseryl	Doxycycline	Sulfadimidine	ESB3	Bremamed
Number	42	22	5	1	28	0	1	27	2
Percentage	42	22	5	1	28	0	1	27	2

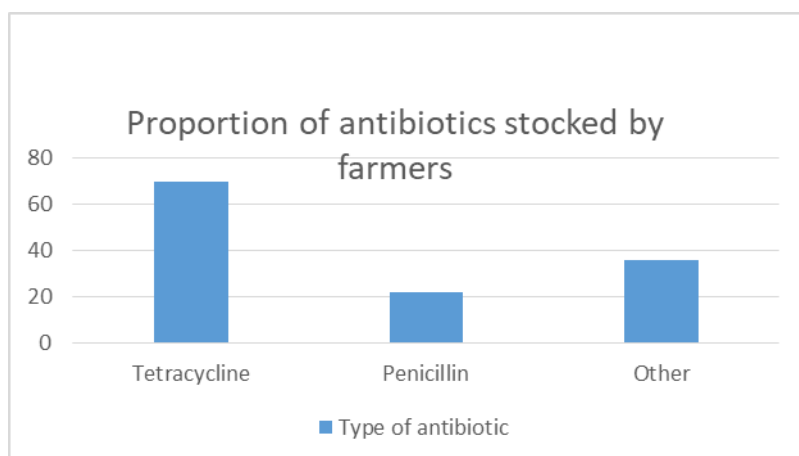


Figure 5 Proportion and type of antibiotics stocked by farmers

Of the 100 farmers sampled, the antibiotic that most farmers used or stocked was tetracycline (tetracycline, terranox, Terramycin and aliseryl) which 70% of the farmers had, followed by sulphur-based drugs (33%) (Sulphonamides, Sulphadimidine, ESB3 and bremamed). 22% of the farmers use penicillins and enrofloxacin was used by 1% of the farmers.

Table 73 Other alternatives that farmers resort to when treating animals

	no other	concoctions	herbs	spiritual
Number	25	16	35	2
Percentage	35.7	22.9	50.0	2.9

Some farmers resort to other drug concoctions as alternatives to treating animals (23%). However, the majority of the farmers sampled use herbs (50%) as alternatives whilst 3% resort to spiritual solutions and 36% have no other alternatives.

4.4.2 Prevalence of antibiotic residues

Table 4.4 Prevalence by sample (beef, milk, poultry)

	Number of antibiotic positive samples	Total number of samples	Prevalence
Beef	27	41	66
Milk	32	49	65
Poultry	45	78	58
Total	104	168	62

A total of 168 samples were collected (beef=66, milk=65 and poultry=78)
 66% of beef samples collected were contaminated with antibiotic residues, 67% of milk were contaminated with antibiotics and 58% of poultry were contaminated. Of the 168 samples collected 104 (62%) were contaminated with antibiotic residues and significantly higher than the number of antibiotic negative samples (64; 38%) at 95% confidence level, $p < 0.05$

Table 8 Prevalence of antibiotic residues for each antibiotic class

	Number of tetracycline positive samples	Number of penicillin positive samples	Number of samples positive for other antibiotics	Total number of samples	Tetracycline prevalence	Penicillin prevalence	Prevalence of other antibiotics
Beef	20	15	10	41	49	37	24
Milk	17	22	2	49	35	45	4
Poultry	42	16	18	78	54	21	23
Total	79	53	30	168	47	32	18

49% of beef samples were contaminated with tetracycline antibiotic residues, 37% by penicillins and 24% other antibiotics.

35% of milk samples were contaminated with tetracycline antibiotic residues, 45% by penicillins and 4% other antibiotics.

54% of poultry samples were contaminated with tetracycline antibiotic residues, 21% by penicillins and 23% other antibiotics.

47% of all samples were positive for tetracyclines, 32% positive for penicillins and 18% positive for other antibiotics.

Table 9 Product sold vs small scale vs antibiotic residues found BEEF

Product sold	Type of production source	Number of farmers	Tetracycline	Penicillin	Other
Beef	Small scale comm	14	6	2	2
Beef	Subsistence	27	14	13	8
Milk	Small scale commercial	27	11	23	0
Milk	Large scale	2	0	2	0
Milk	Subsistence	46	16	20	2
Poultry	Subsistence	78	38	16	16

There is no significant difference at 95% confidence interval between product sold and tetracycline residues in food sold informally. Tetracyclines are commonly used on all products sold. This finding has implications that tetracyclines are most likely very easy to acquire and most used by farmers. Programmes must target regulation of tetracycline supply and use on all products. There was significant difference at 95% level ($p=0.012$) amongst products sold and frequency of penicillin antibiotic residues found. Milk products contained more penicillins than beef and poultry. Measures must look at why milk is mainly contaminated by penicillins.

4.5 Discussion

4.5.1 Prevalence of Antibiotic Residues in Mutare and Mutasa

Three main antibiotic classes were assessed: tetracyclines, penicillins and other antibiotics (for example sulphonamides, bacitracin, enrofloxacin etc) over three animal products, beef, poultry and milk as well as their production systems at source. Previous surveys in Zimbabwe showed that informal and subsistence production of cattle, beef and poultry is common and that these products are widely consumed on a per capita basis (ZimVac, 2023).

The following table illustrates the prevalence of antibiotic residues in many countries.

Table 10 Prevalence of antibiotic residues in food in different countries

Region/country	Prevalence of antibiotic residues in food	Type of food	Reference
North west Ethiopia	76%	Beef	(Agmas and Adugna, 2018)
Iran	22.8%	beef	(Soepranianondo et al., 2019)
Ghana	30.8%	beef	(Soepranianondo et al., 2019)
Pakistan	38.33%	Beef	(Soepranianondo et al., 2019)
Nigeria	44%	Beef	(Soepranianondo et al., 2019)
Turkey	57.7%	beef	(Soepranianondo et al., 2019)
Indonesia	14%	beef	(Soepranianondo et al., 2019)
Vietnam	7.4%	beef	(Soepranianondo et al., 2019)
Sindh province, Pakistan	49.75%	milk	(Mangsi et al., 2014)
Kenya	41.26%		
Zimbabwe	No data		

In Zimbabwe in Mutare and Mutasa, according to this present study, the overall prevalence of antibiotics in all samples was 62%. This tops the list except in Ethiopia when compared to findings in table 5.1 above.

66% of beef samples collected were contaminated with antibiotic residues, 67% of milk were contaminated with antibiotics and 58% of poultry were contaminated. These findings are alarming and should prompt swift action by responsible arms of the government, especially

considering that informal food production and marketing is very significant in Zimbabwe (Nyika, 2021, ZimVac, 2023). Consumers are at risk of consuming food contaminated with antibiotic residues.

4.5.2 Antibiotics types available to farmers

Local vet shops in town and around business centres serve as sources of antibiotics for farmers. There is a strong correlation between antibiotics stocked at vet shops and what farmers use on their animals and what the antibiotic residues found in most samples. Tetracyclines in their oral and parenteral constituted the most commonly used antibiotics and these are the most commonly stocked antibiotics from suppliers. Sulphur based antibiotics, penicillins and other antibiotics were also quite common along the chain. In Zimbabwe, whilst guidelines and legislation are present for control of prescriptions and antibiotic use, this study showed that controls and regulations are weak especially at the level of regulators who are the mandated competent authorities to govern antibiotics starting at suppliers, prescribers to farmers. The high prevalence of antibiotic residues (62% in all samples collected) is partly attributed to this.

Profiling for antibiotic types in use by farmers has not been done in Zimbabwe frequently. In Kenya, a study for antibiotics used from milk samples the most used antibiotics were tetracyclines (30.6%) followed by penicillins (16.7%) and sulphur drugs (9.4%) (Muloi, et. al, 2023). The most contaminant in beef samples was tetracycline, in milk it was penicillin and in poultry it was penicillin (analysed at confidence level 95%, $p < 0.05$ for each category). For milk samples used obtained from this study, penicillins were the most common antibiotic residues (45%) followed by tetracyclines at 35% and other antibiotics 4%. Further studies to describe and evaluate factors that influence the types of antibiotics in particular use from each sector (beef, poultry and dairy) may be necessary to understand why penicillins are most common residue found in milk samples or the other common antibiotic residues in different sectors.

The general antibiotic residue type commonly found for all samples was tetracycline at 47% followed by penicillins at 23% and other antibiotics at 17% prevalence analysed at 95% confidence level, $p < 0.05$). Tetracyclines, penicillins, aminoglycosides macrolides, amphenicols, sulphonamides, quinolones, fluoroquinolones and lincosamides are the most commonly used antibiotics for both animals and humans (Mgonja, et. al, 2023)

According to the Medicines Control Authority of Zimbabwe, tetracycline preparations across for all animal species are over the counter drugs meaning that a customer does not need a prescription as compared to other antibiotics. This may explain the abundance of tetracycline

residues in samples tested. Tetracycline is also a broad-spectrum antibiotic with uses not limited to bacteria but also parasite diseases. Tetracycline products are also packaged in far much wider range of preparations than antibiotics like oral, topical, injectable and infusible forms. Tetracycline preparations are by far the cheapest antibiotic type in the study area and in Zimbabwe. Tickborne diseases are endemic in Zimbabwe and account for over 65% of all diseases affecting livestock. The majority of tick-borne diseases are treated by tetracyclines, make it the most commonly used antibiotic in livestock. These factors will probably account for the abundance of tetracycline residues in food samples.

In milk samples, the most common antibiotic in this study was penicillin (45% of all milk samples). Penicillins are the main treatment for most conditions encountered in dairy cattle, for example mastitis, pyometra, lumpy skin disease. Treatment for mastitis and high somatic cell count involves intramammary infusion of penicillin-based antibiotics (Chen and Han, 202). Should farmers fail to observe the withdrawal period, penicillin residues will most likely be detected in the milk. Worldwide β -lactam group (penicillins) have been detected mostly (36.54%), followed by tetracyclines, (14.01%); fluoroquinolones, (13.46%); sulphonamides, (12.64%); and aminoglycosides, (10.44%) in milk (Sachi, et. al, 2019).

While this study did not focus on establishing the average daily intake for each type of food sampled, the prevalence of 58% to 66% (overall 62%) indicates a huge hazard due to exposure to antibiotics residues in food, in particular with regards to antibiotic resistance. Further antibiotic residue quantifying studies to measure antibiotic residues levels against maximum tolerable levels are required evaluate whether the antibiotic residues measured can have direct or indirect body harm on animals or humans. and presents the intensity of the hazardous effect. Results in a study in Bangladesh using a Hazard Quotient to express the risk posed to human health by consuming milk having residues revealed that the estimated daily intakes (EDI) were much lower than the acceptable daily intakes (ADI) for amoxicillin and oxytetracycline (Rahman, et. al, 2021). A similar study set up in Zimbabwe will build more to the current knowledge established in this study would prove to be of much value in determining food safety and potential adverse impacts of antibiotic residues in food.

Results from this current study revealed that there is no current policy or regulatory requirement to specifically test for antibiotic residues in food production at small scale or commercial scale except for milk collected by the country's main processors. Dairy Services Unit in the Department of veterinary Services tests milk for antibiotic residues from formal producers using qualitative tests. In 2023, 55918 litres of milk were discarded due to the presence of antibiotics. Assuming an average of 200ml milk consumption per day per person,

this represents about 280000 people deprived of milk that day, which can mean 10 days of no milk for Chipinge Urban in Eastern Zimbabwe (Census 25962), just because of antibiotic residue contamination.

For the informal traders where no regulatory checks are done, this means gradual poisoning and perpetuation of the problem of antibiotic resistance. There is a little or no information for detailed investigations on the impact of antibiotic residues and resistance on animals in Zimbabwe. 97% of the veterinarians interviewed in the study indicated that there are not in a capacity to follow up or diagnose cases of antibiotic resistance in animals. Human health studies in Zimbabwe have demonstrated well the evidence of antibiotic resistance but very little on how antibiotic residues, antibiotic resistance and impact on human health are linked in particular, Zimbabwe.

Table 11 Effect of production system on type of antibiotic residues and prevalence

Production system Source	Type of Product	Total number of farmers	Tetracyclines	Penicillins	Other
Subsistence	Beef	27	14	13	8
	Poultry	78	38	16	16
	Milk	46	16	20	2
Small Scale	Beef	14	6	2	2
	Poultry	0	0	0	0
	Milk	27	11	23	0
Large Scale	Beef	0	0	0	0
	Poultry	0	0	0	0
	Milk	2	0	2	0

The table above summarizes prevalence of antibiotic residues per production source and product. Subsistence farming was the main source of animal products sold informally. This agrees with the ZimVac 2023 report that most 90% of national cattle herd is owned by and 37% of low-income households own cattle. Most antibiotic prevalence for all types occurs in rural herds and flocks. It was also noted that a considerable proportion of food originating from small scale production system contained antibiotic residues. Only 2 samples milk were originating from large scale commercial farms and all of them were contaminated with antibiotic residues. It is postulated that informal trade of milk from large commercial farms is purposefully done for milk that is known to be contaminated by antibiotic residues and will otherwise be rejected in the formal market. The informal way thus would be an avenue to salvage milk from mastitis cows treated or recently treated with antibiotics.

As study in Ethiopia showed that pastoralists more commonly used antibiotics (87% of all drugs used) against other drugs used and overall, tetracyclines (36.4%), aminoglycosides (31.3%), and trimethoprim-sulphonamides (6.2%) were the most frequently used classes of antibiotics across the study sites (Gemed, et. al, 2020)

4.6 Recommendations

This study found out that there are weak controls on retail outlets that sell antibiotics to the general public. Dispensers are also governed under the Veterinary Surgeons Act in Zimbabwe. The powers and duties of paraprofessionals working in government service are provided for under the Animal health Act. Administration of veterinary drugs and dispensers falls under the ministry of health in Zimbabwe and most SADC countries. Veterinary drugs always receive the lower priority if they are administered together with human drugs under the control of human health authorities, and this causes delays in the processing of veterinary drug matters (Fingleton, 2004). As such, use of antibiotics is under much better use for humans than for animals and for this reason it may be necessary to make legislative amendments to place some degree of direct control of veterinary drugs under the minister of agriculture. Broadly breaking the ministry of Lands, Agriculture, Fisheries, Water and Rural resettlement to crops production, land and water issues, and other matters from animal health, production, welfare, aquaculture and other matters can be a measure which will align priorities and focus animal affairs for the better.

Requirements for qualification levels and conduct of veterinary drug retailers need to be reviewed to make mandatory that a veterinary doctor, veterinary pharmacy technologist, pharmacist, or specialist pharmacologist veterinary paraprofessional must own at least 55% share in veterinary drug retail shop whose presence must always be within 10 meters of the outlet during business operating hours. Veterinary regulations that open shop practicing of veterinary medicine must be strictly implemented. The department of veterinary services can form a drugs policy enforcing unit with duties of carrying out drug consumption, use monitoring as well as reconciling drug supply and use quantities. The unit will also be responsible for drug residue monitoring in all food samples of animal origin.

4.7 Conclusion

Antibiotics supply to farmers and acquisition by farmers is abundant, albeit, with inadequate regulatory control. Antibiotic misuse and over use is rampant in Mutare and Mutasa amongst livestock farmers. Antibiotic residues, that reflect antibiotics available on the market and in use by farmers, are prevalent and are a huge risk to consumers of food of animal origin in Mutare and Manicaland. Given that they exist similar patterns of informal trade across the country, this study is an eye opener to the stark reality of the risk of antibiotic residues to people and animals. Further special studies must follow to characterise clinical effects of antibiotic residues on people and animals. Medicine control, veterinary profession and farmers must brace up and confront the realities of shortcomings of antibiotic management and use policies highlighted in this study. This study systematically assesses factors associated with antibiotic supply, acquisition by farmers, management by veterinary doctors and paraprofessionals, knowledge and attitudes and the results present a body of information and knowledge applicable to remedial measures for tackling antibiotic residues in food.

4.8 References

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CHAPTER 5: RESULTS (Factors that influence the presence of antibiotic residues in food)

Antibiotic residues in milk, poultry and beef from informal traders and implications on food security: A case of Mutare and Mutasa Districts of Manicaland Zimbabwe

ABSTRACT

Food security has been compromised due to the presence of antibiotic residues in food of animal origin. Antibiotic residues are directly harmful to those that consume antibiotic contaminated food, and cause antibiotic resistance in both people and animals. The problem of antibiotic residues in food is very serious but yet is poorly studied and its magnitude is not objectively outlined in Zimbabwe. A cross sectional study was done in Manicaland Province of Zimbabwe in 2024 on beef, milk and poultry meat sold informally, to determine prevalence of antibiotic residues and antibiotic residues were found to contaminate 62% (104, n=168) of the samples tested. Tetracyclines were the most common antibiotic residues affecting 79/168 samples, followed by penicillins at 53/168 samples and then other antibiotics at 30/168 samples. The most common antibiotic in beef and poultry was tetracycline (49% and 53% respectively). For milk penicillins were the most common antibiotic residues (45%). Antibiotic access system was found to be compromised at the level of antibiotic retail outlets, antibiotic regulation and poor farmer antibiotic use practises and attitudes. Drug retail outlets are operated mostly by unqualified persons and the acquisition of prescription items is almost free, whilst the veterinarians are not well capacitated to provide the best antibiotic stewardship and management practises to farmers. Farmer antibiotic practises were found to be unguided, antibiotic misuse, overuse or irrational use. More education is required to promote practices that promote biosecurity practises on farms which should lead to reduced need to use antibiotics and therefore reduction of antibiotic residues. The findings in this study form one of the earliest pieces of knowledge to better understand the impact of antibiotic residues and the link for animal production to One health family in tackling animal health and public health challenges involving zoonotic pathogens in Zimbabwe.

Keywords: antibiotic residues, antibiotic resistance, prevalence of antibiotic residues, food security, Mutasa, Mutare

5.1 Introduction

This chapter focuses on drivers of factors that cause food of animal origin to end up contaminated by antibiotic residues. These include circumstance that farmers find themselves in to the extent that they end up engaging in practises which result in antibiotic residues in the food that they produce. The results also presented here paint a picture of the impact of antibiotic residues on food security. The chapter then uses the results of the study to discuss possible interventions to address the problem of antibiotic residues in food. Antibiotic supply at veterinary drug shops is driven by desire to achieve sales at the expense of ethics and principles. Farmers find at the mercy of veterinary drug assistants' advice which often is unprofessional and misleading, resulting irrational and overuse of antibiotics. On the other end veterinarians have no capacity to reach out to as many farmers as may be required in order to provide expert guidance on antibiotic use.

5.2 Methodology

Data collection involved administering questionnaires to farmers and drug retail outlets, as well as collecting samples of beef, poultry, and milk. Both secondary and primary data were gathered, with the latter obtained through purposeful sampling, snowballing, and focus group discussions on farmer WhatsApp groups, supplemented by physical enumeration of close-ended questionnaires. Data was uploaded to Kobo, downloaded to MS Excel, and analyzed using SPSS, Excel, and MS Word. Findings were presented in narratives, tables, graphs, and pie charts. The sample size was determined based on secondary data from Local Authorities, which provided household numbers and livestock data per village or suburb. Descriptive statistics, tables, graphs, and pie charts were generated using Excel and SPSS, while themes were analyzed using MS Word's "find" option. The Chi-squared test was employed to measure the significance of associations between frequencies of occurrences across categories.

5.3 Results

Table 12 *Frequency of antibiotic use by farmers*

	Never use antibiotics	Sometimes used antibiotics	Often used antibiotics	Every time
Number of farmers	3	37	20	6
Percentage	4.3	52.9	28.6	8.6

The frequency of antibiotic use between farmers differs significantly (95% confidence level, $p=0.00$). 4% of the farmers interviewed never use antibiotics. 37 (53%) sometimes use antibiotics and 20 (28.6%) indicated that they used antibiotics frequently. 6 (9%) farmers indicated that use antibiotics every time. A total of 96.7% use antibiotics at one time and this has implications for prioritising targeting antibiotic use regulations on farmers.

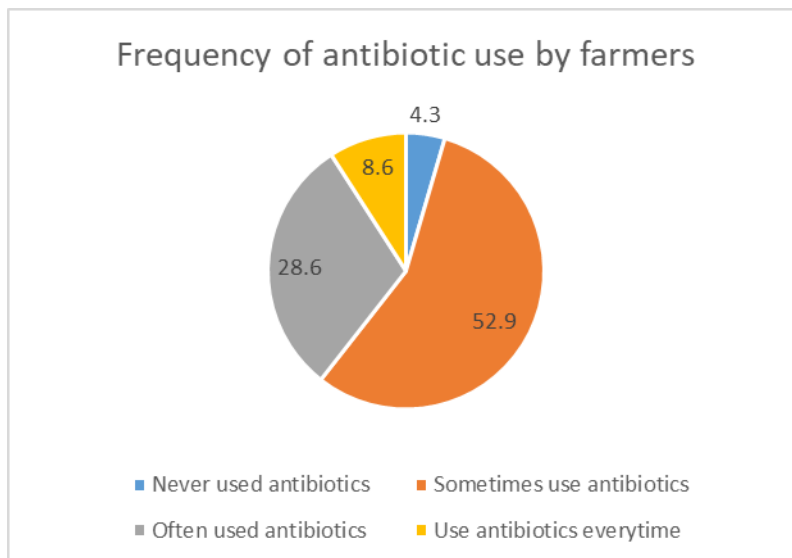


Figure 6 *Frequency of antibiotic use by farmers*

Table 13 *Access to prescription by farmers*

	It is easy and convenient to get a prescription	It is not easy and convenient to get a prescription at all	Prescriptions are moderately accessible
Number	30	25	60
Percentage	26	22	52

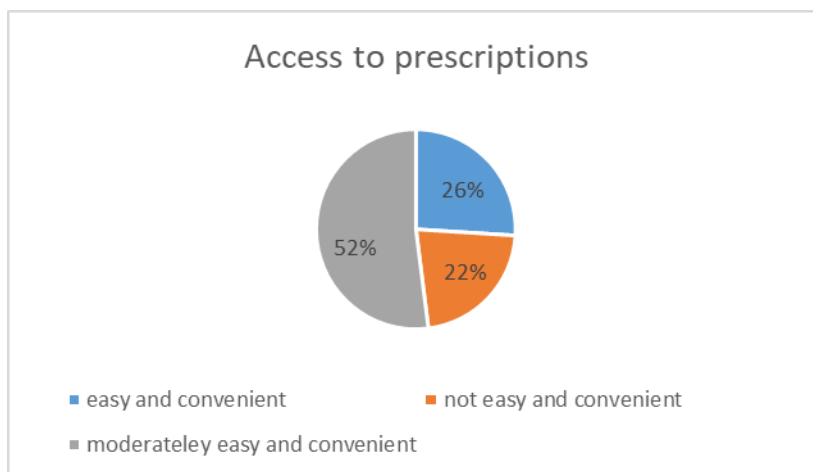


Figure 7 Access to prescriptions

22% of farmers find prescriptions difficult to get while 78% can access easy prescriptions if they need to.

Table 14 Where farmers obtain their antibiotics (antibiotic source for farmers)

	Vet shops	Pharmacy	Animal Health Management Centre	Veterinary doctors	Veterinary Extension Worker	Agric Extension worker	Fellow farmer	Import on their own	Dealers	Clinics
Percentage	73	5	13	16	16	2	3	1	3	2

There is significant association of place antibiotic source, (analysed at 95% level, $p=0.00$). 73% of interviewed indicated that the VMGD (vet shop) was their main source of antibiotics, 5% got antibiotics from a pharmacy, 13% from Animal Health Management Centres 13% from veterinary doctors, 16% from the veterinary extension officer, 2% from the agriculture extension officer, 3% from a fellow farmer, 1 % import down their own, 3% get from dealers and 2 % from clinics. This points out that more effort must be prioritised at controlling antibiotic acquisition by farmers at the veterinary drug shops and relatively significant input at veterinarians and veterinary extension workers that supply farmers with drugs.

Table 15 Access to Antibiotics by farmers through cross border runner

	TRUE	partly true	FALSE
Number of farmers	6	30	48
Percentage	4	21	75

25% of farmers indicated that it is possible to get antibiotics from cross border runners

5.3.1 DETERMINANTS (DRIVERS FOR ANTIBIOTIC USE)

Table 16 *Decision when or what antibiotics to use*

	Advice or prescription from veterinarian	Advice from Veterinary officer (VEO)	Advice at vet shop (VMGD)	Advice from pharmacist	Advice from fellow farmer	Advice from other lay persons, farm workers	own decision
Number	28	31	25	2	12	1	0
Percentage	40.0	44.3	35.7	2.9	17.1	1.4	0.0

The table above shows that farmers decision to use antibiotics is based on advice given by VEO (44.3%), veterinary doctor’s prescription (40%), advice given at the VMGD (36%) advice at the pharmacy (3%), advice from a fellow farmer (17%), advice from lay persons or farm workers (1%) (95% confidence level, p=0)

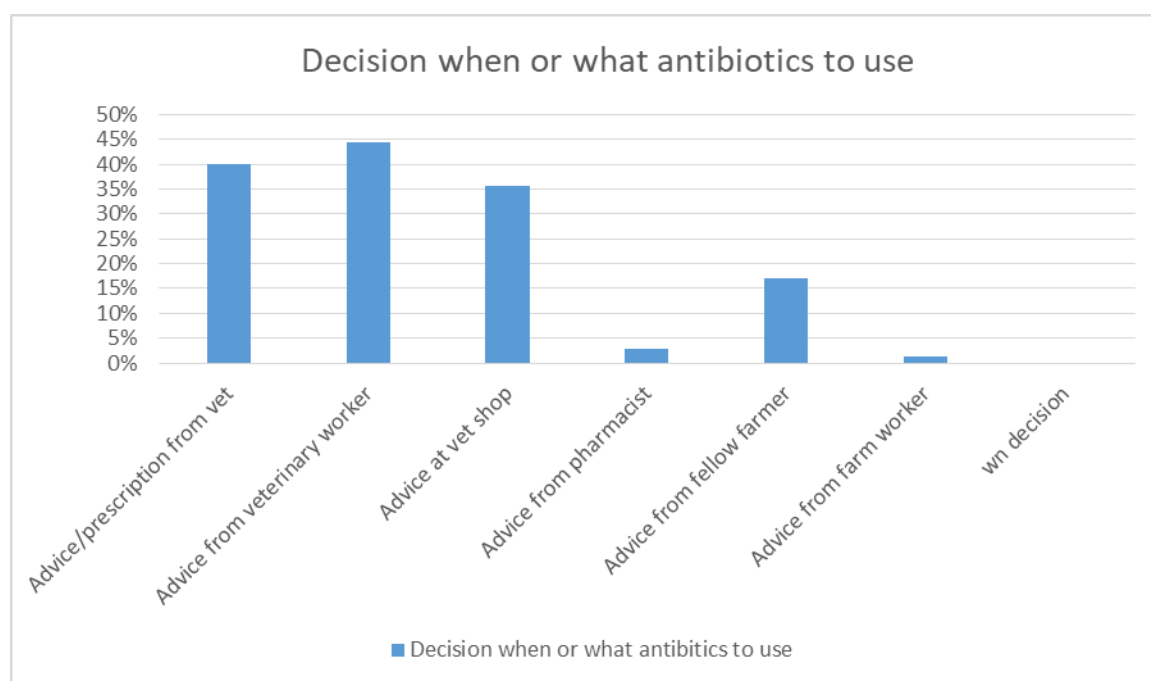


Figure 8 *Decision when or what antibiotics to use*

Table 17 *Farmer’s opinion on who has authority to write a prescription for antibiotics*

	Pharmacist	Veterinarian	Veterinary extension worker	Agriculture extension worker/Mudhumeni	Any person	No need	Vet shop assistants	medical doctor or nurse
Number	0	117	39	13	1	3	10	7
Percentage	0	62	21	7	1	2	5	4

There is association between various farmers perceptions and who has authority to issue out antibiotic prescriptions. 62% of the farmers think that a prescription for antibiotics must come from a veterinarian, 21% think a veterinary extension officer can write out a prescription. 7% of the farmers think that an Agriculture extension worker/Mudhumeni is entitled to write out

a prescription whilst 1%% think that any person can write a prescription, 2% think there is no need for a prescription if one wants to buy antibiotics. 5% think vet shop assistants have authority to write out prescriptions and 4% of the interviewed farmers think medical doctors or nurses can write prescriptions for animals.

Table 18 How farmers use antibiotics on the farm

	Guided by instructions on label	Explained by veterinarian	Explained at vet shop	explained by veterinary extension worker	explained by other farmer	explained by mudhumeni	Thumb suck	Explained by lay person or farm worker
Number	48	20	9	11	3	8	0	0
Percentage	68.6	28.6	12.9	15.7	4.3	11.4	0	0

(Confidence level, 95%, p=0.00)

The majority of farmers (68.6%) determine antibiotic use and administration guided by label instructions whilst 28.6% are explained by the veterinarian, 12.9% get explanation on use at the vet shop, 15.7 % use the VEO for explanations, 4.3% ask a fellow farmer, and 11.4% ask an agritex officer.

Table 19 Time when to use antibiotics

	Antibiotics must be used always at start of rearing (day old)	Antibiotics must be used to sick animals only	Antibiotics must be used to all animals at all times	Antibiotics must be used to those that are nearing slaughter
Number	5	58	8	0
Percentage	7.1	82.9	11.4	0

7.1 % of the farmers interviewed use antibiotics at the start of the rearing period, 82.9% give antibiotics to sick animals only, 11.4% give antibiotics to all animals at all times and no farmers would give antibiotics to animals nearing slaughter.

Table 20 Which group of animals to administer antibiotics

	I will give antibiotics to the rest of the animals even those looking healthy	I will give antibiotics to the sick ones only
Number	51	70
Percentage	42	58

The majority of 121 farmers interviewed (58%) will give antibiotics to sick animals only and 42% will treat all animals including healthy ones

Table 21 *When there is no apparent recovery*

	add more antibiotic	use a different antibiotic	ask the vet for advice	consult the vet shop for advice	ask a fellow farmer for advice
Number	6	24	40	6	0
Percentage	8.6	34.3	57.1	8.6	0.0

When there is no apparent recovery, 8.6% of the farmers would add more antibiotic, 34.3% would shift to a different antibiotic and the majority (57%) would ask a vet for advice whilst 8.6% will consult a vet shop for further advice.

Table 22 *Withdrawal period*

Withdrawal Period	Number	Percentage
Withdrawal period is guided by antibiotic label	57	81
After 3 days	2	3
after 2 weeks	4	6
after 3 weeks	3	4
More than 28 days later	4	6

81% of the farmers correctly know when to observe drug period following antibiotic manufacturer's instructions whilst 19% withdraw antibiotics using practices that are not derived from manufactures instruction.

Table 23 *How farmers deal with an animal that died whilst under antibiotic course*

	Consume	Bury	Burn	Feed to other animals
Number	3	54	35	1
Percentage	4.3	77.1	50.0	1.4

A greater majority of farmers correctly dispose and destroy by burning or burying animals that died under antibiotic therapy whilst 5.7% engage in the risky behaviour of either consuming the meat or feeding to other animals.

Table 24 Knowledge on what an antibiotic is

	Medicines to treat germs and infections	Medicines to prevent animals from acquiring germs or infections	Medicines to make animals grow	medicines to treat worms	antibiotics are vaccines	antibiotics kill viruses
Number	49	9	2	0	4	6
Percentage	70.0	12.9	2.9	0.0	5.7	8.6

70% of the farmers interviewed correctly knew what an antibiotic is and 30% were wrong in their knowledge of what an antibiotic is.

82% of the farmers pointed out correctly what antibiotic resistance meant.

Table 25 Knowledge of approved and registered antibiotic preparations

	Know approved or registered antibiotics	
	yes	no
Number	5	18
Percentage	22	78

Significantly more farmers, (78%) have no idea which drugs are registered and approved for use in Zimbabwe than those that know (22%) when analysed at 95% confidence level, p=

Table 5.15 awareness to effects and dangers of antibiotic residues

	yes	partly	no
Number	7	9	6
Percentage	32	41	27

27% of farmers professed ignorance of the effects of antibiotic residues in food while 41% had some knowledge and 32% agreed that they were aware

Table 26 Awareness to effects and dangers of antibiotic residues

	Antibiotic residues make us sick	antibiotic residues make us grow too fast	antibiotic residues cause antibiotic resistance	antibiotic residues have little or no effect on animal or human health	antibiotic residues actually can protect people or animals that consume the food
Number	6	0	13	2	0
Percentage	29	0	62	9	0

62% of the farmers correctly pointed what antibiotics residues do the body whilst 38% do not know what antibiotics residues do to the body.

Table 27 Awareness to use of antibiotic

Antibiotics are used for	preventing healthy animals from getting sick	treating sick animals	help animals to grow faster and healthier
Number	7	14	1
Percentage	32	64	4

64% of farmers know antibiotic uses and 36% do not know antibiotic uses

Table 5.18 Engaging in practices that prevent antibiotic overuse

Table 28 Engaging in practices that prevent antibiotic overuse

	Vaccination	Cleaning	Disinfection
Number	44	42	25
Percentage	62.9	60.0	35.7

37% of the farmers do not vaccinate their animals, 40% do not engage in cleaning and 64% do not use disinfectants.

Table 29 Reducing antibiotic overuse (identifying actions that prevent antibiotic over use)

	Dipping cattle	Handmilking	separating healthy animals from sick ones	vaccination	branding and ear tagging	keeping records	cleaning and disinfection
Number	3	1	1	5	0	5	1
Percentage	19	6.25	6.25	31.25	0	31.25	6.25

Dipping cattle, segregation, vaccination cleaning and disinfection are the correct practices for preventing antibiotic overuse. 38% of the farmers interviewed incorrectly pointed to handmilking, branding and keeping records as practices that prevented antibiotic overuse. 81% of the farmers did not see how dipping prevented antibiotic use, neither could 94% identify that segregation prevented potential introduction of bacterial infection which in turn reduces antibiotic use. 94% of the farmers were not aware that cleaning and disinfection are important biosecurity practices that reduce the burden of antibiotic use.

5.3.2 Antibiotic Prescribers

Table 30 Effectiveness of policing of antibiotic use in Zimbabwe

	Yes	No	Moderate
Number	0	51	2
Percentage	0	96	4

96% of the veterinarians, who are the authorized prescribers of antibiotics for animal use believe that policing and regulation of antibiotic use is not effective.

Table 31 Control of antibiotic use and consumption is poor at

	Antibiotic importation	Retail outlets (VMGDs, pharmacies)	farmer level	Regulators	Others
Frequency	6	36	17	28	0
Percentage	7	41	20	32	0

Veterinarians believe that control for antibiotic use or consumption is not effective at the level antibiotic retail outlets (VMGDs) (41%) and Regulators (32) (Medicines Control Authority of Zimbabwe, Council of Veterinary Surgeons of Zimbabwe, Zimbabwe Republic Police, Department of Veterinary Services. Control of antibiotic use or consumption is lost at farmer level (20%) and some control is also lost during drug importation.

Table 32 How veterinarians determine which antibiotic to use given a bacterial infection

	Random	Experience	Standard operating protocols/guides	Guided by AST results
Number	0	41	9	6
Percentage	0	73	16	11

Only 11 percent of interviewed veterinary doctors are guided by results from antibiotic sensitivity testing to determine type of antibiotic to use when treating infections. 73% rely on

their experience and 16% use standard operating to help them determine which antibiotic to use.

Table 33 Use of AST to guide in therapy for bacterial diseases

	Never	A few times	Often	Always	Only for clients willing to pay
Number	36	10	0	0	6
Percentage	69.23077	19.23077	0	0	11.53846

69% of the veterinarians do not use antibiotic sensitivity test (AST) results to guide antibiotic therapy. 12% use AST only for clients that are willing to pay and 19% use AST a few times.

Table 34 Basis for final diagnosis is based on

	History	PE	Xray, US, blood and tissue assays	Identification of causative agents
Number	23	46	5	0
Percentage	31.08108	62.16216	6.756757	0

None of the veterinary doctors interviewed use the recommended approach of laboratory identification of the causative agent as basis for their final diagnosis of infections.

Table 35 Diagnosing cases of antimicrobial resistance (AMR)

	Never	Rare	Often	I have no way of knowing/diagnosing/follow up
Number	0	0	1	44
Percentage	0	0	2.222222	97.77778

98% of veterinarians indicated that they have no capacity of making diagnosis or following up on cases of AMR.

Table 36 Advice over the counter

	Advise over the	Advise over the counter in vet	Advise over the

	counter in vet shops always work well	shops sometimes works well	counter in vet shops is not the best
Number	98	102	31
Percentage	43.5	43.5	13

43.5% of farmers find that the advice given over the counter at vet shops (VMGDs) works for the recovery of their animals, 43.5% are skeptical and 13% do not find the advice useful.

Table 37 Practices by antibiotic suppliers

	Accepted without questions	Needed a little persuasion	Insisted on prescription
Number	15	1	1
Percentage	88	6	6

The majority of vet shops selling antibiotics (88%) had no problems selling antibiotics to farmers without a prescription, 6% would not accept to sell antibiotics without a prescription and 6% required a little persuasion to relax conditions of a doctor’s prescription before supplying antibiotics.

Table 38 Presence of qualified professionals to handle and dispense prescription drugs

	Duty veterinarian/Pharmacist/Veterinary extension officer/paraprofessional	
	Present	Absent
Number	4	12
Percentage	25	75

Only 4 outlets visited had either a duty veterinarian present responsible for judicious and compliant dispensing of prescription drugs. Only one outlet was manned by a qualified veterinary doctor.

5.3.3 CONSUMER PREFERENCES

Table 39 Consumer preferences when buying

	Frequency	Percent	Valid Percent	Cumulative Percent
Colour, texture, smell, fat content, price	168	100.0	100.0	100.0
Antibiotic residues	0	0	0	0

No consumer makes decision of their choice to buy food stuffs based on whether the food has antibiotic residues or was tested.

5.3.4 Prevalence of human AMR cases in human patients in Mutare and Mutasa

According to records from the Provincial Medical office, about 5 cases of antibiotic resistance are recorded every week. The provincial medical laboratory has recorded mainly antibiotic resistance to ciprofloxacin, tetracycline, ampicillin and nalidixic acid in the May 2024.

5.4 DISCUSSION

5.4.1 Antibiotic Supply

Only three vet shops possessed the full panel of licenses required for selling veterinary medicines. Only one outlet had a duty veterinarian manning the shop to provide professional assistance. In Zimbabwe, prescriptions can only be dispensed from a licensed premises by a licensed persons (Persons License and Premises Licence)

This means that for the 16 outlets visited 81% sell drugs uncontrolled or unregulated giving rise and chance that subsequent possession and use of antibiotics by farmers is unguided.

5.4.2 Determinants Of Antibiotic Use

5.4.2.1 Access to prescription by farmers

22% of the farmers in this study indicated that a prescription is not easy to get for antibiotics. Mutare and Mutasa are served by one veterinarian each for the district. Veterinarians in the districts often face mobility challenges, which affects the ability to provide adequate services in time. Other veterinary extension officers can assist in providing prescriptions under the direction of the veterinarians but farmers in most case in the low-income bracket find it challenging to access these services. This has the effect of negatively impacting on the ability of the farmers to use antibiotics with full guidance and advice from the competent professionals and results in irrational antibiotic use on animals. It has been explained that irrational antibiotic use is an important factor that causes presence of antibiotic residues and eventual development of antibiotic resistance (Selamawit, 2019).

5.4.2.2 Source of antibiotics for farmers

The vet shop is the place that most farmers obtain their antibiotics. Given that from the study, only one of the 16 shops had a duty veterinarian to assist with proper professional guidance

on prescriptions and the rest were manned by more or less unqualified persons without professional qualifications to prescribe, antibiotic use and stewardship can be regarded as poor. Furthermore, the study noted that acquisition of antibiotics is relatively regarded in the strictness and aptitude required. Unqualified assistants may provide incorrect or misleading advice potentially leading to incorrect antibiotic dosage, unnecessary use or inappropriate drug choice. The high prevalence of antibiotics seen in this study can also be attributed to this set up. This study shows a relatively significant proportion of respondent farmers expressing faith in advice by these unqualified shop assistants. Unqualified shop assistants undermine the expertise and authority of qualified veterinarians leading to a loss in trust and breakdown of the prescription system.

5.4.2.3 Demand for prescriptions

By definition, Rational Antibiotic Prescription refers to the purposeful and appropriate antibiotic prescription with correct dose for patients with real need for antibiotic therapy to produce the most possible positive effects and less possible side effects. Prescriptions reduced irrational antibiotic use (Sami, et. al, 2022). The fact that 94% of the veterinary retailers in the study accepted to sell prescription drugs without a prescription from a competent person signifies rampant antibiotic use likely to cause antibiotic residues in food and consequently other associated negative effects to people and animals.

5.4.2.4 Frequency of antibiotic use by farmers

Antibiotic consumption profiles in developing countries are greatly influenced by the gross abuse and misuse of antibiotics due to their availability over the counter, through unregulated supply chains as well as the purchase without prescriptions (Manyi-Loh, et. al, 2018). Whilst about 9% of the farmers sampled always use antibiotics throughout the lifespan of their animals, 23% to 53% actively use antibiotics. This sets a scenario for potential antibiotic overuse. Antibiotic overuse is when antibiotics are used for instances when not required, or farmers excessively treat all animals even healthy ones when one or a few show signs of sickness. Almost half of the farmers interviewed (42%) confessed to this. Antibiotic overuse also occurs when antibiotics are used as a substitute of disease preventive practices of good hygiene, cleaning, disinfection, vaccination and good nutrition with little or no understanding of the impact of residues on health or development of antibiotic resistance (Shallcross and Davies, 2014). When there is no apparent recovery from antibiotic farmers sampled showed tendencies for antibiotic overuse as quite a number (43%) indicated that there will take things

into their hands and play around with dosages or try different antibiotics at the expense of reverting back to the veterinarian to seek further guidance.

38% of farmers think that other persons other than a veterinarian has authority to issue a prescription for an antibiotic. This reliance and trust in unqualified persons gives chance and risk to wrong diagnoses, wrong treatments and irrational antibiotic use which can give rise to antibiotic residues. Studies with scope of assessing and evaluating death and reliability of shop assistants, veterinary paraprofessionals and other agricultural workers working at with antibiotic dispensing can be done in order to further describe the role and impact on qualification on presence of antimicrobials in food of animal origin.

5.4.2.5 How farmers use antibiotics on the farm

The best way to use antibiotics is to follow instructions on the prescription by the veterinarian and preparation label. In this study, whilst a greater proportion of farmers relied on the veterinarian's prescription and drug label 97%, the same would still rely on unqualified prescribers for usage information. Using unqualified persons has high chances of incorrect, overuse or irrational antibiotic use.

5.4.2.6. Time when to use antibiotics

Antibiotics must be given judiciously and only when necessary to sick animals. Some farmers and some drug retailers subscribe to administration of antibiotics to livestock at various or different points during the rearing period. Some people believe antibiotics given at the start of rearing, for example day old chicks, will prevent the animals from disease. Some believe antibiotics should be given somewhere in midlife. The results of this study showed 7.1% will initiate antibiotic provision at start of rearing, and 11.4% think antibiotics must be administered throughout the life of an animal. This practice is actually irrational and overuse of antibiotics and will give to antibiotic residues and development of antibiotic resistance.

5.4.2.7 Withdrawal period

Antibiotic withdrawal period is the time following antibiotic administration during which the meat or products from animals is considered to contain significant antibiotic residues. The length of this period is based on the time necessary for drug residues in the animal to deplete to levels that are known to be safe and the withdrawal period is not the same for different antibiotics. Consumption of meat or products from animals before the withdrawal period results in exposure to subtherapeutic antibiotic levels which give rise to antibiotic resistance

and potential harm from antibiotic adverse effects (Ibrahim, et. al, 2023). In the present survey 81 % of the farmers rightly pointed out that withdrawal period is guided by product label and 19% showed tendencies of misguided behaviour when observing drug withdrawal period. In practice, farmers may not observe withdrawal periods because it can be costly and regarded uneconomic to keep animals beyond a slaughter age when the time is extended due to antibiotics. Sometimes salvage slaughter happens for animals undergoing antibiotic treatment course in order to meet market pressures. Disregard of withdrawal period may also be unfortunately incentivized due to lack of regulatory requirements on antibiotic residue level or limits. As found in the study, there is evidence of limited farmer guidance on drug use by veterinarians which makes it harder for them to follow withdrawal guidelines. Farmers may lack full understanding on drug residues and importance of withdrawal period. A significant number of farmers (30%) did not fully understand what an antibiotic is and 36% could not correctly point to what antibiotic is used for, whilst 38% of farmers were unaware of the dangers of antibiotic residues. Such lack of knowledge can lead farmers to disregard withdrawal periods.

5.4.2.8 Counterfeit, Unregistered or unapproved antibiotics

Some antibiotics that have been fraudulently manufactured, having incorrect active ingredients, wrong concentrations or contaminated by unsafe substances sometimes find themselves on the market. Some of the antibiotics may also not be approved for use or not gone under efficacy and safety trials. Antibiotic resistance has emerged as a major global issue and if a patient is taking a substandard antibiotic, the outcome is bound to be an increase in antibiotic resistance (Pathak, et. al, 2023). The potential and risk of counterfeit drugs exacerbating the problem antibiotic resistance through antibiotic residues in the study area is real since 78% of the farmers interviewed could not tell between registered or approved antibiotic preparations.

5.4.2.9 Advice over the counter

The farmers' perception is that over-the-counter advice in vet shops usually works (87% of the farmers). Prescription drugs should be sold only after consulting with a veterinarian who is under obligation and principle to write prescriptions for patients under his direct care and supervision. Over the counter diagnoses, advice and prescriptions at veterinary shops are thus based more on history or rumour and are against professional standards and principles of responsible antimicrobial stewardship practices and will most likely cause misuse and overuse of antibiotics.

5.4.3 Measures that prevent antibiotic use or overuse

No studies have been carried out to assess and correlate the use of antibiotics and tick control in livestock in Zimbabwe. However, in Uganda, acaricide application has been associated with lower tickborne disease burden. Tick borne diseases such as heartwater, anaplasmosis and theileriosis are treated using tetracyclines, therefore poor tick control results in high incidence of tick-borne diseases and increased need to use antibiotics which is in itself a hazard for antibiotic overuse and residues (Byaruhanga, et. al, 2020). Similarly other biosecurity practices such as cleaning, disinfection and segregation reduce chance of bacteria from being exposed to animals and causing infections. Vaccination increases immunity of animals to bacterial infections for example brucella vaccine reduces the need to use antibiotics to treat brucellosis in cattle. In this study it was revealed that a significant proportion of farmers are not aware that dipping helps the need to reduce antibiotic use (81%).

Only 6% of the farmers were aware that separating sick animals from healthy ones will prevent antibiotic overuse. Similarly, only 6% worked out that cleaning and disinfection help reduce antibiotic use. 69% were unaware that vaccination is very important in preventing antibiotic overuse. These factors highlight the reasons why antibiotic residues end up in animal products.

5.4.5 Antibiotic use and consumption regulation and control

Ideally antibiotic use and consumption guidelines are enshrined in the government policy, legislation and regulations through several bodies. In Zimbabwe, persons handling antibiotics are regulated, authorized and monitored by the Medicines Control Authority of Zimbabwe (MCAZ) and the Council of Veterinary Surgeons of Zimbabwe (CSVZ). The Department of Veterinary Services is a major stake holder since it also employs many veterinarians and veterinary paraprofessionals in its field services and technical services departments and its activities are outlined in the Animal health Act. Veterinary paraprofessionals lack regulation since there are not registered under any body and their activities are to an extent not accountable hence their advice and use of antibiotics is a potential risk of antibiotic misuse and irrational use. The CSVZ is currently at an advanced stage of amending and reviewing the Veterinary Surgeons Act and its regulations in order to account for activities of all players in the veterinary and animal health profession. Many of the veterinary drug retailers have no MCAZ registration nor are their staff authorized to possess MCAZ Persons and Premises licenses for drugs. Veterinarians involved in this study were of the opinion and view that

control and accountability of antibiotics is poorly done at the level of veterinary drug retailers, at MCAZ, DVS and CVSZ and use by farmers.

5.4.8 Practises by veterinarians that cause antibiotic residues

A look at the expert staff complement of veterinarians indicates that performance of veterinary services (PVS) falls short in Zimbabwe because 60% of the posts are currently filled (DS Human Resources Return, 2023). Shortage of veterinarians, the competent persons responsible for prescription writing and professional advice and guidance for farmers, compromises the access by farmers to information for correct and rational antibiotic use. When veterinarians determine which antibiotic to use given a bacterial infection, it was found out that only 11% rely on antibiotic sensitivity tests (AST) for selecting the best antibiotic use. Antimicrobial susceptibility testing (AST) is a laboratory procedure performed by medical technologists (clinical laboratory scientists) to identify which antimicrobial regimen is specifically effective for individual patients. On a larger scale, it aids in the evaluation of treatment services provided by hospitals, clinics, and national programs for the control and prevention of infectious diseases (Bayot and Bragg, 2022). AST helps reduce overuse and incorrect use of antibiotics therefore reduces chances of antibiotic residues and resistance. AST in animal diagnostics in the study area is expensive and is not conveniently available which forces veterinarians to rely more on experience and other routinely available basis of diagnoses to determine which antibiotic to use. Furthermore, veterinarians use physical examination (62%) as basis for diagnosis and it is not uncommon for them never to use laboratory identification or isolation of the causative as basis of diagnosis. Use of physical examination or minimal diagnostics results in more blanket treatments often involving a panel or protocol of both necessary and unnecessary antibiotics or trial and error (response to treatment approach). These approaches promote overuse of antibiotics.

If veterinarians are not capacitated or are in no position to follow up or monitor for possible antibiotic residues or resistance the problem of antibiotic residue and resistance then becomes unnoticed and lack follow up means no behavioural changes are done to correct for antibiotic overuse.

5.4.9 Consumer preferences

None of the farmers or consumers interviewed showed that they considered drug withdrawal periods or whether antibiotics were ever used in animals that produced the food they buy to determine their choice of purchase. Price, physical and smell were more important

determinants for the choice of food there bought. This behaviour means that the consumers are vulnerable to antibiotic residues and are at the mercy of other players in food production for their food safety and safeguarding of public health. Consumer watch dogs like the Consumer Council of Zimbabwe have no guidelines or check points for ensuring that food is not contaminated by antibiotic residues. A study in Tanzania found out that food was contaminated by antibiotic residues and consumers were largely unaware of the health risks and this study emphasized that farmer and consumer education and awareness should be prioritized. together with policies and actions to promote clean food production can go a long way in discouraging irresponsible antibiotic use by farmers (Mongi, et. al, 2022).

5.4.10 Prevalence of human AMR cases in human patients in Mutare and Mutasa

Evidence of people being directly and indirectly affected by antibiotic residues is available at hospitals. The problem of antibiotic resistance due to antibiotic residues is given less attention with most human health studies focusing on bacterial characteristics of antibiotic resistance at the expense of clinical effects of antibiotic residues and their impact on the spectrum of activities that affected individuals are jeopardised from. However great opportunity exists for one health collaborations for doing further in-depth studies of the detailed effect of antibiotic residues on people. The inclusion of agriculture production into one health concept is particularly interesting.

5.4.11 Veterinarians (Prescribers)

Issues that arose from the study identified weaknesses in diagnosis of infections, availability and convenience of laboratory confirmation of disease and use of antibiotic sensitivity tests to guide treatment. The central role of veterinarians in providing diagnostic advice, coverage and prescriptions was not well appreciated, with farmers preferring to use unqualified shop assistants for advice and prescriptions.

5.4.12 Impact of antibiotic residues

Data on prevalence of cases due to antibiotic residues in people was not well recorded and is not routinely reported in the Ministry of Health. Laboratory cases of antibiotic resistance have been reported in the study area. Whilst sick notes and leave forms due to disease are written, it is not standard practice at hospitals to file the sick leave forms. This area is potential for further dedicated research to fully describe the impact of antibiotic residues in Zimbabwe besides the theoretical possibilities. There is inertia in terms of research in antibiotic resistance against antibiotic residues.

5.5 RECOMMENDATIONS

Antibiotic control and farmer education are crucial to combat the problem of antibiotic residues in food. Veterinarians and paraprofessionals need to be well regulated and capacitated as well in order to strengthen antibiotic use stewardship. Antibiotic residues in food in Zimbabwe are a reality. Farmers have unrestricted access and unrestricted chance to use antibiotics irrationally. A paradigm shift in farmer attitudes and practices is needed as well as reigning on rampant and unethical drug sales at veterinary shops.

The most logical intervention is to tightly control and respect the antibiotics.

5.6 Conclusion

Antibiotic residues are real and prevalent in food. The informal sector has considerable market and food accessed in the sector has potential risk to public and animal health. Addressing the problem now will help avert a future health catastrophe and ensure sustainable safety.

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CHAPTER 6 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The consumption of beef, poultry and milk is major part of the diet. Animal production is a livelihood for a greater majority of rural farmers whose incomes are made through informal trade of the animal products they produce. Proliferation of veterinary shops to cater for the increased demand for animal health products has also been seen. However, the veterinary shops are often not fully accountable to antibiotic prescription principles and legislation on prescription items especially tetracyclines is inadequate. This has seen consumers at the receiving end of food contaminated by antibiotic residues due to a variety of factors expounded in this study. A systematic approach considering some or all the factors that influence the presence of antibiotics residues in food will address the problem.

6.2 Research summary

Food security has been compromised due to the presence of antibiotic residues in food of animal origin. Antibiotic residues are directly harmful to those that consume antibiotic contaminated food, and cause antibiotic resistance in both people and animals. The problem of antibiotic residues in food is very serious but yet is poorly studied and its magnitude is not objectively outlined in Zimbabwe. A cross sectional study was done in Manicaland Province of Zimbabwe in 2024 on beef, milk and poultry meat sold informally, to determine prevalence of antibiotic residues and antibiotic residues were found to contaminate 62% (104, n=168) of the samples tested. Tetracyclines were the most common antibiotic residues affecting 79/168 samples, followed by penicillins at 53/168 samples and then other antibiotics at 30/168 samples. The most common antibiotic in beef and poultry was tetracycline (49% and 53% respectively). For milk penicillins were the most common antibiotic residues (45%). Antibiotic access system was found to be compromised at the level of antibiotic retail outlets, antibiotic regulation and poor farmer antibiotic use practises and attitudes. Drug retail outlets are operated mostly by unqualified persons and the acquisition of prescription items is almost free, whilst the veterinarians are not well capacitated to provide the best antibiotic stewardship and management practises to farmers. Farmer antibiotic practises were found to be unguided, antibiotic misuse, overuse or irrational use. More education is required to promote practices that promote biosecurity practises on farms which should lead to reduced need to use antibiotics and therefore reduction of antibiotic residues.

The findings in this study form one of the earliest pieces of knowledge to better understand the impact of antibiotic residues and the link for animal production to One health family in tackling animal health and public health challenges involving zoonotic pathogens in Zimbabwe.

6.3 Conclusions

A majority of drug retailers may be unscrupulous and regulatory activity for antibiotic use is required as soon as possible. Task forces and national action plans must address antibiotic residues as equally as addressing antimicrobial resistance. Antibiotic residues are real and prevalent in food. The informal sector has considerable market and food accessed in the sector has potential risk to public and animal health. Addressing the problem now will help avert a future health catastrophe and ensure sustainable safety. The effects on food availability cannot be understated.



Figure 9 Postmortem of a goat. Pneumonic lungs. The goat failed to respond to a high dose of tetracyclines for the past week. A typical case of antibiotic resistance impact of antibiotics resistance on production in the informal sector.



Figure 10 The informal sector is thriving so much. Picture clip from a newspaper in Zimbabwe highlighting importance of the informal sector.



Figure 11 A picture from a newspaper in Manicaland showing the possibility of unregulated meat consumption.

6.4 Recommendations

6.4.1 Farmers

The most important aspect in ensuring prudent use of antibiotics by farmers is through education, extension and awareness. Approaches must be considering wholesome and inclusive stakeholder participation and must make effective use of media and technology. Responsible authorities must frequently debunk misinformation, disinformation and myths surrounding antibiotic use and management as well as disease conditions. Education and awareness should touch on aspects but also emphasize on measures such tick control, cleaning, disinfection, methods for segregation of animals and vaccination which prevent bacteria from infecting and creating the need for antibiotics. Long term and future attitude and change of behaviour can be targeted to school going children through including prudent use of antibiotics topics in their educational curricula so that the correct behaviour is inculcated into them at an earlier age.

6.4.2 One health Approach

One health approach recognizes that the health of humans, animals and ecosystems are interconnected. It involves applying a coordinated, collaborative, multidisciplinary and cross-sectoral approach to address potential or existing risks that originate at the animal-human-ecosystems interface

6.4.3 Farmer Field Schools

Farmers are organized in to small groups. Each group is assigned a project and a consultant. Each project typically involves two or more cohorts of animals grown from day old to slaughter or harvest of product. Farmers are given a chance to participate, to learn, to experiment and discover for themselves knowledge, practices and attitudes that promote clean animal production and products free of antibiotic residues (Waddington et al,2014).

6.4.4 Market development

Both private and public must partner to create protected and well governed markets and market systems for agricultural produce with clear conditions and terms of reference in order to for farmers to participate. Such markets must promote production, create demand and enable economically viable businesses that are capacitated to implement measures and systems that reduce production of antibiotic residue contaminated food.

6.4.5 Political buy in

Last but not least, political buy-in is critical to back up all policy measures meant to address antibiotic residues matters. At times it may require education and awareness with political and local leaders so that everyone is on the same page. concept clearly focusses on consequences, responses, and actions at the animal–human–ecosystems interfaces, and especially (a) emerging and endemic zoonoses, the latter being responsible for a much greater burden of disease in the developing world, with a major societal impact in resource-poor settings; antimicrobial resistance (AMR), as resistance can arise in humans, animals, or the environment, and may spread from one to the other, and from one country to another; and food safety. Further research also will add to the body of knowledge, helping in policy formulation and decision making (Mackenzie and Martyn, 2019)

6.4.6 Regulating and controlling antibiotic supply and use

Therefore, in order to reduce antibiotic residues, more effort must be put to account for vet shops, farmers and to strengthen MCAZ, CVSZ and DVS regulation. Lack of regulator controls on antibiotic use results in rampant use and irresponsible use. National regulation of

antibiotic use intended to foster rational use of antibiotics is correlated with reduced antibiotic consumption and reduced chances of antibiotic residues in food. Standard Treatment Guidelines for antibiotic administration, the non-availability of antibiotics without a prescription, and the existence of training modules for animal health professionals covering rational use of medicines can significantly lower use of antibiotics and reduce incidence of antibiotic residues (Mueller and Per-Olof Jøstergren, 2016).

6.4.7 Improving the performance of Veterinary services

The recruitment of veterinarians to fill up vacant posts in the DVS and offering retention packages to reduce brain drain will help in firmly establishing the role of veterinarians for these roles. DVS must improve mobility of veterinarians so through securing dedicated vehicles in government service with fuel support so that services can be provided to a wider area together with monitoring and follow up of antibiotic use and outcomes. The use of modern technology in information management systems will allow quick and real time monitoring and management of antibiotic usage and consumption in animals.

Protocols for diagnosis of disease and treatment must be established with strict adherence and monitoring amongst veterinarians. Laboratory support and capacitation is required for aiding in identification of pathogens, measuring and surveillance so that prudent treatment plans and prescriptions are followed.

6.5 Areas for further research

1. Characterisation of the effects and impacts antibiotic residues on human and animal health
2. Feasibility of organised markets for informal animal farm products
3. Exploration of approaches to reduce antibiotic residues in food
4. Exploration of antibiotic monitoring system in Zimbabwe
5. Expanding antibiotic prevalence studies to the rest of the country and specific systems of production
6. Development of ICT tools to monitor antibiotic use and consumption in animals.

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6.7 Appendices

6.7.1 QUESTIONNAIRE FOR THE VENDOR

Place: District.....
 Ward.....
 Village.....
 Suburb.....

Gender 1=male 2=female		
Age		
Education in years		
Year selling livestock products		

Product sold

- Milk
- Beef
- Poultry

Where is your outlet/place of vending.....?

2 The milk/beef/poultry you sell, is it from

- Your own herd/flock
- You bought for resale

3 If you bought for resale, indicate the sources

Product	Source/Location	Type of production at source 1=Subsistence 2=Small scale commercial 3=Large scale commercial 4=Abattoir 99=Other (specify)
Milk		
Beef		
Poultry		

- What are your average monthly sales per livestock product type

Product	Quantity sold per month	Price per Kg/L
<input type="radio"/> Milk (litres)	<input type="radio"/>	<input type="radio"/>

<input type="radio"/> Beef (Kg)	<input type="radio"/>	<input type="radio"/>
<input type="radio"/> Poultry(birds)	<input type="radio"/>	<input type="radio"/>
<input type="radio"/> Poultry (Kg)	<input type="radio"/>	<input type="radio"/>

Which months are busy?

How do you advertise/market your products? 1=social media 2=customer referrals 3=others (specify)

How much does livestock products vending contribute to your income as a percentage?.....

Do you consider antibiotic withdrawal periods when you purchase livestock products for resale? 1=Yes 0=No

Consumer preferences

What do consumers look for when buying milk products that you sale (1-antibiotic withdrawal periods 2=colour 3=price 4=production source 5=fat content 99=other specify)	
What do consumers look for when buying beef that you sale (1-antibiotic withdrawal periods 2=bone content 3=price 4=production source 5=fat content 99=other specify)	
What do consumers look for when buying poultry products that you sale (1-antibiotic withdrawal periods 2=size of bird 3=price 4=production source 5=fat content 99=other specify)	

Do you get any support or advice to run your business?.....

If yes specify advice source.....

What are the challenges related to your business?.....

How do you overcome those challenges?

Who are your customers? (1=youths 2=adults 3=aged 4=Others (specify))

Specify Customer location (where they hail from. Respondent can indicate market share by location as a %)

Livestock sample number taken (to match with lab information)

Any comments Thank you

6.7.2 QUESTIONNAIRE FOR THE FARMER
Socio-demographic characteristics of farmers

Place: District.....
Ward.....
Village.....
Suburb.....

Gender

- Male
- Female

Age (years).....

Religion

- Christianity
- African Christianity
- Traditional
- Muslim
- Other

What is your highest level of qualification?

- Primary level
- Completed O level
- Completed A Level
- Vocational training
- Certificate
- Diploma
- Bachelor's degree
- Master's Degree
- PHD
- Postgrad certificate/diploma
- Certificate of attendance
- Did not go to school at all

What is an antibiotic? Select correct answer

- Medicine to treat germs or infections
- Medicine to prevent animals from acquiring germs or infections
- Medicines to make animals grow
- Medicines to treat worms

- Antibiotics are vaccines
- Antibiotics kill viruses

Do you have a drugs cabinet? Yes No

Which antibiotics do you stock?

- Tetracyclines
- Penicillin's
- Macrolides
- Sulphonamides

What do you think is Antibiotic Resistance?

Free answer.....

Select

- When bacteria kill people
- When bacteria die from antibiotics
- When bacteria are not killed by antibiotics
- When people don't get infected or affected by bacteria

How often do you use antibiotics?

- Never
- Sometimes
- Often
- Very often
- Every time

Where do you get antibiotics?

- VMGD (Vet Shop)
- Pharmacist
- Veterinary Animal Health Management Centre
- Veterinary Doctor
- Vet Paraprofessional
- Mudhumeni (Agritex officer)
- Dealers
- Other farmer
- Import own antibiotics
- Clinic
- Other

How do you decide to use antibiotics?

- Advice and prescription from veterinarian
- Advice from Vet paraprofessional
- Advice from Agritex officer
- Advice from VMGD
- Advice from pharmacist
- Advice from fellow farmer
- Advice from other lay persons, farm workers
- Own decision

Do you think the treatment is needed for the rest of the animals if one/few animals shows any symptom? Yes / no

Who has authority to write a prescription for antibiotics in animals? (Hassan et al., 2021)

- Pharmacist
- Veterinarian
- Animal Health Worker
- Agritex worker
- Any person

- No need
- VMGD rep/assistant
- Medical doctor or nurse for people

Which diseases commonly affect your livestock?.....

How do you prevent diseases?.....

How often do you

- Vaccinate (what vaccines do you use)
- Clean
- What chemical do you use for cleaning and disinfection
- How often do you dip your animals (if cattle)
- How are your animals separated from mixing with other animals in case of disease outbreak.....
- Quarantine
- Fence
- Restricted movement
- Housed

How do you use antibiotics?

- Instructions on label
- Explained by veterinarian
- Explained by paraprofessional
- Explained by other farmer
- Thumb suck
- Explained by agritex official
- Explained by lay person or farm worker

Antibiotics must be used (Hassan et al., 2021)

- Always at start of rearing (day old)
- To sick animals only when there are sick
- To all animals at all times
- Those that are nearing slaughter

When there is no apparent recovery

- Add more antibiotic
- Use a different antibiotic
- Ask the vet for advice
- Ask a fellow farmer for advice

What other alternatives do you have for treating infections?

- No other
- Concoctions
- Herbal
- Spiritual

When do you decide to slaughter animals for food after antibiotic use?

- 0 days
- 7 days
- 14 days
- 21 days
- 28 days or more
- Guided by label

How do you deal with an animal that died whilst under antibiotic course?

- Consume
- Bury
- Burn

- Feed to other animals
- Sell to other people for food

What challenges do you face to treat your animals.....

Would you recommend your family to consume your product you are selling?.....

Let's discuss livestock ownership

<u>Livestock</u>	<u>Numbers owned</u>	<u>Numbers sold per year</u>	<u>Average price</u>
<u>Cattle</u>			
<u>Poultry</u>			
<u>Milk</u>			

6.7.3 QUESTIONNAIRE FOR ANTIBIOTIC SOURCE- vmgd/pharmacy/vet/paraprofessional

Duty veterinarian/Pharmacist/Veterinary extension officer/paraprofessional

- Present
- Absent
- Part time

Qualifications for sales persons/assistants

- Animal science
- Veterinary science
- Veterinary paraprofessionals
- No professional qualifications

Which antibiotics are sold.....?

Send under cover to buy antibiotics without a prescription

- Accepted without any questions
- Needed a little persuasion without prescription
- Insisted on prescription

6.7.4 QUESTIONNAIRE FOR KEY INFORMANTS Medical epidemiologist

What is the prevalence of human Antibiotic Resistance cases in human patients in Mutare and Mutasa?

Victoria Chitepo Lab (Key Informants)

In the last year

- How many patients were diagnosed with drug first line Antibiotic Resistance therapy.....,
- second line antibiotic therapy resistance.....
- and last line Antibiotic Resistance.....

Which panel of zoonotic bacteria are showing Antibiotic Resistance.....

To which antibiotics was resistance recorded?.....

How were the patients affected?

- Debilitation
- Days off
- Deaths
- Permanent disability

What is the panel of occupations for the affected patients?.....
.....
.....
.....

6.7.5 QUESTIONNAIRE FOR KEY INFORMANTS: veterinary public health officer/dairy services officer

How many litres of milk were discarded due to antibiotic residues in 2023?.....

Is beef and poultry meat subjected to routine regulatory antibiotic residue tests in Mutare and Mutasa.....

How many litres of milk were rejected on import?.....

How many litres of milk were rejected on export?.....

What are the export and import requirements of beef, poultry and milk in as far as antibiotic residues are concerned?

6.7.6 LABORATORY RESULT SHEET FOR ANTIBIOTIC RESIDUES SURVEY

Lab Name..... **Date**.....

Lab Number..... Submitted by.....Rank..... Phone number.....

Type of sample

- Beef
- Poultry
- Milk

Source of sample..... Coordinates.....,.....

Origin of sample.....coordinates.....

Type of production at origin

- Communal
- Small scale
- Resettlement
- Urban
- Growth point
- Commercial
- Other (specify)

Results

Antibiotics present

	Tetracycline	Penicillins	Others			
			Sulphonamide	Macrolide	cephalosporin	quinolones
Absent (0)						
Present (1)						

6.7.7 QUESTIONNAIRE GUIDE FOR FOCUS GROUPS –FARMERS

Anybody knows where to get antibiotics

How can we get antibiotics cheaply across the border/ anyone know a cross border runner for antibiotics

Does anyone know list of proven drugs

How can I get the most appropriate for my sick animal?

