Functionality of the One Health Approach in Reducing Anthrax for Improved Nutrition Security: A Case-control Study in Gokwe South.

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

Bindura University of Science Education

Faculty of Agriculture and Environmental Science

Department of Agricultural Economics, Education and Extension

Takudzwa Blessmore Tiengane

B231789A

Name/s of Supervisor/s: Dr .N. Mafuse

June 2025

RELEASE FORM

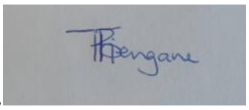
Name of Candidate: Tiengane Takudzwa B

Reg Number: B231789A

Degree: Master of Science Degree in Food Security and Sustainable Agriculture.

Project Title: Functionality of the One Health Approach in Reducing Anthrax for Improved Nutrition Security: A Case-control Study in Gokwe South.

Permission is hereby granted to Bindura University of Science Education Library to produce a single copy of this dissertation and lend such copy for private, scholarly or scientific research only.

Signed……**…………………………..**

Permanent Address: H20 Njube Bulawayo Zimbabwe

APPROVAL FORM

The undersigned certified that they have supervised and recommended to Bindura University of Science Education for acceptance of dissertation entitled **'Functionality of the One Health Approach in Reducing Anthrax for Improved Nutrition Security: A Case-control Study in Gokwe South.'** submitted in partial fulfilment of a Master of Science Degree in Food Security and Sustainable Agriculture.

Name of supervisor: Dr N. Mafuse

Signature: ……………………………………………………..

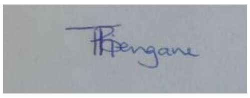
Date: ……………………………………………………………

DECLARATION

I hereby declare that the research project entitled **"Functionality of the One Health Approach in Reducing Anthrax for Improved Nutrition Security: A Case-control Study in Gokwe South."** 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 N. Mafuse 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 of diploma.

Author: Tiengane Takudzwa B

Reg Number: B231789A

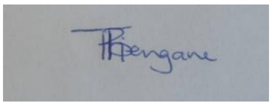
Signature: …………………………………………….

Date: ……………**20/6/2025**……………………………….....

DECLARATION

The undersigned certify that they have read the research project and have approved its submission for marking in relation to the department's guidelines and regulations.

Student: Takudzwa Blessmore Tiengane

Signature: 

Date: 20/6/2025

Supervisor: Dr Never Mafuse

Signature:

Date:

Chairperson: Dr Never Mafuse

Signature:

Date:

DEDICATION

This thesis is dedicated to my lovely daughter Emily.

ACKNOWLEDGEMENTS

I want to thank the almighty God for awarding me the opportunity to conduct this study without any obstacles. Special thanks also go to Dr N Mafuse of the Bindura University of Science Education, Department of Agricultural Economics, Education and Extension my supervisor, and Mr S Betera from the Ministry of Health and Child Care, Environmental Health Department for their tireless efforts and technical guidance during my thesis.

I also extend my gratitude to the Permanent Secretary of Health, Ministry of Health and Childcare, for approval to access the Health Information Management Systems. I would also like to thank the District Development Coordinator for Gokwe South for permitting me to conduct my study in the Gokwe South District. I extend gratitude to the Gokwe South District Environmental Health Practitioners for their support during data collection. Last but not least, I extend gratitude to the Key Informants and community member respondents for providing consent for the research; without them, the objectives would not have been met.

ABSTRACT

Background: This study was to assess the functionality of the One Health Approach in reducing Anthrax for improved Nutrition Security in Gokwe South through establishing the key risk factors contributing to anthrax morbidity and determine key interventions in place towards management of anthrax in the community.

Methods: The research was conducted using a mixed-methods approach utilising a 1:2 unmatched case-control study to assess risk factors associated with contracting anthrax. Data collection was conducted using a structured questionnaire for general participants and a key informant interview guide for KI, and the selection of participants was done using a multi-stage stratified sampling method. Multivariable logistic regression analysis was performed to identify the independent risk factors of anthrax morbidity, and thematic analysis was conducted for the One Health Approach on anthrax management.

Results: 285 participants were interviewed, i.e., 95 cases, along with 190 controls. The Multivariable logistic regression predicted the factors associated with anthrax morbidity as the preferred type of grazing (forest) [game area, OR = 137.12, 95% CI (0.195–96420.507); grass fields OR = 5.03, 95% CI (0.52-48.39)], handling of dead livestock (veterinary notification) [sell/consume carcass OR = 10.82, 95% CI (2.17–53.98)], and perceived anthrax risk (low) [moderate OR =39.89 , 95% CI (6.68–238.36); severe OR =20.20 , 95% CI (4.51–90.53)]. Through interactions with district stakeholders, it was observed that the request for the adoption of the One Health Approach was still theoretical, with insignificant implementation within the district due to a lack of adequate resources and weak coordination.

Conclusion: This study highlights the key factors related to knowledge attitudes and practices contributing to the endemicity of anthrax in the Gokwe South district. It also highlights the need for a multisectoral response through the One Health Approach to ensure a reduction in anthrax cases so as to minimise livestock losses and transmission of disease to humans to ensure community resilience and improved sustainable food systems.

Keywords: One Health Approach, Anthrax, Knowledge-attitudes-practices, nutrition-security, multisectoral-response

LIST OF ACRONYMS AND ABBREVIATIONS

CLAFA	Crops, Livestock, and Fisheries Assessment
DVS	Department of Veterinary Services
FEWSNET	Famine and Early Warning System Network
FPL	Food Poverty line
GOZ	Government of Zimbabwe
KI	Key informant
MOHCC	Ministry of Health and Childcare
SDG	Sustainable development goals
TCPL	Total Consumption Poverty Line
ZHIMS	Zimbabwe Health Information Management System
ZIMSTATS	Zimbabwe National Statistics Agency

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Food systems are interconnected, involving humans, animals, plants, and ecosystems, which can contribute to fragmented oversight and governance for food-related issues. Sustainable food security maintenance is fundamental for the achievement of Sustainable Development Goals, that is, SDG2 Zero hunger, SDG 3 human health and well-being. However, emerging Zoonotic viruses have been posing challenges to efforts to maintain food security through spills to humans via the food system, for example, the severe coronaviruses, Ebola, and anthrax. In addition, other threats to sustainable food systems and health include climate change, natural disasters, overgrazing, antibiotic and pesticide use, heavy metal pollution, and unrestricted land reclamation. Hence, through the One Health Approach, food systems challenges may be addressed and food safety across the entire value chain through integrated approaches that are aimed at optimizing the health of people, plants, animals, and ecosystems (Gu et al. 2023).

Anthrax, a bacterial disease that is of great public health and economic threat in most agricultural systems, has been observed to be endemic in most parts of the world, including in Africa. The disease mainly affects herbivores and animals, and livestock gets affected through ingestion or inhaling spores from contaminated soil, water, or plants. Humans are infected through contact with infected dead animals or their products, or through consuming meat obtained from infected livestock, usually cattle. Anthrax contributes to animal and human illnesses, death, and economic losses to the agricultural systems, hence the need to enhance surveillance, outbreak response, and diagnostics as mitigation strategies (Vieira et al. 2017). Several factors have been associated with the emergence of anthrax which includes, including climate change, increased human and animal population, poor grazing systems, human behaviour, livestock, and wildlife interaction, hence the recommendation for vaccination (Kungu et al. 2020). In Africa, five countries have reported anthrax outbreaks these include Kenya, Malawi, Uganda, Zambia, and Zimbabwe. In Zimbabwe, since 2019, cases have been recorded, hence the need to strengthen prevention measures. (FEWSNET, 2023)

Livestock is an important part of all smallholder farming systems, with cattle constituting the bulk of domesticated animals. The majority of Animal Source Foods are produced by smallholder farmers and traded in formal and informal value chains; production and trade of Animal Source Foods constitute an important source of livelihood in developing countries. Hence, Food safety compliance is integral across the food systems value chain, and compliance gaps are a major public health concern in developed and emerging economies due to the risks associated with the consumption of contaminated foods, such as zoonotic foodborne diseases (Nyokabi et al. 2023), hence the need for One Health Approach.

In Zimbabwe, One Health implementation has been through the One Health Antimicrobial Secretariat since 2022. The main activities conducted include research, training, prevention, and control of neglected tropical diseases and zoonotic diseases, antimicrobial resistance, and food safety. The committee is dominated by government officials with minimal coordination, which includes Health and Child Care, Lands, Agriculture, Fisheries, Water and Rural Development, and the Environment, Tourism, and Hospitality Industry (Matope et al, 2024). Hence, there is a need to strengthen the One Health Approach as a way of ensuring food safety, food security, and control of anthrax in agricultural systems.

1.2 Statement of the Problem

Livestock is an integral part of smallholder farming in Zimbabwe, and in Gokwe South, cattle are the most common species kept for commercial purposes and a form of livelihood and food security. 83% of cattle mortality is due to diseases (GOZ, 2023). Animal diseases hinder the progress towards the availability of animal source products, with research estimating zoonotic diseases contributing approximately 60% of human infectious diseases as a result of livestock production activities, thus posing a direct threat to food security due to low productivity (Akash et al., 2021). In addition, there is a link between food safety and food security, with pathogens from animal source products contributing also to illnesses in humans, raising public health risks, which can also affect the utilisation of nutrients, thus affecting nutrition security. Hence, there is a need for good husbandry practices and veterinary services to prevent spillover along the food value chain (Mohammed & Elseory, 2024).

Earlier in 2024 about six (6) district in Zimbabwe recorded 513 human infections of anthrax and several infections and thirty six (36) livestock deaths. These districts included Chipinge, Gokwe South and North, Mazowe, Makonde and Hurungwe. As part of the response strategy the government imported 426000 anthrax vaccine doses which contributes to only 25% of the required doses (Mambondiyani, 2024).

Despite routine and control vaccination programmes in livestock, Gokwe South has continued to face recurrent human anthrax cases for the past five (5) years, as shown in Figure 1.1 below. According to the Round 1 Crop and Livestock Assessment 2024, it has been highlighted that Gokwe South was one of the five (5) districts where anthrax was recorded for the year 2023 (eighteen (18) animal deaths and forty-two (42) human cases) (GOZ, 2024)Hence the recurring outbreaks are posing a threat to agricultural systems, food safety, and food and nutrition security since high cases of human anthrax are being recorded this indicating that people are consuming meat from the dead carcasses which might be due to food insecurity.

Hence this study seeks to feel the gap on why anthrax is becoming endemic in Gokwe South and also assess the functionality of the One Health Structures in the district towards anthrax management so as to Improve Nutrition Security.

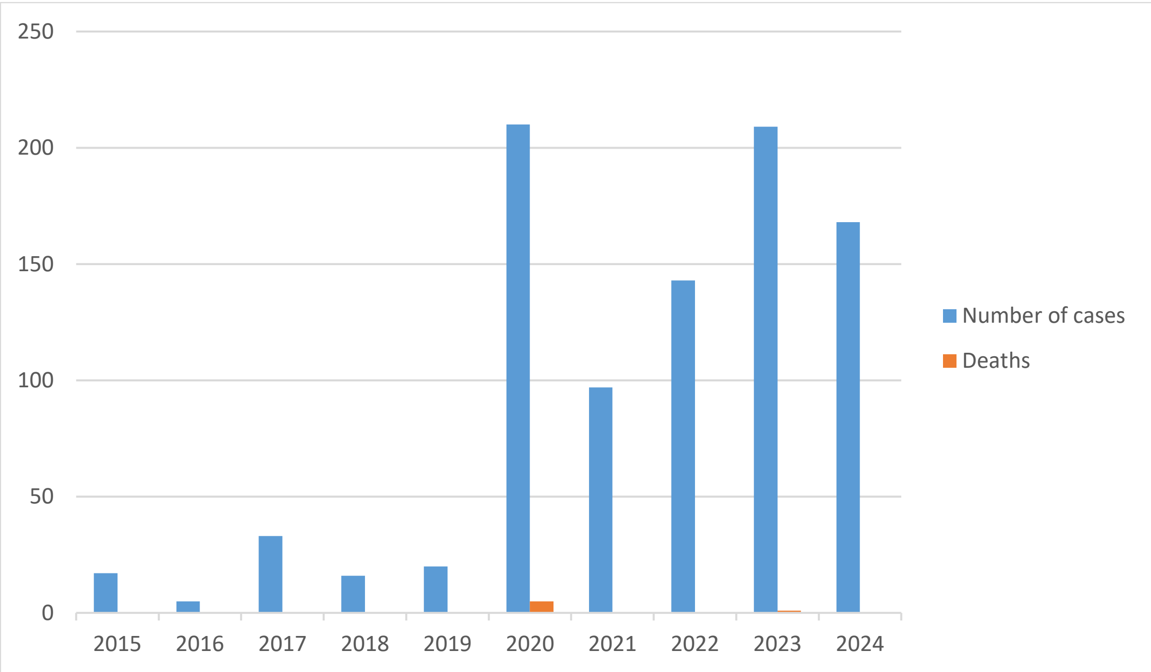


Figure 1. 1 Human anthrax cases notified at health facilities (ZHIMS, 2024)

1.3 Objectives of the study

1.3.1Main objective

This study was to assess the functionality of the One Health Approach in reducing Anthrax for improved Nutrition Security in Gokwe South through establishing the key risk factors contributing to anthrax morbidity and determine key interventions in place towards management of anthrax in the community.

1.3.2 Specific objectives

1. To examine the influence of socio-demographic determinants on the risk of anthrax infection.

2. To evaluate community knowledge, attitudes, and practices on anthrax prevention, transmission, and control.

3. To investigate the effects of household dietary diversity on anthrax endemicity.

4. To determine the role of key stakeholders within One Health Approach/framework on anthrax outbreak management (preparedness, response, and control).

1.4 Research Questions

1. What influence do socio-demographic determinants have on the risk of anthrax infection?
2. What is the level of community knowledge, attitudes, and practices on anthrax prevention, transmission, and control?
3. What are the effects of household dietary diversity on anthrax endemicity?
4. Which roles are being played by key stakeholders within One Health Approach/framework on anthrax outbreak management (preparedness, response, and control)?

1.5 Significance of the study /Justification

Anthrax poses serious public health concerns through animal and human illnesses and deaths. In addition, it contributes to economic losses to the agricultural systems, hence affecting food safety and food and nutrition security. Hence, the need to enhance surveillance, outbreak response, and diagnostics as mitigation strategies through the One Health Approach.

Hence, this study on the assessment of the functionality of the One Health Approach on reducing Anthrax for Improved Nutrition Security in Gokwe South will shed light on the current status of the One Health structures in Gokwe South and what activities are being conducted in response to endemic cases of anthrax. In addition, the study examined the influence of socio-demographic determinants on the risk of anthrax infection and evaluated community knowledge, attitudes, and practices on anthrax prevention, transmission, and control. Also, the study investigated how household food security through household dietary diversity contributes to anthrax endemicity. Lastly, the study determined the role of key stakeholders within the One Health Approach/framework on anthrax outbreak management (preparedness, response, and control) to inform policy on how strategies can be put in place to ensure that agricultural systems can be improved to contribute to food safety and food and nutrition security in Gokwe South.

1.6 Scope/Delimitations and Limitations of the study

The research was conducted in Gokwe South, targeting different stakeholders, which included local community members and Key Stakeholders implementing the One Health Approach at the district level. The study focused on establishing risk factors contributing to endemic cases of anthrax. In addition, the effect of dietary diversity was assessed, as well as determining the roles and responsibilities of the key stakeholders under the One Health Approach in anthrax management within the district, using both qualitative and quantitative methods to establish the results of the study. However, this study's limitations were generalising, which may be specific to Gokwe South only. In addition, the study was conducted in a short space of time, which may not yield adequate information on the outbreaks. Also, inadequate resources limited the researcher from reaching every household affected by anthrax to gain in-depth information. Furthermore, the research may be subject to bias from respondents as they may have provided information in a manner in which they may think that there might be some benefits they will have after taking part in the research. Hence, acknowledging this limitation will assist the researcher in contextualising these findings and informing future researchers.

1.7 Outline of thesis

Chapter 1, covered the introduction part of the thesis. **Chapter 2**, reviews the literature that is relevant to One Health Approach, Anthrax, and Food and Nutrition Security. **Chapter 3**, describes the methodology that was used which includes research design, data collection, and data analysis. **Chapter 4** covers the results for all four specific objectives of the research. **Chapter 5** summarises, concludes, and provides recommendations on the research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

One Health is the concept that views the health of humans, animals, and the environment as interconnected. The One Health Approach multidisciplinary approach consisting of multidisciplinary stakeholders working together to address problems to improve health, society, and safeguard natural resources. The main goals of the team are to ensure control and combat diseases such as Anthrax, achieve food security, environmental quality stewardship, and uphold humane values in society. Hence, its failure poses public health threats as well as affecting food and nutrition outcomes (Garcia et al., 2020).

2.2.1 Food Security, Nutrition, and Livestock

Malnutrition continues to be a major problem in public health, with complications at the global level, such as stunting affecting about 25% of children under five, while anaemia affects more than half a billion women, with a significant proportion of pregnant women at risk due to poor nutrition. These deficiencies worsen susceptibilities to both development and health, particularly for pregnant women and children (FAO Knowledge Repository, 2023).

Livestock production contributes to the diet of households with animal sources such as milk and meat, including eggs in poultry production. These sources, compared to plant-based diets, contribute to nutrition security by providing high-quality nutrients such as proteins, essential fatty acids, and micronutrients that are bioavailable for absorption, such as iron, vitamin A, Vitamin B12, and Zinc, which contribute essentially to growth and development. Several factors, such as socio-economic status, contribute to dietary intake of animal-source foods differ from region to region, with other countries having high consumption compared to other countries with meat consumption ranging from less than 4kg to 100kg annually per capita (Zahir et al., 2024). Despite these factors, the consumption of animal-source foods contributes greatly towards growth and development, including cognitive development among children as well as muscle maintenance in adults (Akash et al., 2021).

The world population is expected to double its requirement of animal sources from livestock production by 2050 as a result of population increase and changes attributed to an increase in income and urbanisation in developing countries. Animal-source protein is currently contributing about 26% of dietary needs and 13% of total calories (Research et al., 2015; Zahir et al., 2024). Livestock production also contributes 1.5% of the global gross domestic product, with livestock contributing 40% towards agricultural activity. In Zimbabwe, it contributes about 15-18% of the gross domestic product and contributes to 70% of employment, thus supporting livelihoods with smallholder farmers in semi-arid areas, making up a larger share where shocks are prevalent and affect production. In these regions, production is affected by climatic variability, and extensive livestock production of goats and cattle is usually practiced, with livestock depending on natural pastures and sometimes on crop residues from production. In addition, production faces challenges such as water shortages, labour, diseases, and feed shortages, thus contributing to high mortality and morbidity, thus affects overall production (FAO, 2020; Melesse et al., 2023). Apart from livelihood and dietary provision, livestock also contribute towards social aspects (payment of lobola) as well as crop production as drought power (Makiwa et al., 2023).

Furthermore, livestock production contributes to food security through direct provision of food and indirectly through income, which can be used for access to a diverse diet, especially during times of shock such as diseases and climatic variability (drought and floods). Indicators that can be used to measure food security include the per capita food expenditure and household dietary diversity score, and these can be jointly used to evaluate food security. The household dietary diversity score is a measure that reflects the quality of diet consumed at the household level for 24 hours or the past 7 days, utilising twelve food groups. Studies have revealed positive relationships in livestock ownership, level of education, as well as access to extension services access signifying the importance of knowledge toward overall outcomes on nutrition behaviour. However, to achieve positive results, production must be done adhering to proper livestock production practices (Bruhn, 2019; Melesse et al., 2023).

However, animal diseases hinder the progress towards the availability of animal source products, with research estimating zoonotic diseases contribute approximately 60% of human infectious diseases as a result of livestock production activities, hence posing a direct threat to food security due to low productivity (Akash et al., 2021). In addition, there is a link between food safety and food security, with pathogens from animal source products contributing also to illnesses in humans, raising public health risks, which can also affect the utilisation of nutrients, thus affecting nutrition security. Hence, there is a need for good husbandry practices and veterinary services to prevent spill over along the food value chain (Mohammed & Elseory, 2024).

Thus, addressing food security is complex and requires a multisectoral approach through the One Health Approach concept since addressing food security requires a focus on factors such as climate change, crop production, animal and plant health, environmental degradation and resource depletion, pests, and also food distribution (Roth & Galyon, 2024).

2.2.2 Overview of Anthrax

Anthrax is an ancient zoonotic disease that primarily affects herbivores and may also affect humans. It is caused by a gram-positive aerobic spore-forming bacteria Bacillus anthracis which is very resistant for a long time to environmental conditions and can lie dormant for decades putting at risk grazing animals such as goats, sheep, cattle, and wild animals (wild deer and antelope). Anthrax cases usually peak during summer. (Simonsen and Chatterjee, 2023) (Doganay et al., 2023).

Anthrax is a notifiable disease according to the Animal Health and Public Health Act; thus, every case is mandated to be reported to the relevant authorities. The geographic distribution includes several parts of the world, with sub-Saharan Africa included, with anthrax being endemic in those parts of the region (John et al., 2024). Annually, between 2000 and 20000 cases of anthrax are recorded globally. Sub-Saharan Africa recorded (through the Inter-African Bureau for Animal Resources) a total of 629 outbreaks, 5655 cases, and 1735 deaths in 2011, with Zimbabwe recording 119 cases (Yadeta et al, 2020). A Meta-analysis for Estimating Global Anthrax Prevalence in Livestock revealed the global prevalence at 28% through the fixed effects model. Through the random effects model, the continent-wise subgroup revealed that the prevalence of anthrax was 29% in Africa and 21 % in North America (Sushma et al, 2021). In Africa, five countries have reported anthrax outbreaks these include Kenya, Malawi, Uganda, Zambia, and Zimbabwe. In Zimbabwe, since 2019, cases have been recorded each year, hence the need to strengthen prevention measures (FEWSNET, 2023).

The spread of anthrax may occur due to livestock interaction with wildlife, ingestion, or inhalation of spores from contaminated soil. However, the most common cause for transmission is the dead carcass since it contains large amounts of Bacillus anthracis. The disease is mostly common in cattle and sheep, and less likely in goats and hoarse and pigs, dogs and cats are usually resistant. In humans, anthrax can be transmitted through handling sick or dead animals due to anthrax or consumption of infected meat, among other causes. The incubation period of the disease is 2-7 days (Doganay et al., 2023) (Yadeta et al, 2020).

Anthrax can be diagnosed based on case history, epidemiology of the disease, clinical signs, and laboratory tests, which provide a confirmatory diagnosis of Anthrax through the isolation of Bacillus anthracis. Epidemiological diagnosis of the disease involves considering all species in affected areas, and the sudden death of animals in endemic areas after agricultural activities and flooding. Clinical signs involve two forms that are rapid onset, one to three days incubation, almost always fatal if left untreated (per acute), and acute forms (cutaneous, inhalation, and gastrointestinal form) of the disease with an incubation period of one to seven days (Yadeta et al, 2020).

2.2.3 Risk Factors and Determinants of Anthrax

Several factors influence the distribution of anthrax. Environmental distribution of viable spores determines risky landscapes for herbivore exposure and subsequent anthrax outbreaks. Spore survival and longevity depend on suitable conditions in its environment. A study in Uganda used the Maximum Entropy modelling algorithm method to predict suitable niche and environmental conditions that may support anthrax distribution and spore survival. The findings revealed a predicted suitable niche favouring the survival and distribution of anthrax spores as a narrow-restricted corridor within the study area, defined by hot-dry climatic conditions with alkaline soils rich in potassium and calcium. The predicted suitable soil properties likely originate from existing sedimentary calcareous gypsum rocks. This has implications for the long-term presence of Bacillus Anthracis spores and might explain the long history of anthrax experienced in the area (Driciru et al, 2020).

Human behaviour contributes significantly to anthrax transmission. This is influenced by the community's knowledge, attitudes, and socio-demographic characteristics. A study aimed at exploring awareness, attitudes, and meat consumption practices of communities affected by anthrax in Zambia revealed that awareness of anthrax among respondents was high, while attitudes towards the consumption of anthrax-contaminated meat and vaccination of cattle were poor. This could be attributed to socio-demographic characteristics (poverty, economic reasons), cattle being an important asset in the community (cultural beliefs), and perceived low risk of infection due to anthrax (Sitali et al, 2017).

A study in the Koraput District in India on the assessment of socio-behavioural correlates and risk perceptions regarding anthrax indicated that socio-demographic characteristics from the community were significantly associated with the knowledge of anthrax, which contributed to the risk of anthrax exposure and underreporting of cases to health professionals. In addition, risk practices such as consumption of livestock blood, distribution of carcasses amongst community members, and sometimes disposal of carcasses in undesignated areas were observed, which may contribute to environmental contamination with anthrax spores (Pattnaik et al, 2022).

Furthermore, issues of food insecurity worsened by the fact that meat a rare source of protein in most households appeared to be the primary reason for handling and consuming meat from animals found dead, as people contract anthrax by eating meat from an infected carcass, belonging to a household with cattle deaths, assisting with skinning anthrax infected carcasses, assisting with drying infected meat, assisting with cutting and cooking infected meat, having cuts or wounds during skinning as well as selling some of the meat to regain some losses from the death of the livestock (Gombe et al., 2010)(Sitali et al, 2017).

Another study to investigate an outbreak of sheep anthrax in Karkihalli Village, Karnataka, India identified the key factors influencing disease emergence among sheep farmers as demographic (literacy rate 49,59%) and ecological (semi-arid climate with annual average temperature 27.0 °C; average rainfall 587mm; soil type red loamy soils) characteristics of the region. Socio-economic factors and Risk and Emergency Management Behaviour (REMB) were also observed to be critical anthrax incidence determinants. The livestock farmers could not take their animals for vaccination and were not willing to pay for the vaccine, which was a poor practice contributing to the failure in control of the disease. In addition, sheep migration and proximity to water bodies also contributed to outbreaks in the area (Suresh et al, 2023).

In Zimbabwe, surveillance and control have been observed to be sub-optimal, and the disease is causing a lot of losses in terms of livestock and human life. Poor practices of carcasses upon deaths due to anthrax have been observed to risk environmental contamination, hence contributing to the expansion of the geographic range and re-occurrence of anthrax cases (Mukarati et al, 2020). In a study for predicting bioclimatically suitable areas for the anthrax disease, it was revealed that there is an increase in highly suitable areas, that is, the eastern and the western parts of Zimbabwe, thus the need for increased surveillance of the disease (John et al., 2024).

The role of the central government in coordinating programs for anthrax prevention and control is very crucial. A study to assess the knowledge, attitudes, and practices towards anthrax in northern Ethiopia revealed that no interventions were in place, as observed by participants' low scores. In addition, community traditional beliefs and socioeconomic factors affected the control, as the community preferred traditional approaches to animal health instead of seeking advice from health professionals. Hence need for community-centered programmes organised by the government to improve recommended practices (Romha & Girmay, 2020).

2.2.4 Food Security and Anthrax Nexus

Food insecurity throughout sub-Saharan Africa has improved in recent years; however, drought, hunger, and malnutrition continue to be concerns in many sub-Saharan countries, including Zimbabwe. Natural disasters affect food security as they disrupt agricultural production, food availability, access to food, utilisation, and food stability. In addition, trans boundary animal diseases threaten food security as they affect food availability and prices (Garcia et al., 2020).

Chronic food insecurity can force communities with food shortages and who lack dietary diversity to risk consuming unsafe meat, as observed during the study to assess the role of food insecurity in an anthrax outbreak after the death of a hippopotamus in Zambia. During the hunger peak that is December to March, livestock search for food and water in riverbeds, digging deep and exposing dormant anthrax spores to the surface, increasing the chances for transmission. Due to food unavailability, residents have a practice of consuming dead animals in the area, hence developing anthrax (Lehman et al, 2017).

2.2.5 One Health Framework and Anthrax Management

The detection, management, and elimination of zoonotic diseases such as Anthrax requires collaborative efforts from the animal health, human health, food, and environment sectors through a One Health Approach, which is an efficient and reliable way in low-income countries. The collaborative efforts rely on communication strategies and data-sharing practices through frequent face-to-face meetings and the establishment of standard operating procedures. A lot of gaps exist among the responsible stakeholders, which include a lack of integrated control systems that address gaps across sectors, knowledge gaps, unavailability of investigation protocols, and poor coordination, hence contributing to the failure to eliminate the zoonotic diseases (Bhattacharya et al, 2021).

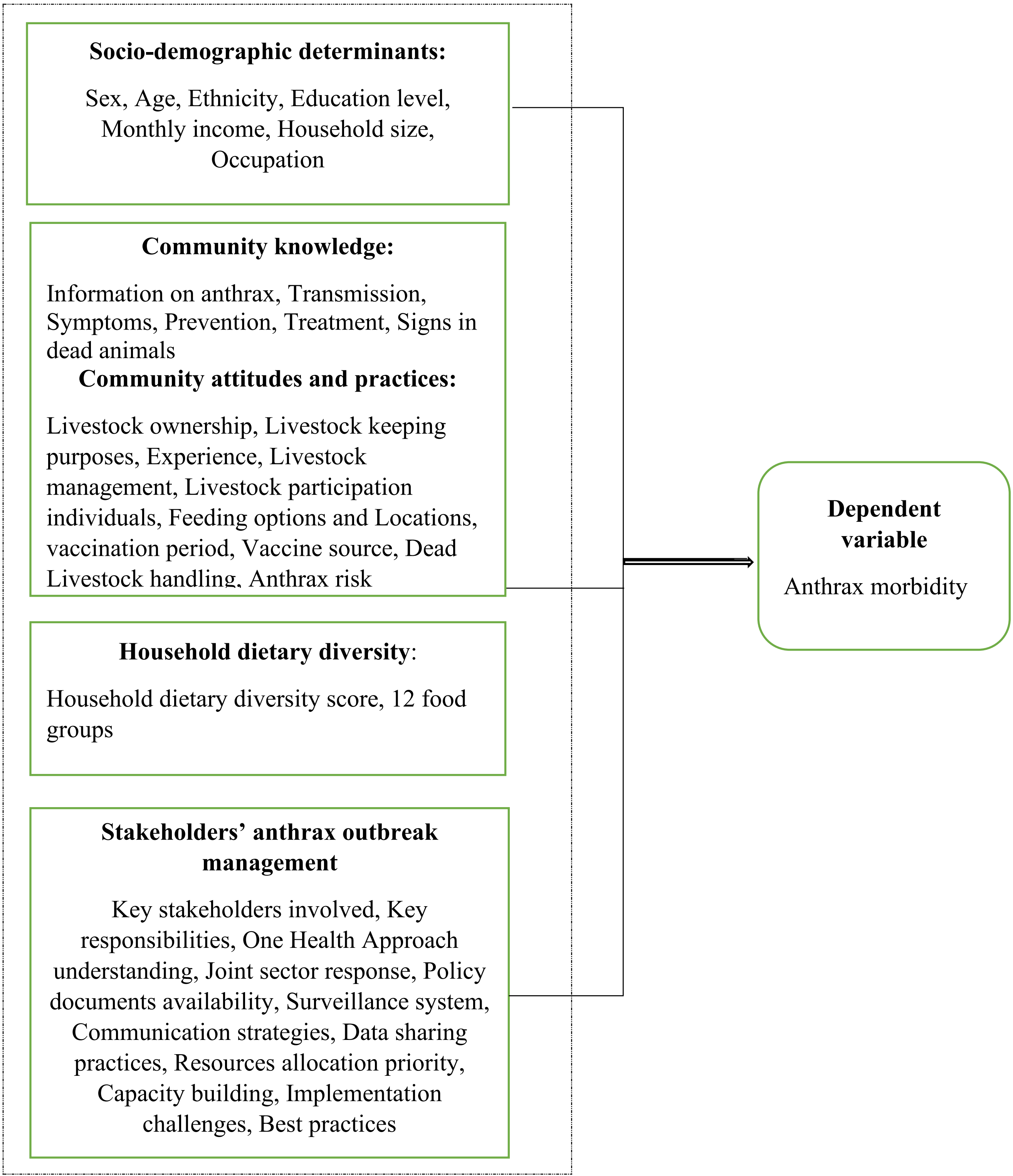
Countries like Rwanda have managed to develop and approve their One Health strategic plan, which focuses on key areas aimed at minimising duplication of activities and ensuring maximum efficient use of public resources, strengthening leadership and governance, capacity building, strengthening lifelong learning, health care delivery, and disaster management. These areas are an addition to traditional areas of disease surveillance, outbreak investigation, and response. Amongst the goals of the strategic plan is the need to address nutritional access through the development of safer practices related to animal consumption and bush meat (Nyatani et al, 2017).

In Zimbabwe, one health implementation has been through the One Health Antimicrobial Secretariat since 2022. The main activities conducted include research, training, prevention, and control of neglected tropical diseases and zoonotic diseases, antimicrobial resistance, and food safety. The committee is dominated by government officials with minimal coordination which includes, Health and Child Care, Lands, Agriculture, Fisheries, Water and Rural Development; and the Environment, Tourism, and Hospitality Industry (Matope et al, 2024).

Key enablers for the implementation of the One Health framework include social and political stability of government with transparent representation across all regions, i.e., locally, regionally, and internationally. Having structures and representatives at the grassroots level, such as the existence of community health workers, who are a key component in primary healthcare delivery. In addition, developing rapid response teams who have a mandate of coordinating surveillance, information sharing, and planning of risk communication and community engagement. Furthermore, gender equity amongst health professionals is essential for addressing gender and cultural issues relevant to improving One Health (Nyatani et al. 2017).

2.3 Conceptual framework

Independent variables



2.4 Summary of Literature Review

Conclusively, although the true worldwide incidence of anthrax is unknown, official reports show that the disease is enzootic in many countries and that sporadic outbreaks are common. Experience shows that countries with inadequate veterinary and public health facilities and areas where it is difficult to implement control programmes are the most affected. The repeated occurrence of anthrax in livestock with a spill over to humans. Thus, suggestions for improved prevention and control measures to protect both animal and human health are provided. These include a preventive strategy involving annual vaccination of susceptible livestock animals (usually cattle, sheep and goats) in areas prone to the disease using quality-assured vaccines, an effective surveillance system both in the public health and the veterinary sectors to ensure earliest reporting and investigation of sudden death in livestock and wildlife, prompt disposal of dead animals, bedding and contaminated materials and control of scavengers; increased public awareness and observation of principles of general hygiene, including use of personal protective measures by people who may have contact with diseased or dead animals and enforcement of regulations about anthrax control including quarantine (Chadambuka A et al., 2010)

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter gives an outline of research methods that were followed in the study. The instrument that was used for data collection is also described and the procedures that were followed to carry out this study are included. The researcher also discusses the methods used to analyse the data.

3.1 Description of study area

Gokwe South District (18.2172°S and 28.9422°E) lies North-West of Midlands Province in Zimbabwe, covering a total area of 11,477.41 km, including Chirisa game park and Sengwa wildlife research area, covering 1,338 square km and 373 square km respectively (Jaison et al., 2023 & Government of Zimbabwe et al., 2022). The District has a total estimated population of 366643 (Zimbabwe National Statistics Agency (ZIMSTATS), 2022). The Shangwe and Tonga are the indigenous inhabitants, but most people come from all over Zimbabwe. It has 32 communal wards (Government of Zimbabwe et al., 2022), one Small Scale Commercial Farming Area (Ward), and 6 (six) urban wards with a total of seven Chiefs. In terms of public health infrastructure, it has 1 (one) district hospital owned by the government, 1 (one) Mission hospital, and 33 clinics owned by the local board, mission, and private sector (Government of Zimbabwe et al., 2022).

Agriculture is the main source of livelihoods in the District. The district is characterized by its semi-arid climate with erratic and unreliable rainfall ranging 650-800mm and 450-650mm in the Southern and Northern parts of the respectively (Jaison et al., 2023). It falls under agro-ecological regions III (60% of the district) and IV (40% of the district). Soils in Gokwe South are mainly sands (LuvicArenosols—FAO) of Kalahari origin, inherently infertile (Nyamangara et al, 2011). The main food crops cultivated include cereals (maize, sorghum, pearl and finger millet), oils (sunflower), pulses (groundnuts and cowpeas), and horticulture. Cattle and goat herds are the main livestock owned and have since declined dramatically in the last 20 years due to droughts and disease (Brazier, 2022). In addition, the district experiences the highest shock exposure indices in the Province, which include waterlogging, cash shortages, cereal price changes, crop pests, livestock deaths due to drought and diseases, exposing households to vulnerability (Brazier, 2022). This means the area experiences significant challenges in terms of agricultural productivity and food security.

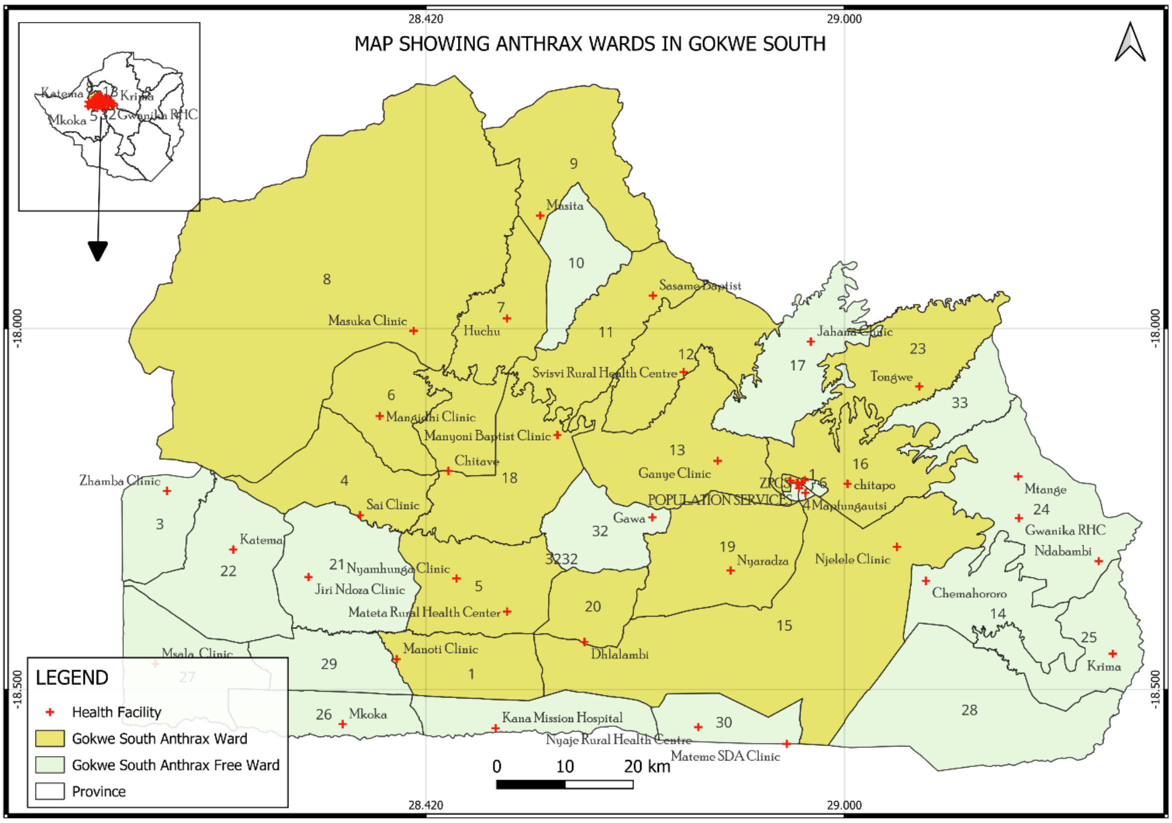


Figure 3. 1 Map showing Gokwe South District and Anthrax distribution

3.2 Research design

This study employed a mixed-methods design, utilising an unmatched case-control study for the quantitative comparative analysis among participants, whereas the qualitative aspect involved key informant interviews to capture in-depth perspectives. Case-control studies are usually conducted to establish factors associated with diseases or outcomes (Tenny et al., 2023; Makurumidze et al., 2021). The study design enabled the researcher to investigate multiple risk factors at once, and also was ideal for outbreak diseases such as anthrax, making it the best for this study. Therefore, this retrospective case-control study was done to understand the current situation and relationships between the variables from 1 January 2024 to 31 December 2024. Furthermore, the qualitative technique ensured the researcher gathered in-depth and key insights, which might not be possible with random sampling (Hassan, 2024).

3.3 Study population

The study included all people residing in the Gokwe South district during the study period. Key informants included key stakeholders under the One Health Approach involved in anthrax management based at the district level in Gokwe South.

3.3.1 Cases: Individual diagnosed to be clinically or laboratory confirmed anthrax, presenting the following symptoms: itching in an affected area, a painful lesion, papules, and depressed black Escher, between the periods 1st of January 2024 to 31st December 2024.

3.3.2 Control: Individuals without a clinical or laboratory-confirmed anthrax diagnosis between the period 1st of January 2024 to the 31st of December 2024 (Makurumidze et al, 2021).

3.3.3 Inclusion and exclusion criteria

The research adhered to the inclusion and exclusion criteria below for selection of the participants as part of the methodology:

Inclusion criteria

Cases:

- Individuals clinically or laboratory-confirmed with anthrax.
- Diagnosed between 1st January 2024 and 31st December 2024.
- Residing in the study area during the anthrax outbreak period.
- Willing to provide informed consent (or assent for adolescents with guardian consent).

Controls:

- Individuals with no clinical or laboratory confirmation of anthrax.
- Residing in the same geographical area as the cases.
- Willing to provide informed consent (or assent for adolescents with guardian consent).

Exclusion for Both Cases and Controls:

- Individuals with an unclear or missing medical history regarding anthrax.
- Those who were outside the study area during the outbreak period.
- Individuals with chronic skin conditions may mimic anthrax lesions.
- Those who refuse to give consent or are unable to participate in interviews.

3.4 Sampling Procedure

Probability sampling was employed for the selection of participants. Sampling is crucial in research, and if the sample size is not done properly, it may lead to inappropriate conclusions. The majority of sampling approaches aim to guarantee that every unit in the sample frame has an equal probability of being included (Oribhabor & Anyanwu, 2019). A multi-stage sampling technique was employed in this study to recruit participants in three stages from thirty-three (33) wards in the Gokwe South District. The first step involved stratified sampling to enrol one hundred and one (101) villages from sixteen (16) wards that were identified during review of weekly disease surveillance reports as anthrax hotspots against one thousand one hundred and fifteen (1215) villages from seventeen (17) wards that did not report anthrax cases (ZHIMS, 2024). In the second step, one hundred and thirty-eight (138) households who reported anthrax cases were enrolled against nine thousand and nine (9009) households that did not report anthrax cases using a stratified sampling technique (ZHIMS, 2024). The last stage involved simple random sampling of the cases, i.e., individuals who were diagnosed with anthrax and those without an anthrax diagnosis as controls. To ensure a representative sample, a household list was created for each village within each stratum. A unique identity was assigned to each household. Using proportional stratified sampling, the households were then selected within each stratum. To select KI for the qualitative aspect, purposive sampling was used to enrol department heads from each of the following Sectors: Ministry of health and childcare, Ministry of Primary and Secondary Education, Zimbabwe republic police, Ministry of Agriculture Department of Veterinary Services, Local government, Montana Carswell Meats Abattoir head (private sector), traditional leaders, and Rural District Council.

3.4.1 Sample size determination and sampling technique

In a previous case-control study conducted on the anthrax outbreak in Makoni District, Zimbabwe, it was observed that being in contact with cattle meat was a significant cause for the outbreak. The study was a 1:1 case control study, which employed an odds ratio of 7.7, a two-sided significance level of α = 0.05, with a percentage of exposed controls of 59,7 and of cases 91, 94 and the power of 80% (Makurumidze et al, 2021). Similarly, this current study employed the Fleiss formula with continuity correction factor using the same odds ratio 7.7, two-sided significance level of α = 0.05, percentage of exposed controls of 59, 7 and of cases 91, 94. However, contrary the present study used the power of 90% and 1:2 case control ratio to come up with the sample size as shown below for increased statistical power. The sample size was computed using the Epi Info™.

$$n_1 = \frac{\left[Z_{\alpha/2}\sqrt{(r+1)\overline{p}\overline{q}} + Z_{1-\beta}\sqrt{rp_1q_1 + p_2q_2}\right]^2}{r(p_1 - p_2)^2}$$

$$n_2 = r\,n_1$$

Figure 3.2 Fleiss formula

Table 3.1 Summary of Fleiss formula variables

Where:

Variable	Case Control
n_1	cases (number of individuals suffered from anthrax)
n_2	controls (number of individuals who did not suffer from anthrax)
$Z_{\alpha/2}$	z-score for two-tailed test based on α level (1.96)
$Z_{1-\beta}$	z-score for one-tailed test based on β level (0.84)
r	cases: controls (r=2)
p_1	proportion of cases (91.94% or 0.9194)
q_1	1- p_1 (0.0806)
p_2	proportion of control (59.7% or 0.597)
q_2	1-p_2 (0.403)
α	0.05

As a result, this case control study used a sample size of 285 individuals from the selected households. Out of 285 individuals, those who were clinically or laboratory diagnosed with anthrax, were (n_1 = 95) and those without a clinical or laboratory confirmed anthrax diagnosis were (n_2 = 190). The Figure 3.2 below illustrates the sampling procedure of cases and controls of the study.

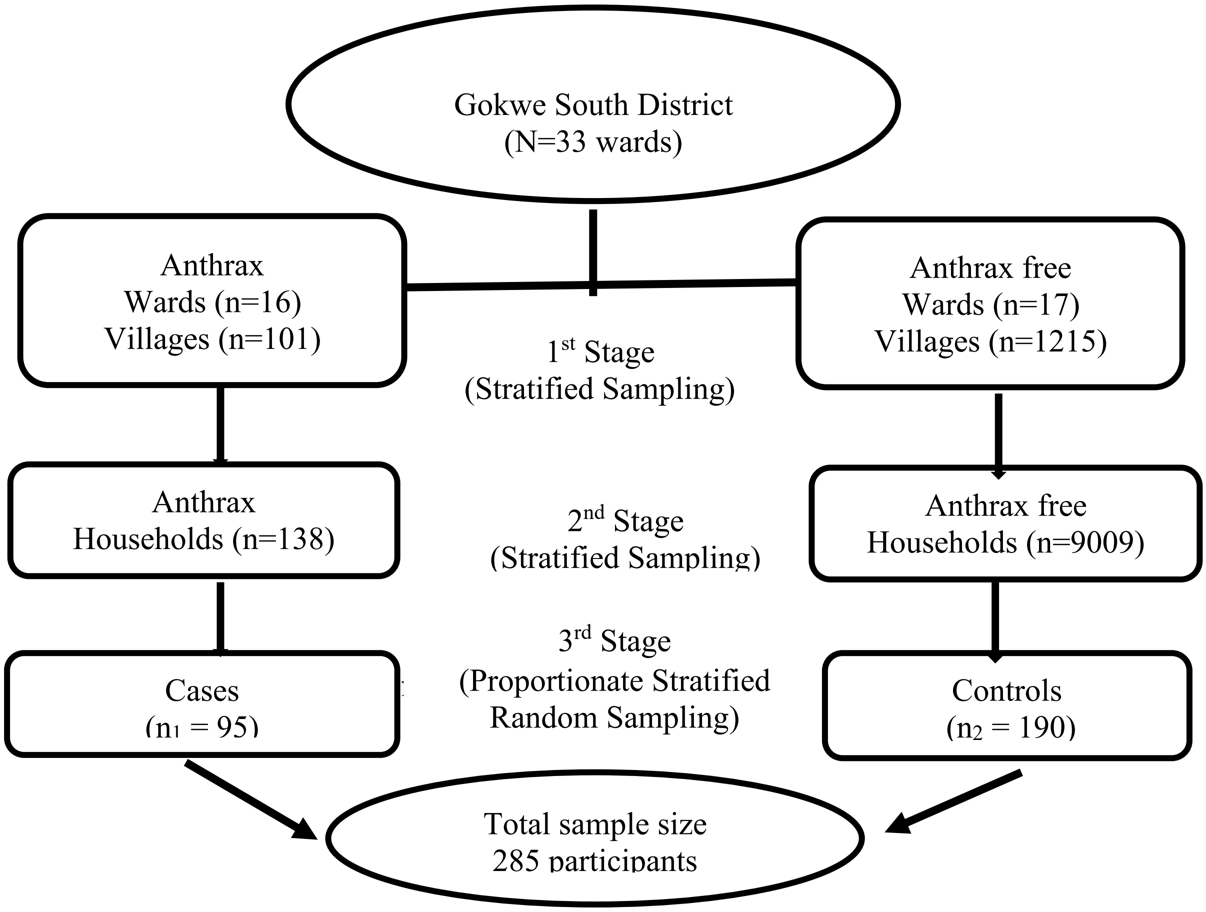


Figure 3.3 Sampling framework

The total number of key informants interviewed during the study was eight (8).

3.4 Data collection methods

A questionnaire with closed-ended questions designed using research objectives was used to gather information related to the research objectives of the study. The researcher chose the most important variables for the study and set up the instrument in three main areas: socio-demographic determinants (research objective 1), community knowledge, attitudes and practices related to anthrax affecting anthrax morbidity (research objective 2), household dietary diversity score which is a qualitative measure of access to a variety of foods amongst households and nutrient adequacy for individuals (research objective 3). An interview guide with structured open ended questions was used understand the Stakeholders' anthrax outbreak management focusing on the following: key stakeholders involved, key responsibilities, One Health Approach understanding, joint sector response, policy documents availability, surveillance system, communication strategies, data sharing practices, resources allocation priority, capacity building, implementation challenges and best practices (research objective 4). Adult respondents, selected as cases and controls, were interviewed directly;

while for adolescents, parents were involved in the interview process. An interview guide was used to interview the key informants.

3.5 Data analysis methods

Data analysis is one of the important elements in research with the purpose to identify, transforming, supporting decision making, and drawing a conclusion. The method puts facts and figures to solve the research problem, and it is vital to finding the answers to the research question. Data analysis can be quantitative or qualitative, or both. In this research, data analysis employed both (Ashirwadam, 2022).

3.5.1 Quantitative data analysis

Univariate analysis: The quantitative data collected was analysed using the Statistical Package for the Social Sciences (IBM SPSS 25) for Windows. Descriptive statistics were used in the study to present an overview and summary of key variations in the anthrax risk factors among the study groups. Data was presented, indicating frequencies and percentages along with confidence intervals. The results for the mean and standard deviation were concluded at 95% confidence intervals on univariate analysis.

Bivariate analysis: Bivariate analysis was used to compare the relationships and identify each strong independent variable related to the response variable (anthrax morbidity) using parametric and non-parametric tests. The study utilized contingency tables (cross-tabulations) to summarize data both numerically and in percentages. To test for associations, the study applied the Chi-Square Test (χ^2 Test) to determine whether each independent variable (sex, anthrax knowledge, transmission, symptoms, prevention, treatment, signs in dead animals, livestock ownership, livestock vaccination status, vaccine source, age group, income, household size, livestock keeping experience and household dietary diversity score, ethnicity, education level, occupation, major livestock, livestock keeping purpose, individual involved in livestock handling, preferred place for livestock grazing, period of conducting vaccination and dead livestock handling) is statistically independent to anthrax morbidity. If any of the contingency table's cells had an expected frequency below five or if more than 20% of the expected counts were less than five, Fisher's Exact Test was used in the study (Lee, 2017). A p-value of less than 0.05 ($p < 0.05$) indicated a significant relationship in either the Chi-Square Test or Fisher’s Exact Test at the bivariate analysis stage.

Multivariate Logistic Risk Factor Model: A Multivariate Binary Logistic Regression Model was employed to predict the outcomes of the dependent variable (anthrax morbidity with categories 0 and 1 code; '0' for not having anthrax and '1' for having anthrax) in this study. The logistic regression model's appropriateness, usefulness, and adequacy are assessed using various evaluation parameters such as statistical tests, goodness-of-fit statistics, and mode discrimination (Rastogi & Singh, 2019). In the multivariate analysis, independent variables with a p-value less than 0.25 ($p<0.25$) in bivariate analysis were considered for inclusion in the model. All selected variables were loaded simultaneously, and those with a p-value less than 0.05 ($p<0.05$) remained, but if the removed variable changed the odds ratio (OR) of the remaining variables by more than 10%, it was reintroduced into the model. Interaction amongst independent variables was tested, and if an interaction term had a p-value less than 0.05 ($p<0.05$), the interacting variables were not included in the model together. Collinearity was assessed using cross-tabulation, and if the p-value is less than 0.05 ($p<0.05$) with a percentage difference of events between groups exceeding 80%, those variables were also excluded together in the model. Only variables with a p-value less than 0.05 ($p<0.05$) in the final multivariate model were retained in the model. The Hosmer-Lemeshow test was applied to evaluate the model's goodness of fit, while the Nagelkerke R-squared value explained the variability accounted for by the model.

3.5.2 Qualitative data analysis

Qualitative information gathered from Key Informant Interviews (KIIs) on the One Health Approach on anthrax management was analysed using thematic analysis. First, the recorded interviews were transcribed verbatim to make sure the information is accurate. The transcripts were then read multiple times to familiarize with the data and identify emerging patterns on: key stakeholders involved, key responsibilities, One Health Approach understanding, joint sector response, policy documents availability, surveillance system, communication strategies, data sharing practices, resources allocation priority, capacity building, implementation challenges and best practices. Using an inductive approach, key themes and sub-themes were developed based on recurring ideas, concepts, and perspectives from the key informants. The qualitative data were coded using the Word cloud software to systematically categorize responses. Themes were then refined, and representative quotes extracted to support the findings. Triangulation with other data sources was conducted to enhance validity and reliability. Finally, the results were interpreted about the study objectives (research objective 4), highlighting key insights on the One Health framework policy and practice.

3.6 Ethical considerations

Clearance to conduct the research was sought from the Bindura University of Science Education research board. Necessary research approvals and permissions from relevant authorities and institutions such as the Ministry of Health and Childcare, Department of Veterinary Services, Local government, and Research Council of Zimbabwe (RCZ). Research protocols and procedures complied with the provided ethical guidelines and regulations. Informed consent was obtained from participants, and their anonymity and confidentiality were ensured.

3.7 Summary

This study employed a mixed-method case-control study using a multistage sampling approach to enroll ninety-five (95) anthrax cases against one hundred and ninety (190) controls and eight (8) key informants from Gokwe South District. The data was collected using a structured questionnaire and a structured interview guide. The data was analysed using Statistical Package for the Social Sciences (IBM SPSS 25) for Windows and Word cloud for thematic analysis. The research then employed a multivariate logistic risk factor model to determine the relationship between the anthrax morbidity (dependent variable) and the independent variables (socio-demographic determinants, knowledge, attitudes, and practices) using backward stepwise selection. The Hosmer-Lemeshow test was applied to evaluate the model's goodness of fit, while the Nagelkerke R-squared value explained the variability accounted for by the model. Clearance to conduct the study was sought from relevant authorities, and consent from participants sought. The findings of the research will be shared to the relevant stakeholders following approved and officially procedures.

CHAPTER 4

RESULTS

(Functionality of the One Health Approach in Reducing Anthrax for Improved Nutrition Security: A Case-control Study in Gokwe South.)

Abstract

Background: This study was to assess the functionality of the One Health Approach in reducing Anthrax for improved Nutrition Security in Gokwe South by establishing the key risk factors contributing to anthrax morbidity and determining key interventions in place for the management of anthrax in the community.

Methods: The research was conducted using a mixed-methods approach utilising a 1:2 unmatched case-control study to assess risk factors associated with contracting anthrax. Data collection was conducted using a structured questionnaire for general participants and a key informant interview guide for KI, and the selection of participants was done using a multi-stage stratified sampling method. Multivariable logistic regression analysis was performed to identify the independent risk factors of anthrax morbidity, and thematic analysis was conducted for the One Health Approach on anthrax management.

Results: 285 participants were interviewed i.e., 95 cases, along with 190 controls. The Multivariable logistic regression predicted the factors associated with anthrax morbidity as the preferred type of grazing (forest) [game area, OR = 137.12, 95% CI (0.195–96420.507); grass fields OR = 5.03, 95% CI (0.52-48.39)], handling of dead livestock (veterinary notification) [sell/consume carcass OR = 10.82, 95% CI (2.17–53.98)], and perceived anthrax risk (low) [moderate OR =39.89 , 95% CI (6.68–238.36); severe OR =20.20 , 95% CI (4.51–90.53)]. Through interactions with district stakeholders, it was observed that the request for adoption of the One Health Approach was still theoretical with insignificant implementation within the district due to a lack of adequate resources and weak coordination.

Conclusion: This study highlights the key factors related to knowledge attitudes and practices contributing to the endemicity of anthrax in the Gokwe South district, rendering food safety risks as well as affecting livelihoods and productivity among households thus affecting Food and Nutrition Security. It also highlights the need for a multisectoral response through the One Health Approach to ensure a reduction in anthrax cases so as to minimize livestock losses and transmission of disease to humans to ensure community resilience and improved sustainable food systems.

Keywords: One Health Approach, Anthrax, Knowledge-attitudes-practices, nutrition-security, multisectoral-response

4.1 Introduction

Food systems are interconnected, involving humans, animals, plants, and ecosystems, which can contribute to fragmented oversight and governance for food-related issues. Sustainable food security maintenance is fundamental for the achievement of Sustainable Development Goals, that is, SDG2 Zero hunger, SDG 3 human health and well-being. However, emerging Zoonotic viruses have been posing challenges to efforts to maintain food security through spills to humans via the food system, for example, the severe coronaviruses, Ebola, and anthrax. In addition, other threats to sustainable food systems and health include climate change, natural disasters, overgrazing, antibiotic and pesticide use, heavy metal pollution, and unrestricted land reclamation (Gu et al. 2023).

Anthrax, a bacterial disease that is of great public health and economic threat in most agricultural systems, has been observed to be endemic in most parts of the world including in Africa. The disease mainly affects herbivores and animals, and livestock gets affected through ingestion or inhaling spores from contaminated soil, water, or plants. Humans are infected through contact with infected dead animals or their products, or through consuming meat obtained from infected livestock, usually cattle. Anthrax contributes to animal and human illnesses, death, and economic losses to the agricultural systems, hence the need to enhance surveillance, outbreak response, and diagnostics as mitigation strategies (Vieira et al. 2017).

Several factors have been associated with the emergence of anthrax which includes, including climate change, increased human and animal population, poor grazing systems, human behaviour, livestock, and wildlife interaction hence the recommendation for vaccination (Kungu et al. 2020). In Africa five countries have reported anthrax outbreaks, these include Kenya, Malawi, Uganda, Zambia, and Zimbabwe. In Zimbabwe since 2019 cases have been recorded hence the need to strengthen prevention measures. (FEWSNET, 2023)

Livestock is an important part of all smallholder farming systems, with cattle constituting the bulk of domesticated animals. The majority of Animal Source Foods are produced by smallholder farmers and traded in formal and informal value chains; production and trade of Animal Source Foods constitute an important source of livelihood in developing countries. Hence Food safety compliance is integral across the food systems value chain and compliance gaps are a major public health concern in developed and emerging economies due to the risks associated with the consumption of contaminated foods, such as zoonotic foodborne diseases (Nyokabi et al. 2023) hence need for One Health Approach.

In Zimbabwe, the One Health implementation has been through the One Health Antimicrobial Secretariat since 2022. The main activities conducted include research, training, prevention, and control of neglected tropical diseases and zoonotic diseases, antimicrobial resistance, and food safety. The committee is dominated by government officials with minimal coordination which includes, Health and Child Care, Lands, Agriculture, Fisheries, Water and Rural Development; and the Environment, Tourism, and Hospitality Industry (Matope et al, 2024). Hence there is a need to strengthen One Health Approach as a way of ensuring food safety, food security, and control of anthrax in agricultural systems.

4.2 Material and Methods

4.2.1 Description of study area

The study was conducted within the Gokwe South District (18.2172°S and 28.9422°E) which lies North-West of Midlands Province in Zimbabwe covering a total area of 11, 477,41 square km including Chirisa game park and Sengwa wildlife research area covering 1,338 square km and 373 square km respectively. The district encompasses thirty-three (33) administrative wards.

4.2.2 Research Design

This study employed a mixed-methods design, utilising a 1:2 unmatched case-control study for the quantitative comparative analysis among participants whereas the qualitative aspect involved key informant interviews to capture in-depth perspectives.

4.2.3 Sampling procedure

A multi-stage sampling technique was employed in this study to recruit participants in three stages from thirty-three (33) wards in the Gokwe South District up to the household level. Using stratified sampling 9147 households were placed in a stratum of anthrax households (138) and anthrax-free households (9009). Using a household list simple random sampling was employed to select cases (95) and controls (190) to make a total of 285 participants in the study. The sample size was calculated using the Fleiss formula with a continuity correction factor using a 1:2 unmatched case-control. Eight key informants were selected using purposive sampling from the Ministry of Health and Childcare, Ministry of Primary and

Secondary Education, Zimbabwe Republic Police, Ministry of Agriculture Department of Veterinary Services, Local government district development office, Montana Carswell Meats Abattoir head (private sector), traditional leaders, and Rural District Council.

4.2.4 Data collection procedure

A twenty-five-item closed-ended questionnaire was developed for participants deriving the content from the research objectives and categorised into distinct domains (socio-demographic characteristics, knowledge-attitude-practices related to anthrax affecting anthrax morbidity, and household dietary diversity). An interview guide with structured open-ended questions was used to understand the Stakeholders' anthrax outbreak management (preparedness, response, and control).

4.2.5 Data analysis procedure

Quantitative data analysis was performed using Statistical Package for the Social Sciences (IBM SPSS 25) for Windows. Descriptive statistics were performed in the study to present an overview and summary of key variations in the anthrax risk factors among the study groups, computing frequency distributions, and percentages. Bivariate and multivariate logistic regression analysis were conducted to assess if the independent variables are statistically independent of anthrax morbidity and to predict the outcomes of the dependent variable respectively with a significance threshold set at 0.05. Qualitative information gathered from Key Informant Interviews (KIIs) on the One Health Approach to anthrax management was analysed using thematic analysis on Word Cloud. Using an inductive approach, key themes and sub-themes were developed based on recurring ideas, concepts, and perspectives from the key informants. Results were then interpreted concerning study objectives highlighting key insights on one health framework policy and practice.

4.2.6 Challenges encountered during data collection

The major challenge was the lack of adequate funds to conduct comprehensive research.

4.3 Results and Discussion

4.3.1 Quantitative data

Two hundred and eighty-five (285) questionnaires were analysed i.e. ninety-five (95) cases and one hundred and ninety (190) controls in order to answer the research objectives.

4.3.1.1 Sociodemographic Determinants

Table 4.1 Descriptive Statistics on Socio-demographic characteristics

Anthrax	Morbidity	N	Minimum	Maximum	Mean	Std. Deviation
Control	Age	190	8	72	41.6	12.3
	Monthly income in ZIG	190	.00	13000.00	2119.3	3367.7
	Household Size	190	2	12	6.14	2.327
Case	Age	95	5	77	33.06	17.750
	Monthly income in ZIG	95	.00	9000.00	544.4	1745.5
	Household Size	95	3	21	6.85	2.806

The average age and standard deviation for participants interviewed were control ($\bar{x}$=41.6, s.d= 12.3) and case ($\bar{x}$= 33.06, s.d= 17.8), this suggests anthrax being more common amongst younger groups and greater variability amongst cases. The average monthly income was higher amongst controls ($\bar{x}$ = 2119.3) compared to cases ($\bar{x}$=544.4). This amount for cases was lower than the FPL (ZWG 876.03) for one person in May 2025 as well as the TCPL (ZWG 1279.69). The FPL is the amount needed by one individual to afford a minimum of 2100 calories daily i.e. minimum requirement to afford a food basket while the TCPL is the minimum amount required by an individual to purchase food and non-food items per month (ZIMSTAT, 2025). While the standard deviation was lower amongst anthrax cases compared to controls. In addition, the maximum income for controls (13000) and cases (9000), which may suggest economic disparities amongst groups and anthrax seems to be affecting lower income groups. The results suggest that the majority of cases are susceptible to food and nutrition insecurity due to limited access to a diverse and nutritious diet as a result of low income thus risking consuming anthrax-infected meat. A study also revealed that households with income below poverty thresholds are at greater risk of food insecurity (Odoms-Young et al., 2023). Household size was higher amongst the affected population compared to non-affected suggesting that larger households are at risk more compared to smaller households.in addition, lower-income households with larger households' size are more likely to face extra food insecurity challenges (Meyer & Nishimwe-Niyimbanira, 2016).

4.3.1.2 Bivariate analysis

Chi squared was conducted to assess the relationships between the dependent variables and independent variables at p-value of less than 0.05 ($p < 0.05$).

Table 4.2 Socio Demographic determinants associated with anthrax morbidity

Variable	Categories	Case	Control	p-value (χ^2)
Age group (years)	< 26	38 (40)	15 (7.9)	0.000
	26-35	19 (20)	45 (23.7)	
	36-45	17 (17.9)	61(32.1)	
	46-55	8 (8.4)	42(22.1)	
	>55	13(13.7)	27(14.2)	
Sex	Male	67 (70.5)	108 (56.8)	0.035
	Female	28 (29.5)	82 (43.2)	
Ethnicity	Tonga	2 (2.1)	14 (7.4)	0.000
	Shangwe	41 (43.2)	33 (17.4)	
	Shona	51 (53.7)	112 (58.9)	
	Karanga	1 (1.1)	21 (11.1)	
	Ndebele	0 (0)	10 (5.3)	
Education level	Never attended	2 (2.1)	4 (2.1)	0.000
	Primary	25 (26.3)	23 (12.1)	
	Secondary	67 (70.5)	137 (72.1)	
	Tertiary	1 (1.1)	26 (13.7)	
Household size	1-3	10 (10.5)	19 (10)	0.222
	4-6	41 (43.2)	102 (53.7)	
	>6	44 (46.3)	69 (36.3)	
Occupation	Not employed	55(57.9)	40 (21.1)	0.000
	Civil service	5 (5.3)	35 (18.4)	

	Private Service	1 (1.1)	20 (10.5)	
	Farmer	33 (34.7)	90 (47.4)	
	Casual labour	1 (1.1)	5 (2.6)	
Monthly income	0-1255.78 ZIG	86 (90.5)	123 (64.7)	0.000
	> 1255.78 ZIG	9 (9.5)	67 (35.3)	

4.3.1.3 Knowledge, Attitudes and Practices

The table provides a statistical analysis of the socio-demographic factors associated with anthrax morbidity comparing affected populations (cases) and non-affected populations (controls) to establish statistical significance among the groups. The key findings highlighted age being statistically significant (p=0.000). The age group below 26 years contributed to a larger proportion of cases (40%) compared to controls (7.9%) suggesting them to be more vulnerable and exposed to anthrax compared to older populations. This is consistent with other studies which have also revealed the probability of anthrax morbidity being higher among younger people than adults especially those involved in animal husbandry (Nigusse et al., 2023).

The sex variable was also significant (p=0.035) with males affected more compared to females suggesting the possibility of gender-related risk factors resulting from occupational exposure. Other researchers have also identified significant differences in health outcomes related to agricultural activities among women where men have been observed to experience more risk compared to women though there is a need to be cautious in generalising across the contexts. In addition, the relationship between age and gender has been observed to be significant due to reasons that males engage in agricultural activities more at a younger age and during old age (Habib et al., 2014; Shandilya et al., 2023).

Ethnicity also was significant (p= 0.000), with the Shangwe (43.2%) and Shona (53.7%) groups contributing to a greater percentage amongst the affected population. In addition, education level was also significant (p=0.000), with lower education levels (primary (cases=26.3%); (controls= 12.1%) tertiary level (cases= 1.1%; controls= 13.7%)) correlating to high anthrax exposure suggesting education might be playing a role in anthrax through influencing access to information as well as the ability to grasp key health messages among individuals (Sitali et al., 2017b). There was no statistical difference amongst household size groups (p= 0.222) suggesting that the variable did not affect anthrax morbidity. Occupation indicated statistical significance (p=0.000) amongst groups, with unemployed (57.9%) and farmers (34.7%) contributing to the largest proportion of cases compared to civil service (5.3%) and private sector (1.1%). Monthly income was also statistically significant amongst groups, with lower income groups (90.5%) affected compared to higher income (9.5%). Overall, gender-related risk factors, economic status, and education had an influence on anthrax morbidity. Furthermore, the socioeconomic status of households can influence food and nutrition security and this can be revealed in choices made when accessing food and consumption patterns. Research reveals that income and employment status have an effect on food access. In addition, demographic factors such as age, education, and gender have been observed to have a relationship with food and nutrition security by affecting food choices. Those who are less educated are most likely to be less employed and end up engaging in risky behaviours in this case consuming unsafe meat from anthrax carcasses. In addition due to food insecurity as a result of a lack of economic access to quality and nutritious diets and with dead carcasses providing an opportunity for protein, they end up forced to consume (Lehman et al., 2017b; Placzek et al., 2021; Senyange et al., 2022).

Adequate income is necessary to ensure people live healthier and it contributes to full participation in society. Income is a significant factor in access to health resources necessary for animal management. If households lack access to nutritious adequate foods or struggle to obtain adequate food it may also affect animals under their care, in this case, livestock hence end up susceptible to diseases like anthrax due to lack of preventive measures such as vaccination. Also, those individuals who are educated are likely to value preventive measures for themselves and their livestock (Card et al., 2018).

Table 4.3 Descriptive Statistics on livestock keeping experience

Anthrax Morbidity		**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Control	Livestock keeping experience	190	0	40	10.76	8.054
Case	Livestock keeping experience	95	0	50	10.98	11.500

There was no greater average difference amongst groups on livestock keeping experience (case; $\bar{x}$=10.98; control $\bar{x}$=10.76). While the variation was higher amongst cases (s.d= 11.5) compared to controls (s.d= 8.1).

Table 4. 4 Knowledge, Attitudes and Practices related to Anthrax morbidity

Model	Variable	Categories	Case	Control	p-value (χ^2)
Anthrax Knowledge	Heard about Anthrax	Yes	75 (78.9)	169 (88.9)	0.037
		No	20 (21.1)	21 (11.1)	
	Anthrax transmission	Yes	57 (60)	141 (74.2)	0.020
		No	38 (40)	49 (25.8)	
	Human anthrax symptoms	Yes	54 (56.8)	138 (72.6)	0.011
		No	41 (43.2)	52 (27.4)	
	Signs in dead animals	Yes	33 (34.7)	104 (54.7)	0.002
		No	62 (65.3)	86 (45.3)	
	Anthrax Prevention	Yes	49 (51.6)	135 (71.1)	0.002
		No	46 (48.4)	55 (28.9)	
	Anthrax Treatment	Yes	61 (64.2)	116 (61.1)	0.698
		No	34 (35.8)	74 (38.9)	
Anthrax Attitude & Practices	Major livestock	Goats	9 (9.5)	31 (16.3)	0.053
		Cattle	86 (90.5)	153 (80.5)	
		Pigs	0 (0)	6 (3.2)	
	Livestock handling experience	0-4 years	27 (28.4)	34 (17.9)	0.108
		5-9 years	24 (25.3)	61 (32.1)	
		≥ 10 years	44 (46.3)	95 (50)	
		Income	13 (13.7)	77 (40.5)	0.000

Livestock keeping purpose	Food supply	3 (3.2)	26 (13.7)	
	Agricultural function	79 (83.2)	87 (45.8)	
Individual involved in livestock handling	Respondent	51 (53.7)	95 (50)	0.000
	Wife/husband	12 (12.6)	48 (25.3)	
	Parents	24 (25.3)	13 (6.8)	
	Son/daughter	6(6.3)	16 (8.4)	
	Other relatives	2 (2.1)	18 (9.5)	
Preferred place for grazing	Forest	5 (5.3)	13 (6.8)	0.000
	Game area	4 (4.2)	1 (0.5)	
	Agricultural land	17 (17.9)	89 (46.8)	
	Purchase fodder	0 (0)	5 (2.6)	
	Grass fields	69 (72.6)	82 (43.2)	
Livestock vaccination status	Vaccinated	59 (62.1)	144 (75.8)	0.023
	Not vaccinated	36 (37.9)	46 (24.2)	
Period of conducting vaccination	Annually	10 (10.5)	57 (30)	0.001
	During outbreaks	51 (53.7)	88 (46.3)	
	Never vaccinate	34 (35.8)	45 (23.7)	
Vaccine source	Own purchase	24 (25.3)	129 (67.9)	0.000
	Government support	71 (74.7)	61 (32.1)	
Dead livestock handling	Veterinary notification within 24 hours	23 (24.2)	59 (31.1)	0.000

	Bury/burn	19(20)	85 (44.7)	
	Sell carcass/ consume	53 (55.8)	46 (24.2)	
Anthrax perceived risk	Low risk	27 (28.4)	84 (44.2)	
	Moderate risk	20 (21.1)	20 (10.5)	0.009
	High risk	48 (50.5)	86 (45.3)	

Table 4.4 provides a statistical analysis of the knowledge, attitudes, and practices associated with anthrax morbidity comparing affected populations (cases) and non-affected populations (controls) to establish statistical significance amongst the groups with a threshold set at p=0.05. All variables with a p-value less than 0.05 ($p < 0.05$) were considered statistically significant implying that the variable and anthrax morbidity have a meaningful relationship and the differences observed reflect an association. Key findings on anthrax knowledge indicated the following: Having heard about anthrax was significant (p=0.037), and the control group (88.9%) had a greater percentage compared to the case group (78.9%) implying that awareness affects anthrax morbidity. Knowledge of anthrax transmission was statistically significant (p=0.020) with lower knowledge among cases (60%) compared to controls (74.2%). Knowledge of symptoms of human anthrax was statistically significant (p=0.011) control group (72.6%) had a greater percentage compared to cases (56.8%). In addition, knowledge of the signs in dead animals was also significant (p=0.002) with control groups (54.7%) and cases (34.7%) implying failure to identify signs could contribute to further spread. Knowledge of preventive measures was also significant (p=0.002) with a higher percentage amongst the control group (71.1%) compared to cases (51.6%). Knowledge of anthrax treatment was not statistically significant (p= 0.698) indicating no difference across both groups. Overly, the majority of anthrax knowledge variables were statistically significant among both groups suggesting the importance of education towards control of anthrax. Studies have also highlighted that frequent anthrax outbreaks may reinforce learning through experience (Choudhary et al., 2025).

Findings on attitudes and practices related to anthrax revealed that cattle were the major livestock amongst cases (90.5%). However, major livestock was slightly statistically insignificant (p= 0.053), suggesting no differences between both groups. While the livestock-keeping purpose variable was statistically significant (p = 0.000). Keeping livestock for agricultural purposes (draught power/ manure) amongst cases (83.2%) was the major compared to controls (45.8%), while controls had other reasons dominating which included income (40.5%). In addition cases (83.2%) had a greater involvement with handling livestock compared to other persons in the household. The variable was statistically significant (p = 0.000) suggesting the high risk of anthrax exposure through handling livestock. The variable on the type of grazing options preferred was also statistically significant (p= 0.000). Livestock amongst cases grazed in grass fields (72.6%) while amongst control the most grazing option was agricultural land (p= 0.000) hence, suggesting that grazing options could influence exposure to anthrax spores. Studies have revealed that open grazing is a common practice among farmers, where livestock are environmentally exposed to anthrax spores, particularly in forest or open areas where contamination with anthrax spores is more likely (Choudhary et al., 2025). Vaccination status was statistically significant (p=0.023). There was higher vaccination coverage among controls (75.8%) against cases (62.1%) suggesting that vaccination reduces the risk; an evidence-based prevention measure of anthrax (Rao et al., 2019b). Most cases (53.7%) reported that their livestock was vaccinated during outbreaks against controls (46.3%). While controls (30%) reported that they vaccinate annually against cases (10.5%). The variable was statistically significant (p=0.001). Thus, suggesting protection being offered by regular vaccination. Government support (74.7%) on vaccine source dominated amongst cases whilst controls (67.9%) were obtained through own purchase. The variable on vaccine sources was statistically significant (p=0.000) highlighting a significant gap in vaccine accessibility. A study in Zambia also revealed low annual vaccination rates, resulting from logistical challenges as well as inadequate provision of veterinary signifying a gap in accessibility hence recommended strengthening of veterinary services and decentralisation of cold chain facilities as a means of improving access to vaccines (Sitali et al., 2017). The practice of how dead livestock is handled revealed that (55.8%) of the cases either sold or consumed the carcass. This practice is common where the majority of households rely on livestock as a source of livelihood such that in case of livestock death meat from the dead carcass is sold in order to try and regain losses despite knowledge of the potential risks (Musewa et al., 2022). Burying or burning was the major option amongst controls (44.7%), highlighting the role of the environment in anthrax transmission. However, the anthrax spores are resistant to harsh environments e.g. temperature, pH, ultraviolet radiation, and pressure; and they can persist in the environment for a long period (some researchers suggest up to 90 years) thus the need for proper disposal to prevent spread of outbreaks (Subedi et al., 2024; Mohamed et al., 2019). The variable was statistically significant (p=0.000), suggesting that improper disposal could increase the risk of anthrax transmission. Lastly, the variable on anthrax perceived risk was statistically significant (p=0.009). Most cases (50.5%) considered being at high risk against controls (45.3%). The results indicated that the affected group recognised their vulnerability but could not practice adequate preventive measures due to various reasons such as lack of access to preventive strategies e.g. anthrax vaccines. Overly, poor attitudes and practices such as improper carcass handling, over dependence on government support contributed to increased anthrax susceptibility. However with the government sometimes, offering support to households some end up reluctant and developing a dependency syndrome that the government will assist hence posing disease risks for livestock in case of logistical delays (Makiwa et al., 2023).

Livestock in rural communities aids as a source of livelihoods and a contribution to food production. Livestock ownership can contribute to improved income, improved food, and nutrition security (food rich in micronutrients, proteins, and calories essential for health), and reduced poverty at the household level (Akash et al., 2021; Zahir et al., 2024). However, this can only be achieved through sustainable livestock production in which animal health is essential. Zoonotic diseases such as anthrax if not managed pose a risk of failure to achieve the goal (FAO Knowledge Repository, 2023). Animal disease contributes to more than 20% of deaths in the world with the burden higher in Sub-Saharan Africa and these deaths can contribute to food unavailability. Hence, agricultural practices and veterinary practices contribute immensely towards safe, available, and accessible animal source food from farm to fork (Galvmed, 2024; Mohammed & Elseory, 2024).

4.3.1.4 Household dietary diversity

A 24 hour recall of twelve food groups consumed at the household was conducted and results were as highlighted below.

Table 4.5 Descriptive Statistics on Household dietary diversity score

Anthrax	Morbidity	N	Minimum	Maximum	Mean	Std. Deviation
Control	Household dietary diversity score	190	4	12	6.46	1.735

Case	Household dietary diversity score	95	4	9	6.01	1.595

The average household dietary diversity was slightly higher amongst the control group (x̄= 6.46) while amongst the cases group (x̄= 6.01). The stand deviation was higher amongst the control groups (s.d= 1.735) against cases (s.d= 1.595) suggesting a wider range of dietary diversity amongst the non-affected group. In addition, the maximum number of food groups was higher amongst non-affected (12 groups) than affected (9 groups) which may suggest that a higher dietary diversity would be contributing toward strengthening the immunity and contributing to overall immunity thus the control group being less susceptible to anthrax. A study on predictors of food security and dietary diversity in Cameroon revealed that low household income influenced food insecurity through reduced access to dietary diversity. This is in line with the current study where those affected with anthrax had low monthly income (Tambe et al., 2023). Another study on determinants of dietary diversity in Tanzania also highlighted socio-economic status as a key determinant in dietary diversity both directly (through purchasing of food) and indirectly through modifying the agro biodiversity (purchasing agricultural inputs) (Powell et al., 2017).

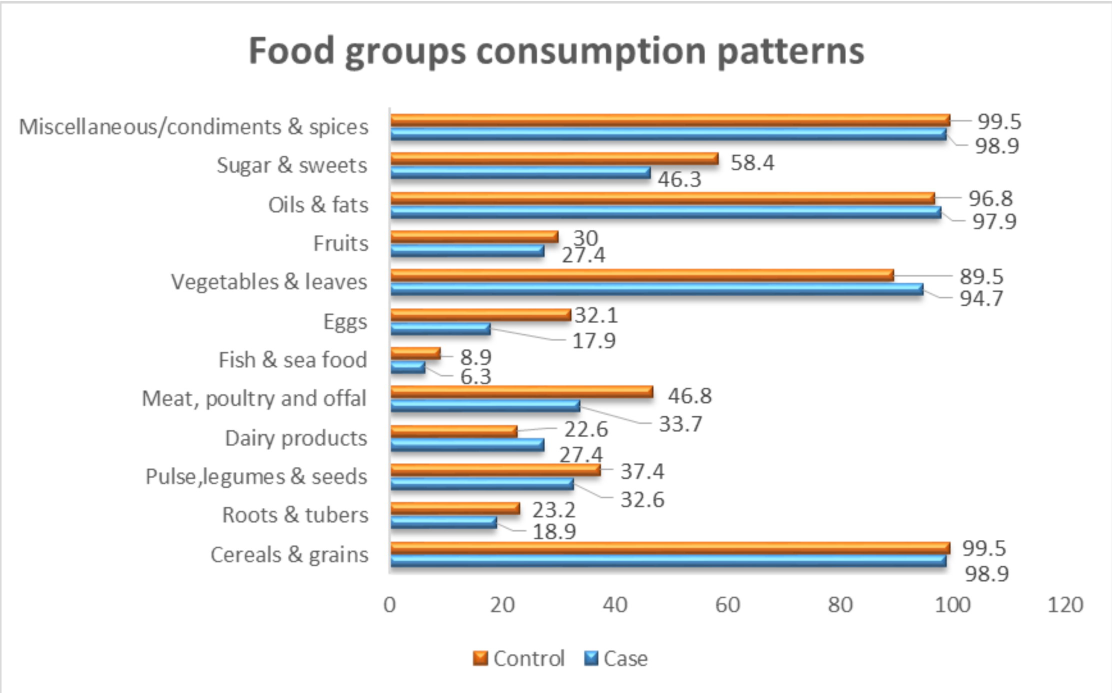


Figure 4.1 Consumption patterns amongst study participants

The major food groups that contributed to the diet of respondents included cereals and grains, oils and fats, vegetables and leaves including miscellaneous/ condiments. There was poor consumption of food groups such as fruits, fish and seafood, pulse, legumes and seeds, eggs and dairy and dairy products amongst both groups suggesting that the overall dietary quality of respondents was poor with unbalanced nutrients with a possible risk of micronutrient deficiency at household level. Research has revealed that a dietary diverse diet has a positive response to health status (Cheteni et al., 2020; Zhu et al., 2024).

Table 4.6 Relationship between household dietary diversity and anthrax morbidity

Variable	**Categories**	**Case**	**Control**	**p-value (χ^2)**
Household dietary diversity score	< 6 food groups	58 (61.1)	114 (60.0)	0.966
	≥ 6 food groups	37 (38.9)	76 (40.0)	

Table 4.6 highlights the relationship between household dietary diversity and anthrax morbidity to establish the effect of food insecurity on anthrax morbidity within the Gokwe South population. There was a slight difference between individuals who consumed less than six food groups among the affected (61.1%) to those who were not affected (60.0%). The results of the chi-squared test indicated that there was no statistical significance amongst both groups suggesting that dietary diversity was not a major factor towards anthrax susceptibility, implying a food system challenge and that outbreaks of anthrax occur in households already struggling to access a diverse diet such that in chronic food insecurity communities with food shortages and who lack dietary diversity will be forced to risk consuming unsafe meat as observed during the study on to assess the role of food insecurity on anthrax outbreak after the death of a hippopotamus in Zambia (Lehman et al, 2017).

4.3.1.5 Multivariate logistic regression analysis output of independent factors associated with Anthrax morbidity

Binary logistics were used to determine whether independent variables (Sex, Ethnicity, Education, Occupation, Heard about anthrax, anthrax Transmission, anthrax Symptoms, anthrax Prevention, Signs, Major, livestock Purpose, Individual involved in livestock handling, Preferred grazing, Vaccination status, Vaccination period, Vaccine Source, Dead livestock handling practice, Perceived anthrax Risk, Age, Income, House Hold Size, and livestock handling Experience) were associated with the likelihood of having anthrax morbidity. The variables selected had a p-value less than 0.25 (p< 0.25) at bivariate analysis.

The multicollenearity assumption was met (tolerance value of >0.1). An inspection of standardised residual values revealed that there were thirteen (13) outliers with (Standard residuals ranging from -5.607 to 8.789) which were kept in the data set.

Table 4.7 Logistic regression predicting the factors associated with Anthrax morbidity

		B	S.E.	Wald	df	p value	O.R	95% C.I. for O.R	
								Lower	Upper
Sex	Female	-0.584	0.691	0.713	1	0.399	0.558	0.144	2.163
Age group	< 26 years			4.311	4	0.366			
	26-35	-1.643	0.96	2.928	1	0.087	0.193	0.029	1.27
	36-45	-1.915	1.036	3.415	1	0.065	0.147	0.019	1.123
	46-55	-2.236	1.14	3.844	1	0.05	0.107	0.011	0.999
	>55 years	-2.032	1.263	2.589	1	0.108	0.131	0.011	1.557
Ethnicity	Tonga			3.932	4	0.415			
	Shangwe	1.386	1.429	0.941	1	0.332	3.998	0.243	65.765
	Shona	1.077	1.386	0.604	1	0.437	2.935	0.194	44.374
	Karanga	-1.333	1.989	0.449	1	0.503	0.264	0.005	13.006
	Ndebele	-19.505	10308.13	0	1	0.998	0	0	.
House hold size	1-3			1.228	2	0.541			
	4-6	-0.669	0.782	0.733	1	0.392	0.512	0.111	2.37
	>6	-0.934	0.843	1.227	1	0.268	0.393	0.075	2.051
Education	Never attended			1.768	3	0.622			
	Primary	2.484	2.692	0.851	1	0.356	11.993	0.061	2347.898

	Secondary	2.577	2.667	0.934	1	0.334	13.163	0.071	2450.23
	Tertiary	0.462	3.102	0.022	1	0.882	1.588	0.004	693.095
Occupation	Not employed			1.672	4	0.796			
	Civil Service	0.319	1.567	0.041	1	0.839	1.376	0.064	29.649
	Private Service	-1.574	1.949	0.652	1	0.419	0.207	0.005	9.452
	Farmer	-0.289	0.595	0.236	1	0.627	0.749	0.234	2.403
	Casual labour	-1.96	3.114	0.396	1	0.529	0.141	0	62.958
Monthly income	> 1255.78 ZIG	-0.599	1.108	0.292	1	0.589	0.549	0.063	4.818
Knowledge on anthrax	Heard (No)	-0.386	0.82	0.222	1	0.638	0.68	0.136	3.391
	Transmission (No)	1.062	0.818	1.685	1	0.194	2.891	0.582	14.363
	Symptoms (No)	-0.461	1.046	0.194	1	0.659	0.631	0.081	4.899
	Prevention (No)	-0.151	0.952	0.025	1	0.874	0.86	0.133	5.557
	Signs (No)	0.632	0.749	0.711	1	0.399	1.881	0.433	8.162
Major Livestock	Goats			0	2	1			
	Sheep	0.022	1.074	0	1	0.984	1.022	0.125	8.384
	Cattle	-20.446	12765.66	0	1	0.999	0	0	.

Livestock handling experience	0-4 years			1.631	2	0.442			
	5-9 years	-1.13	0.99	1.303	1	0.254	0.323	0.046	2.249
	≥ 10 years	-0.535	0.986	0.294	1	0.587	0.586	0.085	4.042
Purpose of livestock	Income			3.352	2	0.187			
	Food supply	-2.693	1.488	3.275	1	0.07	0.068	0.004	1.251
	Agricultural function	0.156	0.664	0.055	1	0.814	1.169	0.318	4.292
Individuals involved in handling	Respondent			1.508	4	0.825			
	Wife/husband	-0.896	0.942	0.904	1	0.342	0.408	0.064	2.587
	Parents	-0.843	1.206	0.489	1	0.485	0.431	0.041	4.574
	Son/daughter	0.08	0.985	0.007	1	0.936	1.083	0.157	7.458
	Other relatives	-2.007	2.609	0.592	1	0.442	0.134	0.001	22.341
Preferred grazing	Forest			14.85	4	**0.005**			
	Game area	4.921	3.345	2.164	1	0.141	137.117	0.195	96420.51
	Agricultural land	-0.664	1.131	0.345	1	0.557	0.515	0.056	4.724

	Purchase fodder	-17.971	13624.84	0	1	0.999	0	0	.
	Grass field	1.616	1.155	1.957	1	0.162	5.032	0.523	48.391
Vaccination status	Not vaccinated	3.24	1.734	3.492	1	0.062	25.535	0.854	763.793
Vaccination period	Annually			3.957	2	0.138			
	During outbreaks	1.232	0.758	2.643	1	0.104	3.429	0.776	15.148
	Never vaccinate	-1.219	1.767	0.476	1	0.49	0.296	0.009	9.441
Vaccine source	Government support	0.52	0.557	0.87	1	0.351	1.682	0.564	5.013
Handling of dead livestock	Veterinary notification within 24 hrs			14.134	2	**0.001**			
	Burn/bury	-0.382	0.62	0.381	1	0.537	0.682	0.202	2.299
	Sell/ consume carcass	2.381	0.82	8.428	1	0.004	10.816	2.167	53.975
Perceived risk	Low			20.036	2	**0.000**			
	Moderate	3.686	0.912	16.334	1	0.000	39.892	6.676	238.362
	Severe	3.005	0.765	15.417	1	0.000	20.196	4.505	90.533
	Constant	-5.767	3.904	2.182	1	0.140	0.003		

The model was statistically significant χ^2 (46, N=285) = 206.56, p= 0.000, suggesting that it could distinguish those with and without anthrax. The model explained between 51.6% (Cox & Snell R Square) and 71.6% (Nagelkerke R Square) of the variance of the dependent variable and correctly classified 88.1% of cases.

Table 4.7 above indicates a negative coefficient of Sex (Female-0.584). The results suggested that the odds of contracting anthrax amongst females decreased. However, the variable sex was insignificant (p = 0.399). Variable Age indicated that as age category increase the odds of contracting anthrax decreased as compared to lower age groups (<26 years). However, the age group 46-55 was significant (p = 0.05) with low odds of anthrax morbidity (O.R =0.107). The variable Ethnicity was insignificant, while the Shona (OR =2.935) and the Shangwe (OR=3.998) indicated high odds of anthrax morbidity. Education, Occupation, and monthly income variables were insignificant. The variables on anthrax knowledge (heard, transmission, signs, and symptoms in humans, signs in dead animals, and anthrax prevention), major livestock owned, livestock handling experience, purpose of livestock owned, individuals involved in handling livestock, vaccine source and vaccination period did not indicate significance towards anthrax morbidity. However, the vaccination period during outbreaks (OR= 3.429) indicated high odds of anthrax morbidity and those who relied on government support (OR= 1.682) had high odds compared to those who purchased the vaccine on their own. The fact that the government sometimes offers support is creating some dependency syndrome with some households being reluctant and developing a dependency syndrome that the government will assist hence posing disease risks for livestock in case of logistical delays (Makiwa et al., 2023).

Livestock vaccination status was indicated to be an important predictor in the model although it was insignificant (p=0.062). However, the coefficient for unvaccinated livestock was positive (3.24) and (OR=25.535) suggesting high odds of anthrax morbidity amongst groups with unvaccinated livestock.

The overall significance for the preferred type of grazing for livestock was statistically significant (p=0.005) to anthrax morbidity. The coefficient of the game area was strongly positive (B = 4.921) and the odds of anthrax morbidity were extremely high (OR = 137.117). However, the confidence interval (95% CI 0.195- 96420.507) is extremely wide, suggesting high uncertainty in the estimate. The coefficients for agricultural land (B= -0.664) and purchasing fodder (B= -17.971) were negative indicating that the options have a reduction effect on the odds of anthrax. However, they were statistically insignificant (p=0.557) and (p=0.999) for agricultural land and purchasing fodder respectively. Furthermore, the coefficient for choosing grass fields was positive (B=1.616) and the odds indicated an increase in the occurrence of anthrax (OR=5.032), however with the effect being insignificant (p= 0.162).

Handling practices of dead livestock showed a strong significance on anthrax morbidity (p= 0.001). Selling/consuming carcasses showed a strong association (OR = 10.816, p = 0.004).In addition, the variable on perceived anthrax risk indicated highly significant effects on anthrax (p=0.000). The results indicated that as the level of perceived risk increased the odds also decreased; moderate (0R=39.892, p= 0.000) and severe (OR= 20.196, p=0.000) risk.

In conclusion, Table 4.7 above highlights some factors having some trends, preferred type of grazing (p= 0.005), handling practices of dead livestock (p=0.001) and perceived risk towards anthrax morbidity (p= 0.000) indicated a statistically significant contribution to the model. The results of this study revealed some poor practices that exist in the community that are likely to be contributing to anthrax morbidity in Gokwe South. The results are consistent with other studies which also revealed that poor practices such as consumption of uninspected meat as well as poor disposal are likely to harbour spores in the environment for a long time and lead to the spread of anthrax outbreak (Mohamed et al., 2019). Another study linked anthrax outbreak to the handling and consumption of meat from dead animals with unknown causes and suggested a One Health Approach in a multi-sectoral stakeholder approach to facilitate the process of preventing future outbreaks (Musewa et al., 2022). In addition, livestock-human-wildlife interaction also contributes to transmission in endemic regions with communal grazing areas and game reserves acting as hotspots for anthrax spores (Mumba et al., 2025).

Hence, with livestock production being a pillar contributing to food security and nutrition security through the provision of protein and micronutrients, a source of livelihood for income to access dietary diversity, and income to access resources for animal health the occurrence of outbreaks that affect the productivity of livestock risk affecting availability and access to diverse diet. This can be further exacerbated in cases where the community is already struggling with food insecurity. Hence the need for strengthening of One Health Approach involving multisectoral stakeholder involvement towards anthrax management (Lehman et al, 2017; Tirivanhu et al., 2023).

4.3.2 Qualitative data: Key themes identified

Figure 4.2 Anthrax management word cloud visual

Figure 4.2 above is a word cloud visual representing the frequency of the anthrax management-related words. The more the word appeared in the data set the larger the word on the visual.

4.3.2.1. Key stakeholders and their responsibilities

Table 4.8 below highlights the roles and responsibilities of stakeholders as highlighted through key informant interviews. There were variations in the roles and responsibilities among stakeholders with others active and informed while other stakeholders proved to lack awareness of their roles and responsibilities.

Table 4.8 Roles and Responsibilities of One health framework stakeholders

Stakeholder	Roles and responsibilities
Local Government (District Development office)	• Coordination of activities amongst the various government agencies and Non-governmental organisations and international organisations. They also act as the bridge between the community and higher level authorities. • The office also facilitates community engagement and resource mobilisation

Ministry of agriculture (Department of Veterinary services)	• Animal health (anthrax vaccination for livestock) • Animal anthrax surveillance (case identification and notification) • Law enforcement (quarantine measures and livestock movement restrictions during outbreaks) • Training and capacity building (farmers trainings) • Public awareness campaigns
Ministry of health and childcare	• Human health (case management) • Disease surveillance (case identification and notification in humans) • Health promotion (risk communication and community engagement) spreading of accurate information and dispel myths and misconceptions. • Community level education through Village health workers.
Police Department	• Law enforcement (livestock movement restrictions during outbreaks and enforcing quarantine measures)
Local authority (Rural district council/ Town council)	• Public awareness through community leaders (chiefs, headmen, village heads and councillors). • Law enforcements • Resource mobilisation
Ministry of Primary and secondary education	• Public awareness through school health coordinators and school children (who act as whistle blowers). • Monitoring of health conditions of pupils through school health coordinators and reporting of anthrax cases amongst students.
Non-governmental Organisation/ Community Based Organisations	• Public awareness • Resource mobilisation • Logistical support during outbreaks
Community members	• Adhering to programme interventions (livestock vaccination, livestock quarantine protocols,)

The key players in stakeholder engagement identified that are central to anthrax management involved the Department of Veterinary Services and the Ministry of Health and Childcare. Awareness and training (educational campaigns) and preparedness activities are critical and the frequent mention of the words indicates how well-informed the community members are in Gokwe South district.

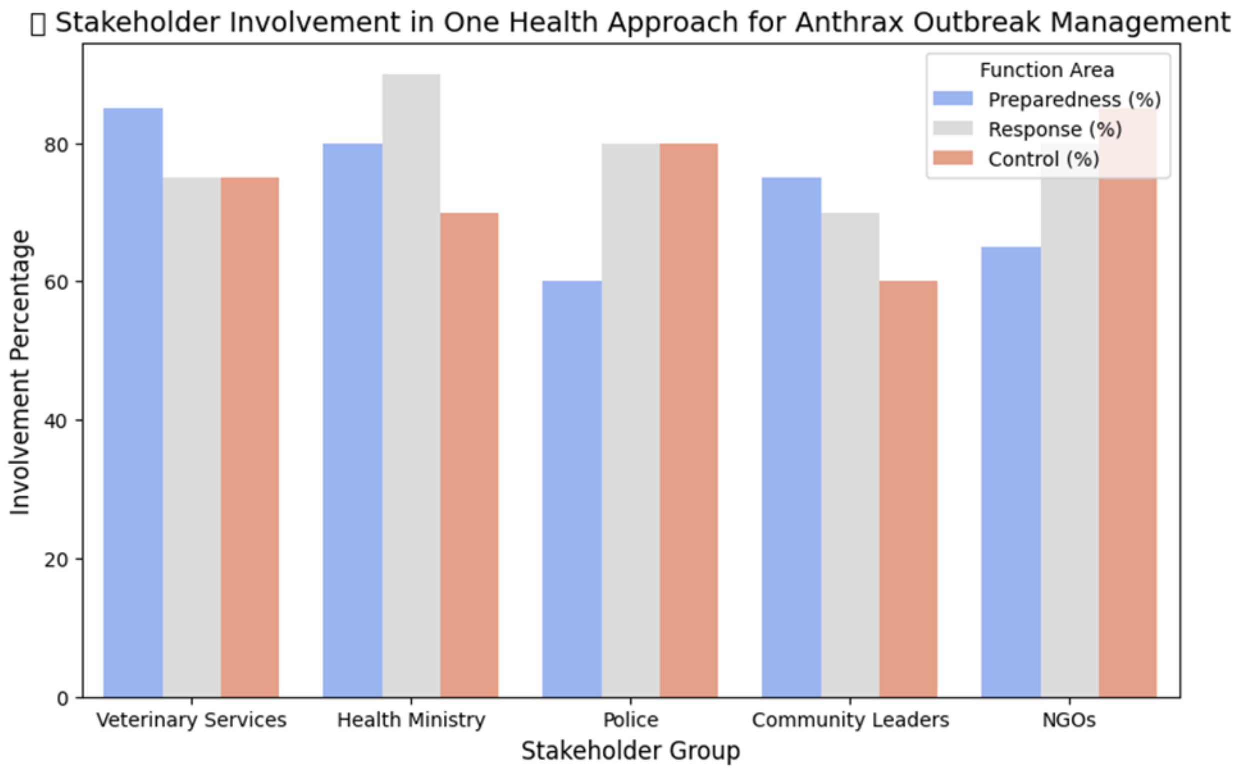


Figure 4.3 Stakeholder involvement in One Health Approach for anthrax management

Figure 4.3 above highlights that the Department of Veterinary Services has the highest engagement in preparedness while slightly lower in control. The Ministry of Health and Childcare is strongly involved in the response pillar and has lower engagement in control effects while the police department is more engaged in control highlighting their key role in law enforcement.

4.3.2.2: One Health Approach Understanding and stakeholder collaboration

The concept of the One Health Approach was recognised by some stakeholders as the concept of integrating human, animal and environmental health. However, there were concerns that actual collaboration was weak among stakeholders and activation was only done during outbreaks. Some stakeholders highlighted that structures for multisectoral work were in place but lacked consistency in coordination and formal district policies. In addition, some stakeholders e.g. Department of Veterinary Services and MOHCC reported that good collaboration existed but with overall fragmented. One of the participants confirmed that;

'*As a district collaboration efforts still have gaps since the committee is reactive towards cases and there are no emergency preparedness and response plans in place hence the need for strengthening routine meetings including strengthening disease surveillance meetings in a multisectoral approach.' (KI-2)*

'There are multiple subcommittees in existence working without alignment and fragmented efforts between departments.'(KI-1)

Another area of concern was weak enforcement of regulations regarding livestock movement and the lack of penalty fees for individuals who violate regulations.

4.3.2.3: Anthrax Surveillance systems and Data sharing practices

The anthrax surveillance system in the district relies on disease notification every week through community health workers and health facilities. It was highlighted that early detection was a challenge due to limited surveillance capacity. Insights revealed that in as much as disease detection is a priority, reporting gaps coupled with inconsistencies in monitoring rapid response efforts may be hindered

'*Anthrax has no premonitory signs which makes it difficult for early detection in livestock. Hence we rely on death and risk missing some cases due to underreporting.'(KI-1)*

'As MOHCC there are structures up to village level which consist of VHWs who were trained on Integrated Disease Surveillance Response and they have knowledge on the case definitions for anthrax. Reports of anthrax undergo normal disease surveillance reporting weekly and notification forms are available and line lists generated.'(KI-2)

Key insights revealed an effective disease surveillance flow that exists at MOHCC while on the other hand, there is limited integration across-sector collaboration mechanisms between DVS (animal) and MOHCC (human health sector).

With regards to data sharing it was observed that data sharing was sporadic. Data sharing was mostly done during outbreaks and there were no standardised protocols hence risking delays in timely decision making.

'Data sharing is done by DVS and MOHCC and they then inform stakeholders when there are outbreaks. They call for stakeholder sensitisation meeting once there are outbreaks so that all departments become aware of the situation.'(KI-3)

4.3.2.4 Communication strategies in anthrax management

A range of communication strategies highlighted that are in place includes face-to-face meetings with stakeholders (advocacy meetings), and the use of social media platforms e.g. WhatsApp groups, community meetings, emails, and notice boards at public premises. Key messages are tailored based on audience segmentation using local languages and the effectiveness of interventions measured through reductions in cases.

4.3.2.5 Resource allocation and budget

Several respondents highlighted a lack of budgets for anthrax management that is affecting programming. If budgets are availed allocation of resources is based on caseload and outbreak severity. The issue of lack of designated budgets was over-emphasised by respondents as follows:

'Resource allocation is usually based on caseload. For the vaccination population of livestock, the distance between dip tanks is essential for resource allocation. Resource allocation impacts overall effectiveness to response both negatively and positively. Lack of resources affects negatively because sometimes anthrax outbreaks happen when the department doesn't have vaccines or fuel making it difficult for the response team to conduct its duties.'(KI-1)

'*Anthrax management has no special allocation like other programmes hence resources are allocated based on areas with outbreaks where RCCE activities would have been planned for. Sometimes we lack the fuel to provide ward level cadres to conduct follow up investigation hence affecting control of the disease.' (KI-2)*

'We sometimes provide fuel support and we have managed to procure bikes for councillors for easy mobility especially during outbreaks such as anthrax so that they disseminate information in communities.' (KI-4)

'*Resources are shared based on number of cases since this has an impact on combating the outbreak.'(KI-6)*

4.3.2.6 Capacity Building and Training

Training on anthrax and awareness programs exist for stakeholders such as (school children, farmers, and community leaders) in partnership with government and NGOs. However, most stakeholders raised concerns that the training is insufficient and lacks technical support hence contributing to gaps in knowledge and suboptimal response.

4.2.3.7 Challenges and barriers to anthrax management

Several challenges were identified the main being the lack of dedicated budgets to strengthen the management of anthrax (preparedness, response, and control) There is also a shortage of resources such as fuel, vaccines, and human resources with other dip tanks with no cadres manning them. In addition, knowledge attitudes, and practices within the community also contribute to weak responses (community misconceptions and practices of consuming meat from dead carcasses (Romha & Girmay, 2020b). In addition, food and nutrition insecurity also contributes to the consumption of unsafe meat and risking underreporting of cases of animal deaths. Furthermore, fragmented work plans amongst stakeholders and weak law enforcement proved to be affecting integrated efforts aimed at reducing anthrax in the district. Also, environmental and climatic determinants such as extreme weather events (flooding) might influence the spread of anthrax bacteria spores.

'Some people may claim it's witchcraft in cases where anthrax affects the brain and they sought traditional medicine hence contributing to underreporting of cases as well. Communities' attitudes, the use of herbs such as "mkundanyoka" as condiments they believe destroys the bacteria. In one of the villages a person died after consuming meat from a dead animal after adding "mkundanyoka".' (KI-8) The role of tradition and cultural practices highlights the need for interventions that are culturally sensitive to ensure local tradition is respected while safe behaviours are promoted (Mumba et al., 2025).

'There is poor coordination amongst stakeholders resulting in departments working in silos. Shortages of human resources, out of 98 dip tanks 14 do not have extension officers. Hence other extension officers end up manning more than one dip tank.' (KI-1)

'Food insecurity affects control of anthrax as some hide the meat they would prefer eating and claim that when they fall sick they will get treatment. Some have myths and misconceptions they believe that if you boil 3 times discarding water the meat will be safe due to knowledge gaps.'(KI-3). A study in Kenya on anthrax among pastoralists highlighted that the practice of throwing soup severely was also practiced by community members when

cooking anthrax-suspected meat, hence suggesting the need for further research to validate the effectiveness of the practice (Mohamed et al., 2019).

'There are gaps in coordination making it difficult for stakeholders to integrate their activities. In addition, there are no work plans which may lead to poor coordination resulting in fragmented work and duplication of efforts.' (K-4)

4.3.2.8 Best practices

Some best practices were noted from past outbreaks where there was evidence of multisectoral joint response including partners, government stakeholders and business community. Community engagement has been instrumental with support and by-in from community leaders towards ensuring communities adhere to legal and regulatory measures.

'Joint response during the 2020 and 2021 outbreaks made response and control easier. Partners assisted with resource allocation of fuel and vehicle as well as assisting in burning and burying including follow-ups. The education department also assisted in awareness in schools.' (KI-1)

'Communities along the game area are not allowed to leave their livestock grazing in the game area to minimise wildlife and livestock interference. Wildlife rangers do monitoring to ensure no livestock is grazing in the game park. In addition in case of wild animals escaping from the game reserve, the reaction time to ensure the animal is returned to its area is fast to minimise interaction hence minimizing risks for anthrax spreading. In case communities are found breaking the law local Chiefs will charge those fines.' (KI-4) Involvement of local leaders plays a significant role in encouraging participation among communities to ensure a reduction in economic losses through the reduction in anthrax outbreaks, by lowering transmission of the diseases to humans and hence, contributing to improved food and nutrition security (Ogundeyi, 2023).

Insights from key informants highlight that anthrax in Gokwe is still a neglected condition as seen by the lack of funding by the government despite its negative effects on household livestock production, and the health of communities. A study in Ethiopia also highlighted that anthrax is still a neglected tropical disease up to now the government has not availed any funds specified for anthrax prevention (Romha & Girmay, 2020). In addition, the District performs response activities with challenges. In Uganda, occasional capacity-building trainings exist for District focal persons to boost their knowledge for outbreak responses which is lacking in Zimbabwe, particularly in Gokwe South (Walekhwa, Namakula, Wafula, et al., 2024). Concerns about poor coordination among Gokwe South stakeholders were highlighted, this has been revealed in studies where stakeholders' departments usually respond individually and this has been ineffective yielding less impact and resulting in wastage of resources hence need for improvement in terms of coordination and inter-sectoral collaboration (Buregyeya et al., 2020). Facilitators for responding to outbreaks which were identified in a study in Uganda included the presence of surveillance guidelines, availability of communication channels resources availability among others hence these need to be strengthened in Gokwe South. It has been established that passive surveillance exists in Sub-Saharan Africa risking the spreading of the disease without detection hence the need for a robust surveillance system (Walekhwa et al., 2024).

4.4 Recommendations

Based on the results above gaps in attitudes and practices coupled with socio-economic challenges were identified hence there is a need to address these challenges through multisectoral collaboration interventions tailored to community-specific needs in a One Health Approach. Recommended interventions to be promoted include regular awareness campaigns with education offered in a culturally sensitive manner. In addition, integrated disease surveillance needs to be strengthened from planning to implementation including the sharing of data on human, animal, and environmental health to ensure the reduction or elimination of anthrax to contribute towards achieving food safety, and food and nutrition security (Alhaji et al., 2024; Hapenga et al., 2025; Mumba et al., 2025).

Key drivers of food insecurity and poverty need to be identified and addressed to ensure that communities do not consume unsafe meat. Risk communication and community engagement are crucial to ensure the management of diseases during outbreaks hence the need for stakeholders at all levels to invest in the area. Strengthen capacity-building training for District focal persons to boost their knowledge of outbreak responses (Walekhwa, Namakula, Wafula, et al., 2024). In addition, there is a need for mobilisation of resources to ensure effective preparedness, response, and control of anthrax in One Health Approach (Hapenga et al., 2025).

4.5 Conclusion

The key risk factors linked to anthrax morbidity in Gokwe South were preferred grazing methods (game areas with the highest risk followed by grass fields), selling/ consuming carcass, and perceived anthrax risk (as risk perception increased the odds of anthrax decreased) suggesting the higher the awareness the decrease in odds of being infected. Through interactions with district stakeholders, it was observed that the request for adoption of the One Health Approach was still theoretical with insignificant implementation within the district. Hence the call for strengthening the One Health framework through capacity building of stakeholders on epidemic preparedness and response, support with funds to strengthen routine risk communication and community engagement activities, improving supply chain of anthrax vaccines, strengthening integrated surveillance, establishment of strategies to alleviate food and nutrition insecurity drivers, promotion of multisectoral collaboration as well as activation of the zoonotic subcommittee by adopting the One Health Approach anthrax risks will be mitigated, community resilience enhanced thus contributing to sustainable human and animal health outcomes thus contributing to improved food and nutrition security.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter covers the summary, conclusion of the whole research. The chapter highlights the policy implications of the research findings and provides suggested areas for further research based on the research findings.

5.2 Research summary

This study was aimed at assessing the functionality of the One Health Approach in reducing Anthrax for improved Nutrition Security in Gokwe South by establishing the key risk factors contributing to anthrax morbidity and determining key interventions in place for the management of anthrax in the community.285 participants were interviewed i.e. 95 cases, along with 190 controls. The predicted risk factors associated with anthrax morbidity were preferred type of grazing (forest) [game area, OR = 137.12, 95% CI (0.195–96420.507); grass fields OR = 5.03, 95% CI (0.52-48.39)], handling of dead livestock (veterinary notification) [sell/consume carcass OR = 10.82, 95% CI (2.17–53.98)], and perceived anthrax risk (low) [moderate OR =39.89 , 95% CI (6.68–238.36); severe OR =20.20 , 95% CI (4.51–90.53)]. Through interactions with district stakeholders, it was observed that the request for the adoption of the One Health Approach was still theoretical with insignificant implementation within the district due to a lack of adequate resources and weak coordination. The study concluded the need to strengthen the One Health Approach to reduce anthrax in agricultural systems to ensure improved nutrition security.

5.3 Conclusion

This study highlights the key factors related to knowledge attitudes and practices contributing to endemicity of anthrax in Gokwe South district. It also highlighted the need for a multisectoral response through One Health Approach to ensure reduction in anthrax cases so as to minimise livestock losses and transmission of disease to humans to ensure community resilience and improved sustainable food systems.

5.4 Policy implications and recommendations

This study highlights the key factors related to knowledge attitudes and practices contributing to the endemicity of anthrax in the Gokwe South district. Hence the call for strengthening the One Health framework through the following:

1. Capacity building of stakeholders on epidemic preparedness and response.

2. Lobby for funds to strengthen routine Risk Communication and Community Engagement activities.
3. Strengthening integrated surveillance.
4. Improving the supply chain of anthrax vaccines.
5. Establishment of strategies aimed at alleviating food and nutrition insecurity drivers.
6. Promotion of multisectoral collaboration as well as activation of the zoonotic subcommittee.

By adopting the One Health Approach anthrax risks will be mitigated, community resilience enhanced thus contributing to sustainable human and animal health outcomes thus contributing to improved food and nutrition security.

5.5 Areas for further research

Based on the findings of this study areas for further research include the following:

1. Investigation of the existing national anthrax surveillance systems, (focusing on the Strengths, weaknesses, opportunities, and threats) and inter- sectoral collaboration to provide key insights on the areas development to enhance anthrax surveillance.
2. A review on Anthrax and its Economic Impact on livelihoods of rural communities in Gokwe South. With a special focus on the financial burden resulting from anthrax outbreaks in Gokwe South.

5.6 References

Akash, N., Hoque, M., Mondal, S., & Adusumilli, S. (2021). Sustainable livestock production and food security. In Elsevier eBooks (pp. 71–90). https://doi.org/10.1016/b978-0-12-822265-2.00011-9

Alhaji, N. B., Abdullahi, H., Aliyu, M. B., Usman, A. H., Adeiza, A. M., Mai, H. M., Odetokun, I. A., & Fasina, F. O. (2024). Risk perceptions and preventive preparedness toward anthrax re-emergence within the lens of one health in Northcentral Nigeria. Tropical Animal Health and Production, 56(8). https://doi.org/10.1007/s11250-024-04173-x

Ashirwadam W, J. (2014). Communication Research Methods Methods of Data Analysis. http://en.wikipedia.org/wiki/Narrative_inquiry

Bhattacharya, D., Kshatri, J. S., Choudhary, H. R., Parai, D., Shandilya, J., Mansingh, A., Pattnaik, M., Mishra, K., Padhi, S. P., Padhi, A., & Pati, S. (2021). One Health Approach for elimination of human anthrax in a tribal district of Odisha: Study protocol. *PLoS ONE*, *16*(5), e0251041. https://doi.org/10.1371/journal.pone.0251041

Brazier, A. (2022). Gokwe Food System Study Report. https://www.researchgate.net/publication/364071242

Buregyeya, E., Atusingwize, E., Nsamba, P., Musoke, D., Naigaga, I., Kabasa, J. D., Amuguni, H., & Bazeyo, W. (2020). Operationalizing the One Health Approach in Uganda: Challenges and opportunities. Journal of Epidemiology and Global Health, 10(4), 250. https://doi.org/10.2991/jegh.k.200825.001

Card, C., Epp, T., & Lem, M. (2018). Exploring the social determinants of animal health. Journal of Veterinary Medical Education, 45(4), 437–447. https://doi.org/10.3138/jvme.0317-047r

Cheteni, P., Khamfula, Y., & Mah, G. (2020). Exploring food security and household dietary diversity in the Eastern Cape Province, South Africa. Sustainability, 12(5), 1851. https://doi.org/10.3390/su12051851

Choudhary, H. R., Senapati, A., Pattnaik, M., Mohanta, A. R., Parai, D., Jena, S. R., Padhy, B. K., Patra, P. S., Padhi, A. K., Pattnaik, S., Panigrahi, S. K., Behera, K. C., Sahu, S. K., Selvamani, Y., Joseph, A., Rehman, T., Pati, S., & Bhattacharya, D. (2025). Exploring Anthrax Risk and Prevention: a One Health Approach for assessment of human, animal, and environmental interactions. IJID One Health, 100060. https://doi.org/10.1016/j.ijidoh.2025.100060

Doganay, M., Dinc, G., Kutmanova, A., & Baillie, L. (2023). Human Anthrax: Update of the Diagnosis and Treatment. Diagnostics, 13(6), 1056. https://doi.org/10.3390/diagnostics13061056

Driciru, M., Rwego, I. B., Ndimuligo, S. A., Travis, D. A., Mwakapeje, E. R., Craft, M., Asiimwe, B., Alvarez, J., Ayebare, S., & Pelican, K. (2020). Environmental determinants influencing anthrax distribution in Queen Elizabeth Protected Area, Western Uganda. *PLoS ONE*, *15*(8), e0237223. https://doi.org/10.1371/journal.pone.0237223

FAO Knowledge Repository. (2023). https://openknowledge.fao.org/items/34a82132-ac43-4d9a-8679-949941a295d3

Five African Countries Report Anthrax Outbreaks, over 1100 Cases Recorded - Zambia (2023). [Online]. Available at: https://reliefweb.int/report/zambia/five-african-countries-report-anthrax-outbreaks-over-1100-cases-recorded.

Galvmed, T. (2024, August 5). Stronger regulations would bolster food security and livelihoods in Africa - GALVmed. GALVmed. https://www.galvmed.org/stronger-regulations-would-bolster-food-security-and-livelihoods-in-africa/

Garcia, S. N., Osburn, B. I., & Jay-Russell, M. T. (2020). One health for food safety, food security, and sustainable food production. Frontiers in Sustainable Food Systems, 4. https://doi.org/10.3389/fsufs.2020.00001

Gombe NT, Nkomo BM, Chadambuka A, Shambira G, Tshimanga M. Risk factors for contracting anthrax in Kuwirirana ward, Gokwe North, Zimbabwe. Afr Health Sci. 2010;10:159–64.

Government of Zimbabwe, United Nations World Food Programme, Food and Nutrition Council, & Government Ministries and NGOs. (2022). GOKWE SOUTH District Food and Nutrition Security Profile. In GOKWE SOUTH District Food and Nutrition Security Profile. https://fnc.org.zw/wp-content/uploads/2023/04/Gokwe-South-District-Profile.pdf

Gu, SY., Chen, FM., Zhang, CS. et al. (2023). Assessing food security performance from the One Health concept: an evaluation tool based on the Global One Health Index. Infectious Diseases of Poverty [Online] 12. Available at: https://doi.org/10.1186/s40249-023-01135-7.

Habib, R. R., Hojeij, S., & Elzein, K. (2014). Gender in occupational health research of farmworkers: A systematic review. American Journal of Industrial Medicine, 57(12), 1344–1367. https://doi.org/10.1002/ajim.22375

Hameed, H. (2017). Quantitative and qualitative research methods: Considerations and issues in qualitative research. https://doi.org/10.13140/RG.2.2.36026.82883

Hapenga, G., Kazonga, E., Chimfwembe, I., Chuswe, C., Hasalama, M., Hakanyanga, L., Chinza, B., & Tembo, N. (2025). Effectiveness of surveillance systems in combating anthrax outbreaks in Africa: a systematic review. International Journal of Health Sciences and Research, 15(1), 150–170. https://doi.org/10.52403/ijhsr.20250120

Haute, E. van. (2021). Sampling Techniques. In Research Methods in the Social Sciences: An A-Z of key concepts (pp. 247–251). Oxford University Press. https://doi.org/10.1093/hepl/9780198850298.003.0057

Jaison, C., Reid, M., & Simatele, M. D. (2023). Asset portfolios in climate change adaptation and food Security: Lessons from Gokwe South District, Zimbabwe. Journal of Asian and African Studies, 59(8), 2522–2542. https://doi.org/10.1177/00219096231158340

John, L., Shekede, M. D., Gwitira, I., Mazhindu, A. N., Pfukenyi, D. M., & Chikerema, S. (2024). Modelling climate change impacts on the spatial distribution of anthrax in Zimbabwe. BMC Public Health, 24(1). https://doi.org/10.1186/s12889-024-17856-9

Kungu, J.M. et al. (2020). Perceptions and Practices towards Anthrax in Selected Agricultural Communities in Arua District, Uganda. Journal of Tropical Medicine [Online] 2020:1–6. Available at: https://doi.org/10.1155/2020/9083615.

Lee, W. (2017). Rethinking the assumptions of Chi-Squared and Fisher's exact tests. www.academia.edu.https://www.academia.edu/124698789/Rethinking_the_Assumptions_of_Chi_squared_and_Fisher_s_Exact_Tests

Lehman, M. W., Craig, A. S., Malama, C., Kapina-Kany'anga, M., Malenga, P., Munsaka, F., Muwowo, S., Shadomy, S., & Marx, M. A. (2017). Role of Food Insecurity in Outbreak of Anthrax Infections among Humans and Hippopotamuses Living in a Game Reserve Area, Rural Zambia. *Emerging Infectious Diseases*, *23*(9), 1471–1477. https://doi.org/10.3201/eid2309.161597

Lehman, M. W., Craig, A. S., Malama, C., Kapina-Kany'anga, M., Malenga, P., Munsaka, F., Muwowo, S., Shadomy, S., & Marx, M. A. (2017b). Role of Food Insecurity in Outbreak of Anthrax Infections among Humans and Hippopotamuses Living in a Game Reserve Area, Rural Zambia. Emerging Infectious Diseases, 23(9), 1471–1477. https://doi.org/10.3201/eid2309.161597

Makiwa, P., Nyandoro, P., Kapembeza, C., Mutsamba-Magwaza, E.F. and Chakoma, I. 2023. Assessing the challenges hindering livestock productivity, fodder availability and use in Ward 16 of Mutoko District, Zimbabwe. Nairobi, Kenya: ILRI.https://cgspace.cgiar.org/server/api/core/bitstreams/ec775236-f4b1-482c-b6f0-3f2635a38e8b/content

Makurumidze, R., Gombe, N. T., Magure, T., & Tshimanga, M. (2021). Investigation of an anthrax outbreak in Makoni District, Zimbabwe. BMC Public Health, 21(1). https://doi.org/10.1186/s12889-021-10275-0

Mambondiyani, A. (2024). Anthrax in Zimbabwe: Caused by oppression, worsened by climate change. The Revelator. https://therevelator.org/anthrax-zimbabwe/

Matope, G., Mugabe, P.H., Kapungu, F., Marimo, S., De Nys, H., Knight-Jones, T., Caron, A., Richards, S. and Chirenda, J. (2024). One Health landscape in Zimbabwe: Current status, challenges and opportunities for institutionalisation. One Health Cases 2024(2024).

Melesse, M. B., Tirra, A. N., Tui, S. H., Van Rooyen, A. F., & Hauser, M. (2023). Production decisions and food security outcomes of smallholder's livestock market participation: empirical evidence from Zimbabwe. Frontiers in Sustainable Food Systems, 7. https://doi.org/10.3389/fsufs.2023.1222509

Meyer, D. F., & Nishimwe-Niyimbanira, R. (2016). The impact of household size on poverty: An analysis of various low-income townships in the Northern Free State region, South Africa. African Population Studies, 30(02). https://doi.org/10.11564/30-2-811

Mohamed, N. A., Baaro, N. G. P., & Gelle, N. S. J. (2019). Assessment of Knowledge, Attitude and Practices (KAPS) of Anthrax among Pastoralists in Wajir, Isiolo and Marsabit Counties, Kenya. *Journal of Agricultural Science and Technology A*, *9*(1). https://doi.org/10.17265/2161-6256/2019.01.006

Mohammed, S. B., & Elseory, A. M. A. (2024). Animal health and food security in Saudi Arabia. In Springer eBooks (pp. 207–227). https://doi.org/10.1007/978-3-031-46716-5_9

Mukarati, N., Matope, G., De Garine-Wichatitsky, M., Ndhlovu, D., Caron, A., & Pfukenyi, D. (2020). The pattern of anthrax at the wildlife-livestock-human interface in Zimbabwe. PLoS Neglected Tropical Diseases, 14(10), e0008800. https://doi.org/10.1371/journal.pntd.0008800

Mumba, C., Phiri, D., Kabbudula, E., Gondwe, L., Mebelo, N., Simweene, G., Hankolwe, M. N., Besa, K., Sichone, S. S., Kayula, M., Geoffrey, M., Fredrick, K. M., Bebay, C., Baba, S., Jesse, M. N., Filippini, S. P., & Makungu, C. (2025). Exploring community knowledge, perceptions, and the impacts of anthrax among farming communities living in game management areas in Zambia: A qualitative study using a hybrid approach. PLoS Neglected Tropical Diseases, 19(5), e0012852. https://doi.org/10.1371/journal.pntd.0012852

Musewa, A., Mirembe, B. B., Monje, F., Birungi, D., Nanziri, C., Aceng, F. L., Kabwama, S. N., Kwesiga, B., Ndumu, D. B., Nyakarahuka, L., Buule, J., Cossaboom, C. M., Lowe, D., Kolton, C. B., Marston, C. K., Stoddard, R. A., Hoffmaster, A. R., Ario, A. R., & Zhu, B. (2022). Outbreak of cutaneous anthrax associated with handling meat of dead cows in Southwestern Uganda, May 2018. Tropical Medicine and Health, 50(1). https://doi.org/10.1186/s41182-022-00445-0

Nigusse, A. T., Amaha, M. H., Hailu, T. T., Gebremariam, H. G., Cazzoletti, L., Zanolin, M. E., Hailu, A. B., & Alemayohu, M. A. (2023). Human anthrax outbreak and associated factors in the horrific siege of Tigray, Ethiopia. IJID One Health, 1, 100013. https://doi.org/10.1016/j.ijidoh.2023.100013

Nyamangara, J., Makarimayi, E., Masvaya, E. N., Zingore, S., & Delve, R. J. (2011). Effect of soil fertility management strategies and resource-endowment on spatial soil fertility gradients, plant nutrient uptake and maize growth at two smallholder areas, North-Western Zimbabwe. South African Journal of Plant and Soil, 28(1), 1–10. https://doi.org/10.1080/02571862.2011.10640006

Nyatanyi, T., Wilkes, M., McDermott, H., Nzietchueng, S., Gafarasi, I., Mudakikwa, A., Kinani, J. F., Rukelibuga, J., Omolo, J., Mupfasoni, D., Kabeja, A., Nyamusore, J., Nziza, J., Hakizimana, J. L., Kamugisha, J., Nkunda, R., Kibuuka, R., Rugigana, E., Farmer, P., . . .

Binagwaho, A. (2017). Implementing One Health as an integrated approach to health in Rwanda. *BMJ Global Health*, *2*(1), e000121. https://doi.org/10.1136/bmjgh-2016-000121

Nyokabi NS, Lindahl JF, Phelan LT, Berg S, Gemechu G, Mihret A, Wood JLN and Moore HL (2023) Exploring the composition and structure of milk and meat value chains, food safety risks and governance in the Addis Ababa and Oromia regions of Ethiopia. Front. Sustain. Food Syst. 7:1085390. doi: 10.3389/fsufs.2023.108539

Odoms-Young, A., Brown, A. G., Agurs-Collins, T., & Glanz, K. (2023). Food insecurity, neighborhood food environment, and health disparities: state of the science, research gaps and opportunities. American Journal of Clinical Nutrition, 119(3), 850–861. https://doi.org/10.1016/j.ajcnut.2023.12.019

Ogundeyi, E. (2023, June 14). Blog. https://dhse.gov.sl/a-successful-anthrax-vaccination-campaign-in-sierra-leone-safeguards-livestock-and-communities/

Oribhabor, C. B., & Anyanwu, C. A. (2019). Research Sampling and Sample size determination: A practical Application. Federal University Dutsin-Ma Journal of Educational Research, 2(1), 47–56. https://ww.researchgate.net/publication/336723498

Pattnaik, M., Kshatri, J. S., Choudhary, H. R., Parai, D., Shandilya, J., Mansingh, A., Padhi, A. K., Pati, S., & Bhattacharya, D. (2022). Assessment of socio-behavioural correlates and risk perceptions regarding anthrax disease in tribal communities of Odisha, Eastern India. *BMC Infectious Diseases*, *22*(1). https://doi.org/10.1186/s12879-022-07035-9

Pitman, D. (2022, February 25). Animal Diseases and their Threat to Food and Food Security - Center for Infrastructure Protection & Homeland Security. Center for Infrastructure Protection & Homeland Security. https://cip.gmu.edu/2018/02/21/animal-diseases-threat-food-food-security/

Placzek, O., Cecchini, M., Giner, C., Gnych, S., Lee, A., & Jackson, J. (2021). Socio-economic and demographic aspects of food security and nutrition. OECD Food, Agriculture and Fisheries Working Papers. https://doi.org/10.1787/49d7059f-en

Powell, B., Kerr, R. B., Young, S. L., & Johns, T. (2017). The determinants of dietary diversity and nutrition: ethnonutrition knowledge of local people in the East Usambara Mountains, Tanzania. Journal of Ethnobiology and Ethnomedicine, 13(1). https://doi.org/10.1186/s13002-017-0150-2

Rao, S., Traxler, R., Napetavaridze, T., Asanishvili, Z., Rukhadze, K., Maghlakelidze, G., Geleishvili, M., Broladze, M., Kokhreidze, M., Reynolds, D., Shadomy, S., & Salman, M. (2019b). Risk factors associated with the occurrence of anthrax outbreaks in livestock in the country of Georgia: A case-control investigation 2013-2015. PLoS ONE, 14(5), e0215228. https://doi.org/10.1371/journal.pone.0215228

Rastogi, P., & Singh, B. K. (2019). A Multivariate Binary Logistic Regression Modeling for Assessing Various Risk Factors that affect Diabetes. INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH, 8, 8. www.ijstr.org

Research, C. O. C. F. T. F. O. a. S., Program, S. a. T. F. S., Affairs, P. a. G., Resources, B. O. a. a. N., & Sciences, D. O. E. a. L. (2015, March 31). Introduction: Overview of the challenges facing the Animal Agriculture Enterprise. Critical Role of Animal Science Research in Food Security and Sustainability - NCBI Bookshelf. https://www.ncbi.nlm.nih.gov/books/NBK285726/

Romha, G., & Girmay, W. (2020). Knowledge, attitude and practice towards anthrax in northern Ethiopia: a mixed approach study. *BMC Infectious Diseases*, *20*(1). https://doi.org/10.1186/s12879-020-05544-z

Roth, J. A., & Galyon, J. (2024). Food security: The ultimate one-health challenge. One Health, 19, 100864. https://doi.org/10.1016/j.onehlt.2024.100864

Senyange, S., Nsubuga, E. J., Kadobera, D., Kwesiga, B., Bulage, L., Ario, A. R., & Uganda Public Health Fellowship Program, Uganda National Institute of Public Health, Kampala, Uganda. (2022). Knowledge, Attitudes and Practices regarding Anthrax among affected communities in Kazo District, South-western Uganda, May 2022. In Quarterly Epidemiological Bulletin (Vol. 7, Issue 3). https://uniph.go.ug/wp-content/uploads/2022/10/Knowledge-Attitudes-and-Practices-regarding-Anthrax-among-affected-communities-in-Kazo-District-South-western-Uganda-May-2022.pdf

Shandilya, J., Parai, D., Choudhary, H. R., Kshatri, J. S., Padhy, B. K., Pradhan, P. M., Saket, D., Peter, A., Pattnaik, M., Padhi, A. K., Pati, S., & Bhattacharya, D. (2023). Suspected human anthrax outbreak investigation in a tribal village of Koraput, India, 2021. Public Health Challenges, 2(4). https://doi.org/10.1002/puh2.125

Simonsen KA, Chatterjee K. Anthrax. [Updated 2023 Jul 25]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK507773/

Sitali, D. C., Mumba, C., Skjerve, E., Mweemba, O., Kabonesa, C., Mwinyi, M. O., Nyakarahuka, L., & Muma, J. B. (2017). Awareness and attitudes towards anthrax and meat consumption practices among affected communities in Zambia: A mixed methods approach. *PLoS Neglected Tropical Diseases*, *11*(5), e0005580. https://doi.org/10.1371/journal.pntd.0005580

Subedi, D., Pantha, S., Jyoti, S., Gautam, B., Kaphle, K., Yadav, R. K., Ghimire, S., & Dhakal, S. (2024). Anthrax in humans, animals, and the environment and the One Health Strategies for anthrax control. Pathogens, 13(9), 773. https://doi.org/10.3390/pathogens13090773

Suresh, K., Sagar, N., Jayashree, A., Patil, S., Naveesh, Y., Sushma, R., Hemadri, D., & Archana, C. (2023). Investigating a sheep anthrax outbreak in Karkihalli Village, Karnataka, India: An integrated study of demographic, ecological, socio-economic, and risk factors. *International Journal of Veterinary Sciences and Animal Husbandry*, *8*(5S), 292–297. https://doi.org/10.22271/veterinary.2023.v8.i5se.785

Sushma, B., Shedole, S., Suresh, K. P., Leena, G., Patil, S. S., & Srikantha, G. (2021). An Estimate of global anthrax prevalence in livestock: A meta-analysis. *Veterinary World*, 1263–1271. https://doi.org/10.14202/vetworld.2021.1263-1271

Tambe, A. B., Akeh, M. L., Tendongfor, N., Dhlamini, T., Chipili, G., & Mbhenyane, X. (2023). The predictors of food security and dietary diversity among internally displaced persons' children (6–59 months) in Bamenda health district, Cameroon. Conflict and Health, 17(1). https://doi.org/10.1186/s13031-023-00511-2

Tenny, S., Kerndt, C. C., & Hoffman, M. R. (2023). Case control studies. StatPearls - NCBI Bookshelf. https://www.ncbi.nlm.nih.gov/books/NBK448143/

Vieira, A. R., Salzer, J. S., Traxler, R. M., Hendricks, K. A., Kadzik, M. E., Marston, C. K....Walke, H. (2017). Enhancing Surveillance and Diagnostics in Anthrax-Endemic Countries. Emerging Infectious Diseases, 23(13). https://doi.org/10.3201/eid2313.170431.

Walekhwa, A. W., Namakula, L. N., Nakazibwe, B., Ssekitoleko, R., & Mugisha, L. (2024). Are we ready for the next anthrax outbreak? Lessons from a simulation exercise in a rural-based district in Uganda. *Epidemiology and Infection*, *152*. https://doi.org/10.1017/s0950268824001493

Walekhwa, A. W., Namakula, L. N., Wafula, S. T., Nakawuki, A. W., Atusingwize, E., Kansiime, W. K., Nakazibwe, B., Mwebe, R., Isabirye, H. K., Ndagire, M. I., Kiwanuka, N. S., Ndolo, V., Kusiima, H., Ssekitoleko, R., Ario, A. R., & Mugisha, L. (2024). Strengthening anthrax outbreak response and preparedness: simulation and stakeholder education in Namisindwa district, Uganda. BMC Veterinary Research, 20(1). https://doi.org/10.1186/s12917-024-04289-0

Yadeta, W &Jilo, K. (2020). Recent Understanding of the Epidemiology of Animal and Human Anthrax in Ethiopia with Emphasis on Diagnosis, Control and Prevention Interventions-Review. World Journal of Medical Sciences (17). 10.5829/idosi.wjms.2020.01.09

Zahir, A., Nasim, M., Jauhar, S., Naseri, E., Sarwary, A., Noor, A., Amarkhil, R., & Hamdard, E. (2024). The role of livestock resources in sustainable food security and livelihoods in Afghanistan. Journal of Natural Science Review, 2(Special.Issue), 495–516.https://doi.org/10.62810/jnsr.v2ispecial.issue.150

Zhu, Y., An, Q., & Rao, J. (2024). The effects of dietary diversity on health status among the older adults: an empirical study from China. *BMC Public Health*, *24*(1). https://doi.org/10.1186/s12889-024-18172-y

Zimbabwe First Round Crops, Livestock, and Fisheries Assessment 2023/2024 Summer Season, 2024.56-58

Zimbabwe First Round Crops, Livestock, and Fisheries Assessment 2022/2023 Summer Season, 2023.64

Zimbabwe Health Information System. https://hmis.mohcc.org.zw/nhis/dhis-web-reports/index.html#/data-set-report. Retrieved 27 August 2024.

ZIMSTAT. (2025). Poverty datum Lines – MAY 2025. https://www.zimstat.co.zw/wp-content/uploads//Macro/Prices/PDL/2025/PDL_05_2025.pdf

5.7 Appendices

Appendix 1: PARTICIPANTS QUESTIONNAIRE ON ANTHRAX

Questionnaire No…

Takudzwa B Tiengane is a Masters in Food Security and Sustainable Agriculture student with the Bindura University of Science Education (BUSE) currently conducting a research project entitled **"Functionality of One Health Approach in Reducing Anthrax for Improved Nutrition Security: A Case-control Study in Gokwe South''.** Participants in Gokwe South have been randomly selected. The information provided will be kept confidential, and analysis will not involve individual names. There is no way anyone will be able to identify you. You have the right to terminate this interview and you have the right to refuse to answer any question you might not want to respond to at any stage of the process. This interview process will be carried out for approximately 45-60 minutes. If you have understood the explanation above and agreed to participate, please be willing to sign the attached consent form. Thank you for your willingness to participate in this study. For further information regarding this research please contact on +263713912186 (Takudzwa B Tiengane).

Section 1: Socio-Demographic Information

Interview Date……………………..… Interviewer:……………………

Location: Respondent initials:

NB: Tick the appropriate box where necessary

1 **Sex:** Male ☐ Female ☐

2 **Age (In years):** ☐

3 **Ethnicity**

Tonga: ☐ Shangwe: ☐ Shona: ☐ Karanga: ☐ Ndebele: ☐

4 **Education level**

Never attended: ☐ Primary: ☐ Secondary: ☐ Tertiary: ☐

5 **Monthly income** (in Zimbabwe Gold; ZiG): ☐

6 **Household size (number of persons):** ☐

7 **Occupation:**

Not Employed: ☐ Civil Service: ☐ Private Service: ☐

Farmer: ☐ Casual Labour ☐

Section 2: Community Knowledge, Attitudes, and Practices towards Anthrax

8 Have you ever been diagnosed with anthrax?

No: ☐ Yes: ☐

9 Have you heard about anthrax before?

No: ☐ Yes: ☐

10 Do you know how anthrax is transmitted?

No: ☐ Yes: ☐

11 Do you know the symptoms for anthrax infection in humans?

No: ☐ Yes: ☐

12 Do you know how anthrax infection can be prevented?

No: ☐ Yes: ☐

13 Do you know how anthrax is treated?

No: ☐ Yes: ☐

14 Do you know the signs or symptoms that indicate that an animal has died from anthrax?

No: ☐ Yes: ☐

15 Do you own any livestock?

No: ☐ **Yes:** ☐

16 Which major types of livestock you own?

Goats: ☐ Sheep: ☐ Cattle: ☐ Pigs: ☐

17 What is the primary purposes for your livestock keeping?

Income: ☐ Food supply: ☐

Agricultural function (draught power and manure production): ☐

18 How many years have you been into management, caring and interacting with livestock? ☐

19 Who is mainly involved in the management, care, and operation of livestock at your household?

Respondent: ☐ Wife/husband: ☐ Parents: ☐

Son/ daughter: ☐ Other relatives: ☐

20 Which locations or environments do you prefer for livestock grazing and feeding?

Forest: ☐ Game area: ☐ Agricultural land: ☐

Purchase fodder: ☐ Grass field: ☐

20 What is the vaccination status of you livestock?

Vaccinated ☐ **not vaccinated** ☐

22 Which periods do you conduct anthrax vaccination?

Annually: ☐ During outbreaks: ☐ Never vaccinate: ☐

23 How do you obtain anthrax vaccines for your livestock?

Own purchase: ☐ Government support : ☐

24 What is the most practice do you employ when managing the bodies of dead livestock?

Veterinary notification within 24 hrs: ☐ Bury/burn: ☐

Sell carcass/ consume: ☐

25 How do you view the risk of contracting anthrax infection?

Low risk: ☐ Moderate risk: ☐ High risk: ☐

Section 3: Household dietary diversity

26 This section will require you to provide information on Household Dietary Diversity Score – 24hr recall. You are required to provide information about the types of foods that you or anyone else in your household ate yesterday during the day and at night.

Note for enumerator: Read the list of foods. Place a 1 in the box if anyone in the household ate the food in question, place a zero in the box if no one in the household ate this food.

	Food Groups	Score No=0 Yes=1
1.	**Cereals and grains**: Rice, pasta, bread, sorghum, millet, maize	|___|
2.	**Roots and tubers:** Potato, yam, cassava, white sweet potato, taro, plantain	|___|

3.	**Pulses, legumes, nuts and seeds**: Beans, cowpeas, lentils, soy, pigeon pea, peanuts, other nuts	|___|
4.	**Dairy products**: Milk, yogurt, cheese, other dairy products	|___|
5.	**Meat, poultry and offal:** Goat, beef, chicken, pork	|___|
6.	**Fish and seafood:** Fish and other seafood (including canned tuna)	|___|
7.	Eggs	|___|
8.	**Vegetables and leaves**: Spinach, onion, tomatoes, carrots, peppers, green beans, lettuce, etc.	|___|
9.	**Fruits**: Banana, apple, lemon, mango, papaya, apricot, peach, etc.	|___|
10.	**Oils and fats:** Vegetable oil, palm oil, ghee, butter, margarine, other fats or oils	|___|
11.	**Sugar and sweets**: Sugar, honey, jam, candy, chocolate, biscuits/cookies, pastries, cakes, ice cream, and other sweets (including sugary drinks)	|___|
12.	**Miscellaneous/condiments and spices**: Tea, coffee, cocoa powder, salt, garlic, spices, yeast, tomato paste	|___|

Thank you for participating

End of questionnaire

Appendix 2: INTERVIEW GUIDELINES FOR KEY INFORMANT

1) Introductions to the informant and explaining the research.

Takudzwa B Tiengane is a Masters in Food Security and Sustainable Agriculture student with the Bindura University of Science Education (BUSE) currently conducting a research project entitled **"Functionality of One Health Approach in Reducing Anthrax for Improved Nutrition Security: A Case-control Study in Gokwe South''**. Households in Gokwe South have been randomly selected. The information provided will be kept confidential, and analysis will not involve individual names. There is no way anyone will be able to identify you. You have the right to terminate this interview and you have the right to refuse to answer any question you might not want to respond to at any stage of the process. This interview process will be carried out for approximately 60 minutes. If you have understood the explanation above and agreed to participate, please be willing to sign the attached consent form. Thank you for your willingness to participate in this study. For further information regarding this research please contact on +263713912186 (Takudzwa B Tiengane).

2) Giving Informed Consent and asking for willingness to become an informant (by filling in the informant's identity sheet).

3) Asking the name of the informant.

4) Requesting permission to record.

5) Conducting interviews.

a) Questions for stake holder identification

i) Can you highlight the key stakeholders involved in anthrax prevention and control? Probe for specific roles of each stakeholder.

b) Responsibilities

i) What role does your sector plays in the preparedness phase for anthrax outbreaks? (Explore training, resource allocation, and risk assessments.)

ii) During an anthrax outbreak, what immediate actions does your sector take? (Focus on response protocols and mobilization strategies.)

iii) What measures are in place to control anthrax outbreaks once they occur? (Investigate vaccination, culling, and public awareness efforts.)

iv) How do you assess the success of control measures implemented during an outbreak? (Look for indicators or metrics used.)

c) Joint sector response

i) How do you understand the role of the One Health Approach in managing zoonotic diseases such as anthrax?
ii) How would you describe the level of collaboration between the human health, animal health, and environmental health sectors in responding to anthrax outbreaks?
iii) Are there formal district policies in place that align with national policies to facilitate One Health collaboration?

d) Surveillance

i) What surveillance systems are currently in place for detecting anthrax in animals and humans? Please describe their key features and effectiveness.
ii) How do these systems collaborate or share information between the animal and human health sectors?
iii) Are there specific indicators or data points that are monitored closely for early detection of anthrax cases?

e) Communication

i) What methods and approaches do you use to communicate important information regarding anthrax outbreaks to different stakeholders (e.g., government agencies, healthcare providers, farmers, and the public)?
ii) Can you provide examples of specific communication channels (e.g., social media, community meetings, official reports) that have been effective?
iii) How do you ensure that the information is tailored to meet the needs of diverse audiences?
iv) How do you evaluate the effectiveness of your communication strategies during an outbreak?

f) Data sharing

i) How is data related to anthrax surveillance and outbreak response shared among stakeholders, and how frequently is this data shared?
ii) What platforms or systems are used for data sharing (e.g., databases, reports, communication tools)?
iii) Are there established protocols for determining what data to share and with whom?
iv) How does this data sharing influence decision-making and response strategies during anthrax outbreaks?

g) Resources allocation priority

i) What criteria are used to determine priority areas for resource allocation?

ii) How do you ensure that all relevant sectors (human health, animal health, and environmental health) receive adequate resources?

iii) How does resource allocation impact the overall effectiveness of the response to anthrax outbreaks?

h) Training and capacity building

i) What efforts are being made to enhance the knowledge, skills, and abilities of stakeholders involved in preventing, responding to, and controlling anthrax outbreaks?

ii) What specific training programs or workshops have been implemented for different stakeholders (e.g., healthcare providers, veterinarians, public health officials)?

iii) How do you assess the effectiveness of these training initiatives?

iv) Are there partnerships with educational institutions or organizations to support capacity building?

i). **Implementation challenges**

i). What challenges have you encountered in implementing response measures using the One Health Approach for managing anthrax outbreaks?

j). **Best practices**

i). Can you provide examples of successful case studies where joint response efforts using the One Health Approach effectively managed anthrax outbreaks?

ii).What specific strategies or interventions were implemented in these case studies?

iii). How did collaboration between human, animal, and environmental health sectors contribute to the success of these efforts?

iv).What lessons were learned from these case studies that could be applied to future outbreaks?

k). **Conclusion**

i).What recommendations do you have for improving the One Health Approach in managing anthrax outbreaks?

ii). Do you have any additional comments or questions?

Thank you for participating!!!

End of Questionnare

Appendix 3: PARTICIPANT CONSENT FORM

Title: "Functionality of One Health Approach in Reducing Anthrax for Improved Nutrition Security: A Case-control Study in Gokwe South''.

NAME OF RESEARCHER: Takudzwa B Tiengane (B231789A)

PHONE: +263713912186

PROJECT DESCRIPTION:

Anthrax poses serious public health concerns through animal and human illnesses and deaths. In addition it contributes to economic losses to the agricultural systems hence affecting food safety and food and nutrition security. Therefore, the need to enhance surveillance, outbreak response and diagnostics as mitigation strategies through One Health Approach.

Hence this study on the assessment of the functionality of One Health Approach in reducing Anthrax for improved Nutrition Security in Gokwe South will shed light on the current status of the one health structures in Gokwe South and what activities are being conducted in response to endemic cases of anthrax

PARTICIPANT'S RIGHTS:

Before deciding whether or not to volunteer for this study, you need to understand its purpose, benefits, risks, and what is expected of you. This process is called informed consent.

PURPOSE OF THE STUDY:

The study seeks to identify the socio demographic determinants of anthrax risk, the level of knowledge of community towards anthrax infection as well as the attitudes and practices of the community with regards to anthrax control. In addition, the study seek to establish the effects of household dietary diversity on anthrax morbidity so as to inform policy on how strategies can be put in place in ensuring that agricultural systems can be improved to contribute to food safety and food and nutrition security in Gokwe South. Last but not least the research seek to identify the roles and responsibilities of key stake holders in one health framework towards anthrax management.

PROCEDURES INVOLVED IN THE STUDY:

This is a Case Control study and involves the use of a structure questionnaire, and key informant interviews to assess the Functionality of One Health Approach in reducing Anthrax for Improved Nutrition Security in Gokwe South.

PARTICIPATION AND DURATION:

Participation is voluntary and the interview process will be carried out for approximately 45-60 minutes. The study will be completed by end of June 2025.

DISCOMFORTS AND RISKS:

No discomforts and risks will be encountered during the study.

POTENTIAL BENEFITS:

Potential benefits for the participants, include increased knowledge as you will receive more knowledge on benefits of One Health Approach, Anthrax and Nutrition. Also the study will inform policy on how strategies can be put in place in ensuring that agricultural systems can be improved to contribute to food safety and food and nutrition security in Gokwe South.

STUDY WITHDRAWAL:

You have the right to terminate this interview and you have the right to refuse to answer any question you might not want to respond to at any stage of the process.

CONFIDENTIALITY OF RECORDS:

The information provided will be kept confidential, and analysis will not involve individual names. There is no way anyone will be able to identify you.

PROBLEMS/QUESTIONS:

If you have any questions regarding this research now or in future you are free to ask.

AUTHORIZATION:

I have read and acquired information regarding the study. I understand the possible risks and benefits of this study. I understand the study is voluntary. I choose to be in this study: I know I can terminate participation to the study at any point and I will not lose any benefits entitled to me. I will retain a copy of this consent form.

Client name (Printed) and Signature **Date**

……………………………………….. ………………………….

Researcher name (Printed) and Signature **Date**