ASSESSING FOOD SAFETY KNOWLEDGE AND PRACTICES IN RURAL ZIMBABWE

2025 Rural Livelihoods Survey

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ISBN 978-1-77928-654-3

Recommended citation: Kembo D. George, Faith A. Manditsera, Macheka Lesley, Bhekinkosi Ndlovu, Dembedza Mavis P. Assessing Food Safety Knowledge and Practices in Rural Zimbabwe - 2025 Rural Livelihoods Survey, Food and Nutrition Council of Zimbabwe, October 2025, Harare, Zimbabwe.

LIST OF ACRONYMS

AMR	Antimicrobial Resistance
CDC	Centres for Disease Control and Prevention
FAO	Food and Agriculture Organization of the United Nations
FNC	Food and Nutrition Council of Zimbabwe
MoHCC	Ministry of Health and Child Care
MLAFWRD	Ministry of Lands, Agriculture, Fisheries, Water and Rural Development
MHTEISTD	Ministry of Higher and Tertiary Education, Innovation, Science and Technology Development
NDS1	National Development Strategy 1
NDS2	National Development Strategy 2
SDG	Sustainable Development Goal
WHO	World Health Organization
WOAH	World Organisation for Animal Health (formerly OIE)
ZimLAC	Zimbabwe Livelihoods Assessment Committee
ZimSTAT	Zimbabwe National Statistics Agency

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Executive Summary

Food safety is an essential yet often overlooked component of public health, food security and rural development in Zimbabwe. In rural areas, where most households rely on subsistence farming and informal food markets, the risks of foodborne illness, chemical contamination and antimicrobial resistance (AMR) are particularly acute. Despite its critical role in protecting health and livelihoods, food safety has historically received limited policy attention and national-level data on household food safety behaviours and exposures have been scarce. Most food safety interventions in Zimbabwe and sub-Saharan Africa target formal markets or urban centres, neglecting the informal systems and unique socio-cultural dynamics that shape rural food environments. Focusing on rural households allows for context-specific insights that are essential for designing appropriate, equitable food safety interventions. Enhancing food safety practices in these areas can improve child nutrition, reduce illness, support productivity and strengthen local food systems

This study was aimed at assessing food safety knowledge and practices among rural households in Zimbabwe and to identify the socio-demographic and contextual factors influencing safe food behaviours. Specifically, the study examines determinants such as gender, education, religion, household size and access to information; evaluates compliance with national food labelling regulations for staple food groups; explores consumer engagement with food labels; and assesses awareness of antimicrobial resistance (AMR) within the One Health framework.

This technical report presents findings from the 2025 Zimbabwe Rural Livelihoods Assessment, which captured food safety knowledge, practices and risk factors among 17,895 rural households across all 60 rural districts in Zimbabwe. Using both descriptive statistics and regression analysis, the study identifies key determinants of food safety, including education, gender, household wealth, religion and geography. The report further explores critical challenges related to agrochemical misuse, food labelling and AMR awareness. This executive summary synthesises the main findings and offers actionable, evidence-based recommendations to inform national strategies, policy reforms and community-level interventions.

Key Findings

i. Low awareness and inconsistent practice of safe food handling

Most households reported engaging in at least one food safety behaviour, but comprehensive application of safe food handling practices was limited. While 80.7% used clean and fresh utensils, only 34.2% practiced appropriate food temperature control, 37.2% separated raw and cooked foods and 28.4% ensured thorough cooking of food. These gaps indicate a limited understanding of microbial contamination pathways and suggest that food safety messages may not be reaching rural populations in ways that change behaviour. This partially implemented hygiene reflects reliance on visual cleanliness rather than scientific risk perception and highlights a need to reinforce the effects of invisible food safety hazards (e.g., bacteria, toxins, cross-contamination).

ii. Limited food label literacy and unequal access to food safety information

Despite the importance of food labels in consumer protection, only 64.1% of households reported checking expiry dates, 17.1% read nutritional content and fewer than 10% considered storage instructions. Label literacy was positively associated with education level and household wealth, suggesting that rural consumers with limited formal education or access to packaged foods are less likely to engage with labels. Regression analysis confirmed that households with post-secondary education were significantly more likely to interpret food labels, highlighting structural disparities in access to information.

iii. Unsafe agro-chemical use and violation of pre-harvest intervals

The consumption of fruits and vegetables before the pesticide withdrawal period had elapsed was reported by 7.3% of households nationally, with Mashonaland East (10.0%), Manicaland (9.6%) and Masvingo (7.8%) exhibiting the highest prevalence. These figures suggest that unsafe agrochemical practices are widespread in agriculturally active provinces, driven by low awareness of safe application procedures, economic pressure to harvest early and the availability of unlabelled or repackaged pesticides. Many smallholder farmers lacked access to protective equipment and reported receiving limited extension support on chemical use.

iii. Alarmingly low awareness of Antimicrobial Resistance (AMR) and unsafe antibiotic practices

Only 18.3% of rural households reported having heard of AMR and fewer than 5% consistently adhered to safe antibiotic use practices, such as observing withdrawal periods before consuming or selling animal products. These practices contribute to the risk of antimicrobial residues in food and the development of resistant pathogens, posing a serious public health threat. Awareness of AMR was lowest in households with low education and income, and in provinces with limited veterinary coverage.

iv. Sociodemographic and religious factors strongly influence food safety behaviour

Statistical analysis showed that education level was the strongest predictor of food safety knowledge and practices. Households with female heads were more likely to adopt safer food preparation behaviours, particularly thorough cooking, reinforcing the role of women as primary food handlers. Household asset index was also positively associated with food label use and knowledge of AMR. Religious affiliation was a notable determinant: Apostolic, Zionist and traditional religion households had significantly lower engagement in food safety behaviours, suggesting cultural or doctrinal barriers to public health messaging.

v. Provincial disparities reflect geographic inequities in services and outreach

There were clear spatial variations in food safety outcomes. Mashonaland West and Matabeleland South consistently recorded lower knowledge and practice scores across multiple indicators, while Mashonaland East and Matabeleland North performed relatively better. These differences likely reflect variations in service coverage, NGO presence, extension programming and access to infrastructure such as markets, health clinics and schools. The findings suggest a need for decentralised and context-specific interventions to address local drivers of unsafe food handling and consumption.

vi. Governance gaps and absence of a national food safety policy

Zimbabwe lacks a comprehensive national food safety policy to coordinate responsibilities across sectors. Current food safety governance is fragmented among the Ministries of Health, Agriculture, Higher and Tertiary Education and Industry, resulting in weak enforcement, especially in informal markets where majority of rural food transactions occur. The absence of a centralised foodborne illness surveillance system, inadequate laboratory capacity and poor monitoring of pesticide and veterinary drug residues compromise the country's ability to manage emerging food safety threats, including AMR and climate-related foodborne risks.

Recommendations

Based on the findings presented in this report, the following recommendations are put forward to help strengthen food safety management in rural households in Zimbabwe.

i. Develop and implement a comprehensive National Food Safety Policy

Zimbabwe urgently needs to develop a standalone **National Food Safety Policy** that integrates food safety, public health, nutrition, agriculture and trade. The current fragmentation, where responsibility is split between ministries (e.g., Health, Agriculture, Higher and Tertiary Education, Industry), creates enforcement gaps and regulatory incoherence.

ii. Enhance community-based food safety education

Evidence from the report highlights significant knowledge gaps among rural households regarding microbial contamination, antimicrobial resistance (AMR) and safe food handling. These knowledge deficits, particularly among women and youth who are primary caregivers, increase vulnerability to foodborne risks.

iii. Strengthen farmer and consumer education on agrochemical and AMR risks

The findings revealed low awareness and poor adherence to safe pesticide withdrawal periods and AMR guidelines. Given the reliance on informal agricultural extension and agro-dealers, especially in communal farming areas, targeted educational interventions are critical.

iv. Mandate and enforce clear labelling on agrochemical and processed food products

Evidence from the regression analysis and household responses shows poor utilisation of food label information, particularly expiry dates, nutritional content and storage instructions, due to poorly labelled products.

v. Promote gender-responsive food safety interventions

Regression results indicate that female-headed households are more likely to adopt safe food handling practices, particularly in cooking. However, women often face structural inequalities that limit their ability to access food safety information or technologies.

vi. Build institutional capacity for risk surveillance and enforcement

The report underscores Zimbabwe's lack of a national foodborne illness surveillance system, weak laboratory infrastructure and limited capacity for monitoring AMR and chemical contaminants. This governance vacuum allows unsafe practices to persist unchecked.

vii. Formalise and regulate informal food markets

The informal food economy dominates rural Zimbabwe but operates outside formal regulation. Unsafe practices such as the sale of expired goods, improper storage and unlabelled pesticides are prevalent.

viii. Embed food safety into broader rural development and nutrition strategies

Food safety should be mainstreamed into Zimbabwe's rural development, resilience and nutrition policies. Unsafe food undermines not only public health but also national goals on food and nutrition security.

ix. Adopt a One Health Approach to Food Safety and AMR

The interconnected risks of unsafe food, zoonotic pathogens and antimicrobial resistance require a One Health approach, as called for by the World Health Organisation (WHO), Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (WOAH) and Africa Centres for Disease Control and Prevention (Africa CDC). The low AMR awareness in rural households and misuse of veterinary antibiotics highlighted in the report underscores this need.

x. Conduct further research and surveillance

The absence of robust data systems on foodborne illness and antimicrobial resistance significantly hampers targeted policy responses. The literature and findings underscore the importance of regular monitoring to guide adaptive and risk-based programming.

Overall, improving food safety in rural Zimbabwe demands a coordinated, inclusive and multi-sectoral approach that addresses knowledge, behaviour and systemic governance challenges. The recommendations above provide a roadmap for policymakers, development partners and researchers to reduce foodborne risks, build resilience and enhance public health.

CHAPTER 1 INTRODUCTION

Food safety constitutes an essential, yet often underprioritised and investigated, dimension of public health, food security and sustainable rural development. The World Health Organization (WHO) estimates that approximately 600 million people fall ill annually due to foodborne diseases, with 420,000 resulting deaths, most of which occur in low- and middle-income countries (Devleesschauwer *et al.*, 2018; Grace, 2023). Sub-Saharan Africa bears a disproportionate burden of these illnesses, particularly among children under the age of five. This burden is exacerbated by widespread poverty, poor infrastructure, limited access to health services and weak institutional capacity to monitor and enforce food safety standards (Grace, 2015). In this context, understanding and addressing food safety is not only a matter of health but a critical component of achieving sustainable livelihoods in rural areas.

Food safety lies at the intersection of all four dimensions of food security: availability, access, utilisation and stability are fundamental to achieving Sustainable Development Goal 2 (zero hunger) and SDG 3 (good health and wellbeing). Moreover, food safety is a main principle of the One Health approach, which recognises the interconnectedness of human, animal and environmental health. In rural Zimbabwe, food safety concerns are deeply embedded within broader livelihood systems characterised by subsistence agriculture, informal markets and constrained public services. Rural households primarily depend on smallholder farming and local trading networks for their food supply. However, the informal nature of these food systems often bypasses statutory safety inspections, resulting in significant exposure to microbial and chemical hazards. Studies by Chimuti *et al.* (2024) documented practices such as storing cooked foods at ambient temperatures, using untreated water and failure to separate raw and cooked items, behaviours that elevate the risk of foodborne diseases. Further compounding these risks is the limited knowledge and application of food labelling practices among rural consumers and vendors. Moreover, the improper labelling and use of agrochemicals elevate food safety risks.

The absence of critical information such as allergen declarations, expiry dates and nutritional content limits consumers' ability to make informed decisions. In addition to microbiological hazards, rural households are also at risk from chemical contaminants such as pesticide residues and aflatoxins (Gichohi-Wainaina *et al.*, 2021). Zimbabwe's agricultural systems, particularly those supporting high-value crops like maize and groundnuts, are prone to mycotoxin contamination. Ndemera *et al.* (2020) identified aflatoxins as a persistent challenge in Southern Africa's food chains, linked to poor postharvest handling and inadequate storage technologies.

Food safety is thus deeply interconnected with broader determinants of people's livelihoods, including access to education, health services, infrastructure and regulatory governance. Unsafe food undermines household productivity, increases healthcare costs and limits economic opportunities (Akhtar *et al.*, 2014), particularly for women and children who are often the primary food handlers (Grace, 2015). It also affects the nutritional quality of diets. Unsafe or contaminated foods may discourage the consumption of perishable nutrient-rich items such as milk, eggs, fruits and vegetables, contributing to micronutrient deficiencies and chronic undernutrition (Fanzo & Swartz, 2019). This underscores the importance of embedding food safety considerations into national livelihood assessments. Emerging evidence demonstrates that without integrating food safety, such assessments may overlook critical risks that undermine food utilisation and health outcomes.

The 2025 Rural Livelihoods Assessment (RLA), which included food safety modules, offers an important opportunity to empirically examine knowledge, practices and risk exposures across Zimbabwe's rural households. By triangulating survey data from 17,895 households with field observations of food and agrochemical labelling practices, this study fills a critical knowledge gap in the evidence base for food safety governance and rural public health. Furthermore, it provides insights into how gender, education, information access and market dynamics shape household-level practices and systemic vulnerabilities. Such insights are crucial for designing targeted interventions that not only improve food safety but also support the broader goals of rural development, public health and food and nutrition security in Zimbabwe.

1.1 Objectives of the Study

This study was guided by the following objectives:

i. To assess the knowledge and practices related to food safety among rural households in Zimbabwe.
ii. To examine the determinants of food safety behaviours, including socio-demographic factors such as gender, education, region, household size and access to food safety information.
iii. To evaluate the extent of compliance with national food labelling regulations for key food groups, maize meal, milk and dairy products, edible oils, as well as agrochemicals, based on field observations in rural retail settings.
iv. To identify gaps in consumer engagement with food labels, including awareness, interpretation and use of nutritional and safety information.
v. To assess rural households' knowledge of antimicrobial resistance (AMR) and related safe food handling and agrochemical practices, within the context of the One Health framework.

vi. To generate policy-relevant recommendations for strengthening food safety governance, risk communication and consumer protection in rural Zimbabwe, aligning with the National Development Strategy 1 (NDS1) and inform the forthcoming NDS2, the Food and Nutrition Security Policy and the One Health approach.

1.2 Rationale for focusing on rural households in food safety research

Despite the central role of rural households in food production and consumption, they remain understudied in food safety research and underrepresented in national food safety policies. Most research and interventions tend to focus on urban markets, export value chains, or formal sector actors. This leaves significant knowledge gaps regarding food safety risks, practices and outcomes in rural contexts, where regulatory reach is limited and informal systems predominate. Focusing on rural households allows for a better understanding of food safety challenges that are deeply embedded in local culture, gender norms and socio-economic realities. In Zimbabwe, for example, studies have shown that women, who are typically responsible for food preparation, may lack access to information or resources needed to practice safe food handling, particularly in male-headed households or polygamous family structures (Motsi, 2021).

Additionally, food safety interventions designed for urban or commercial settings may not be appropriate or effective in rural areas. For instance, promoting cold chain storage or Hazard Analysis and Critical Control Point (HACCP) principles may not be feasible where electricity is unreliable or where literacy levels are low. Therefore, rural food safety strategies must be locally contextualised and grounded in community realities. Moreover, improving food safety in rural settings has a multiplier effect. It can enhance child nutrition outcomes, reduce healthcare burdens, increase productivity and improve market access (Unnevehr, 2022; Wang *et al.*, 2025). In Southern Africa, where many countries are embarking on nutrition-sensitive agricultural strategies, integrating food safety into rural development plans offers a pathway for holistic, sustainable progress. Hence, focusing on rural households in food safety research is both a practical necessity and a strategic investment.

CHAPTER 2 RESEARCH AND METHODOLOGICAL CHOICES

2.1 Methodological choice

The Zimbabwe Livelihoods Assessment Committee (ZimLAC) ensures that for each research it undertakes, the selection of the research philosophy is based on the relevance of a philosophy to the research questions set out. The intentions of ZimLAC's research shape the methodologies that are employed and consequently influence the results that they obtain. Concomitantly, the findings manifest an epistemological bias by reflecting ZimLAC's persuasions. Thus, the standard employed in identifying the research philosophy focuses on the relevancy of the philosophy behind the research. Different methodologies are used for different research, thereby necessitating that current assessment to review available methodologies and select a methodology that was suitable.

Given the mandate and objectives of ZimLAC that include both surveys and operational research, it is important to recognize that a context-based methodology is adopted at the time of the research. Thus, ZimLAC concurs with Boland (2014) that the objectives of the researcher generally determine the methods of approach and shape the results that are attained. This assessment recognizes that such results manifest an epistemological bias by consequently reflecting the researcher's intentions. In this regard, the authors take note of the epistemological concerns that lie behind the differences in approach between quantitative and qualitative methodologies. Methodological choices and their epistemological base, if not well understood, can create divisions in research communities. Thus, in choosing between the two methodologies or combining them, the current assessment strove to avoid the risk of developing polarized tendencies.

2.2 Sampling Frame and Design

The sampling strategy was based on the Zimbabwe National Statistics Agency (ZimSTAT)'s master sampling frame. A multi-stage cluster sampling technique was adopted to select a representative sample of households in all rural districts. This approach allowed for probability-based selection at multiple levels, district, ward, enumeration area (EA) and household, thereby minimising selection bias and ensuring that all households had a known, non-zero chance of selection. All 60 rural districts in Zimbabwe were included in the assessment. Within each district, wards were selected using Probability Proportional to Size (PPS), meaning wards with larger populations had a higher chance of being selected. Within each selected ward, enumeration areas (EAs) were also selected using PPS. To ensure broad coverage, a minimum of 30 EAs per district were enumerated.

2.2.1 Sample size determination

The formula below was used to calculate the sample size for the assessment:

$$n = (D)(z^2 * p *(1-p))/d^2$$

Where:

n = Required minimum sample size

D = Design effect (often assumed to be 2, but varies by type of sampling and by indicator)

z = z-score corresponding to the degree of confidence (1.96 if degree of confidence is 95 percent)

p = Estimated proportion of key indicator expressed as a decimal (e.g. 20 percent = .20)

d = Minimum desired precision or maximum tolerable error expressed in decimal form (e.g. +/- 10 percentage points = .10)

Design effect (D): The design effect for simple random sampling is equal to 1 (meaning there is no design effect). The design effect for cluster or two-stage cluster sampling is the factor by which the sample size must be increased to produce survey estimates with the same precision as with a simple random sample. A typical value for cluster and two-stage cluster sampling is 2, resulting in a doubling of the sample size requirement. However, it may be possible to reduce this value by increasing the number of clusters and hence having a lesser number of households in each cluster, or when design effect estimates for the same indicator are available from previous surveys.

Z: Since estimates are based on a sample, rather than total enumeration of the population (as in a census), it is not possible to be 100 % confident that the estimate derived from a sample is a true reflection of the population. The conventional degree of confidence for almost all social research is 95 %, meaning that if you were to perform the assessment 100 times, 95 of the 100 assessments would yield range estimates known as confidence intervals (e.g. 20 percent +/- 5 percentage points) containing the true population proportion. By contrast, 5 of the 100 assessments would yield confidence intervals that do not contain the true population proportion due to chance. The z-score corresponding with 95 percent confidence is 1.96, which is the standard used in ZimLAC.

p: An estimate (in decimal form) of the primary food and nutrition security indicator of interest allows the sample size to be produced. Where no reasonably accurate estimate can be found, a default value of 50 percent should be used. This default offers a safe, albeit more expensive, alternative, as the value of 50 percent will yield the largest required sample size. Since the Zimbabwe livelihoods assessment report a variety of indicators (not just percentage of food insecure), it is generally recommended to use the default of 50 percent, knowing that certain indicators with a higher or lower prevalence than 50 percent will have tighter confidence intervals (i.e. more precision). When carrying out a nested ZimLAC food security and nutrition assessment with several indicators of interest, the primary indicator of choice for sample size calculation is the one that yields the largest sample size.

d: The primary technical choice in determining sample size for a non-stratified sample is defining a minimum level of precision (or maximum tolerable error). Precision refers to the degree of error (or confidence interval) around the estimate since the estimate is based on a sample.

2.2.2 Selection of enumeration areas

A two-stage stratified probability sampling design is used. In the first stage enumeration areas are selected using Probability Proportional to Size sampling method (PPS). This type of sampling ensures that all households, whether from a small or a big EA, always have an equal probability of being selected. The number of selected EAs in each stratum/district was 30.

2.2.3 Selection of Households

For the current assessment, once the sampling frame had been constructed, the guidance given for simple random sampling or systematic sampling was followed for selecting households for inclusion. The households were selected systematically. A sampling interval was calculated by dividing the total number of households in an EA by the number of households to be interviewed to get the sampling interval. The following procedures were used for selecting households in each sampled EA:

All the households in valid, i.e. occupied, housing units listed in the sample EA were assigned a serial number from 1 to M'_{hi}, the total number of households listed.

To obtain the sampling interval for the selection of households within the sample EA (I_{hi}), M'_{hi} was divided by m_{hi}, 2 decimal places were maintained. A random number (R_{hi}) with 2 decimal places, between 0.01 and I_{hi} was selected. The sampled households within the sample EA were identified by the following selection numbers:

$S_{hij} = R_{hi} + [I_{hi} \times (j-1)]$, rounded up,

where j = 1, 2, 3... m_{hi}

The j-th selected household was the one with a serial number equal to S_{hij}.

In each selected EA, 10 households were randomly selected. Enumerators first reviewed EA maps provided by ZimSTAT to ensure a clear understanding of boundaries, including alignment with Zimbabwe's devolved administrative structures. Upon entering the EA, enumerators identified the total number of households, using available village registers where possible.

For example, if an EA had 50 households, the interval would be 5. A random starting number between 1 and 5 was selected using the "hat method," and every 5th household thereafter was chosen. In cases where a dwelling unit housed more than one household, one household was randomly selected. If a selected household was vacant, it was replaced by the next household on the right, preserving the original selection sequence. Each district had a minimum sample size of 300 households, yielding a robust data set for both national and sub-national analysis. To carter for any reduction in sample size due to data cleaning and non-response, the enumerators were allowed to select one additional household in an EA.

2.2.4 Data collection protocols

A set of standardised protocols guided the administration of modules to ensure consistency and data reliability. All data collection tools were digitalised and administered using handheld tablets to enhance data accuracy, reduce manual errors and facilitate real-time data submission and monitoring. Data collection was conducted from 21 May 2025 to 4 June 2025 Enumerators and supervisors underwent intensive training on the tools, ethical considerations, anthropometric techniques and community engagement strategies to ensure the integrity of the data collection process.

3.4 Estimation of sampling errors

The estimates from a sample survey are affected by two types of errors: non-sampling errors and sampling errors. Non-sampling errors are when the results of the assessment made in implementing data collection and data processing, such as failure to locate and interview the correct household; understanding of the questions on the part of either the interviewer or the respondent; and data entry errors. Although numerous efforts are made during the implementation of the livelihoods assessment to minimize this type of error, non-sampling errors are impossible to avoid and difficult to evaluate statistically. Sampling errors, on the other hand, can be evaluated statistically.

If the sample of respondents is selected as a simple random sample, it would be possible to use straightforward formulas for calculating sampling errors. However, the assessment sample is the result of a multi-stage stratified design and, consequently, it is necessary to use more complex formulas. Sampling errors are computed in either ISSA or SAS, using programs developed by ICF International. These programs use the Taylor linearization method of variance estimation for survey estimates that are means, proportions, or ratios like the ones in the ZIMLAC survey. The Taylor linearization method treats any percentage or average as a ratio estimate, $r = y / x$, where y represents the total sample value for variable y and x represents the total number of cases in the group or subgroup under consideration. The variance of r is computed using the formula given below, with the standard error being the square root of the variance:

$$V(\hat{Y}) = \sum_{h=1}^{L} \left[\frac{n_h}{n_h - 1} \sum_{i=1}^{n_h} \left(\hat{Y}_{hi} - \frac{\hat{Y}_h}{n_h} \right)^2 \right],$$

where:

$$\hat{Y}_{hi} = \sum_{j=1}^{m_h} w_{hij}\, y_{hij}$$

$$\hat{Y}_h = \sum_{i=1}^{n_h} \hat{Y}_{hi}$$

Many of the estimates are in the form of proportions or percentages, which are types of ratios. The variance estimator of a ratio module can be expressed as follows:

$$V(\hat{R}) = \frac{1}{\hat{X}^2} \left[V(\hat{Y}) + \hat{R}^2\, V(\hat{X}) - 2\, \hat{R}\, COV(\hat{X}, \hat{Y}) \right],$$

where:

$$COV(\hat{X}, \hat{Y}) = \sum_{h=1}^{L} \left[\frac{n_h}{n_h - 1} \sum_{i=1}^{n_h} \left(\hat{X}_{hi} - \frac{\hat{X}_h}{n_h} \right) \left(\hat{Y}_{hi} - \frac{\hat{Y}_h}{n_h} \right) \right]$$

$V(\hat{Y})$ and $V(\hat{X})$ are calculated according to the formula for the variance of a total.

In addition to the standard error, the design effect (DEFT) for each estimate is also calculated. The design effect is defined as the ratio between the standard error using the given sample design and the standard error that would result if a simple random sample had been used. A DEFT value of 1.0 indicates that the sample design is as efficient as a simple random sample, while a value greater than 1.0 indicates the increase in the sampling error due to the use of a more complex and less statistically efficient design. Relative standard errors and confidence limits for the estimates are also calculated. Sampling errors for the assessment are calculated for selected variables considered to be of primary interest.

3.5. Data Triangulation

As shown in
Figure 1, data used in the study was collected from various sources and at different levels.

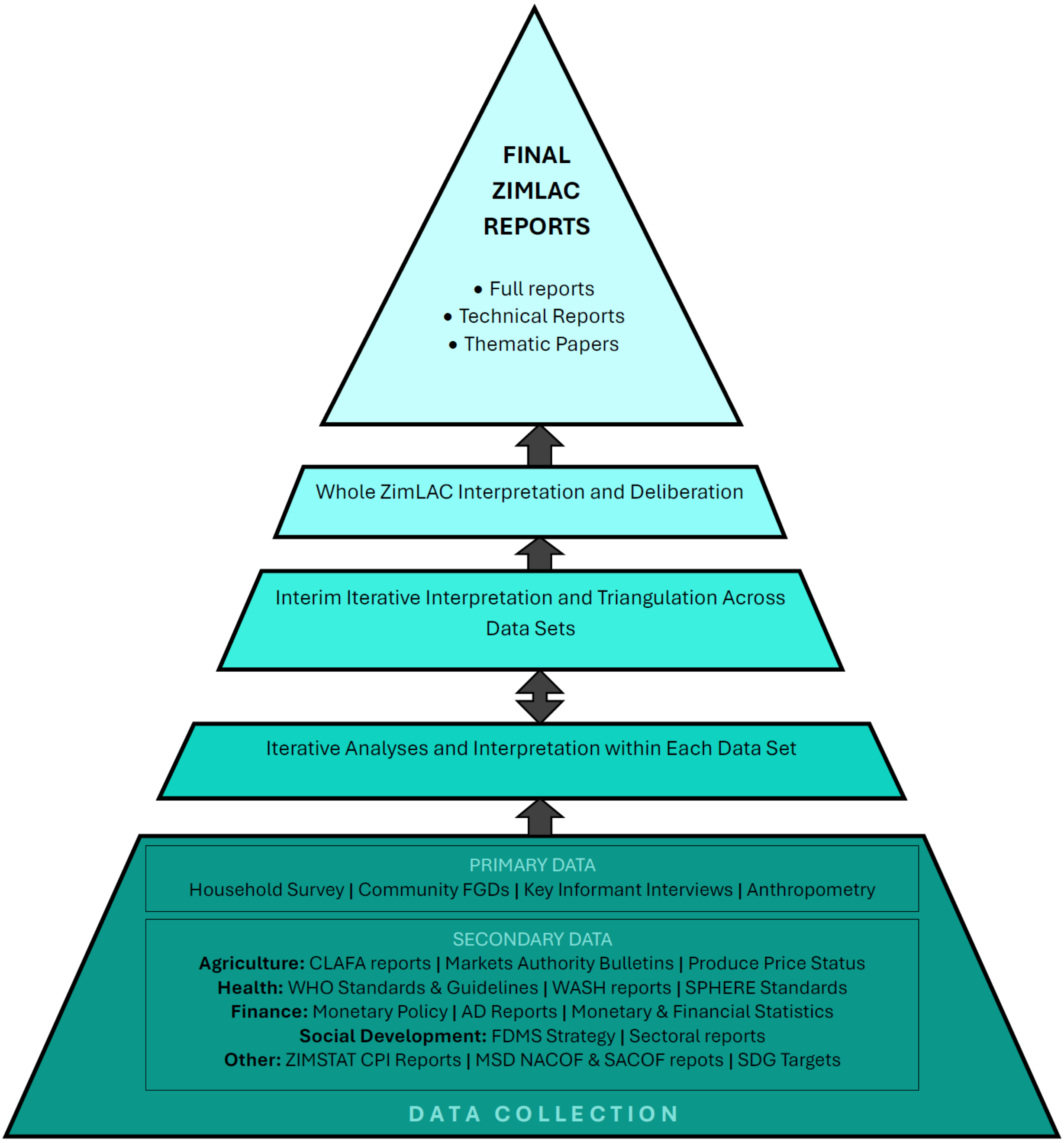

Figure 1. The ZIMLAC Data Triangulation Framework. FNC, 2023

Conclusion

The methodology adopted for the 2025 Rural Livelihoods Assessment provides a robust and integrated foundation for understanding the complex dynamics shaping rural livelihoods in Zimbabwe. The use of a multi-stage cluster sampling design based on the ZimSTAT master frame ensures statistical representativeness across all 60 rural districts, while the standardised household selection procedures and sampling protocols guarantee consistency, transparency and inclusivity in data collection. By incorporating both quantitative and qualitative methods, including household surveys, anthropometric assessments, FGDs and KIIs, the assessment captures a wide spectrum of indicators related to vulnerability, resilience, service delivery, income and nutrition. The integration of resilience analysis, through absorptive, adaptive and transformative capacities, adds a forward-looking lens to the traditional livelihoods approach, enabling a deeper understanding of how households cope with and adapt to shocks over time.

CHAPTER 2 LITERATURE REVIEW

This literature review presents a comprehensive synthesis of theoretical and conceptual frameworks that inform food safety behaviours and practices in rural settings. It also reviews empirical evidence on household food safety knowledge and practices in Zimbabwe and Southern Africa and identifies key research and policy gaps.

2.1 Theoretical and conceptual frameworks for understanding food safety

Understanding food safety behaviours in requires a theoretical foundation that recognises the interplay between individual beliefs, environmental conditions and broader systemic influences. Several behavioural and ecological theories provide useful lenses through which food safety behaviours can be understood. These include the Health Belief Model (HBM), the Theory of Planned Behaviour (TPB), the Socio-Ecological Model (SEM) and the Food Systems Framework. Each of these models contributes unique insights for interpreting how individuals and households perceive and act on food safety risks.

2.1.1 Health Belief Model (HBM)

The HBM suggests that health behaviours are influenced by individuals' perceptions of susceptibility to health risks, the severity of those risks, the benefits of taking action and the barriers that may prevent action (Alyafei & Easton-Carr, 2024). In food safety, this model has been applied to understand why rural households may fail to adopt behaviours such as washing hands, reheating leftovers, or avoiding visibly spoiled food (Wang *et al.*, 2021; Orivri & Ogwezzy-Ndisika, 2023). In Southern Africa, studies have shown that many households assess food safety using sensory cues like smell or appearance, often underestimating risks from invisible pathogens such as *E. coli* and Salmonella (Bukachi *et al.*, 2021). Perceived severity of foodborne illness may also be low in rural contexts where symptoms like diarrhoea are common and attributed to non-food causes such as teething in children or poor water quality (Machava *et al.*, 2022). Additionally, barriers such as water scarcity, lack of soap, or absence of refrigeration limit the feasibility of ideal food safety practices. The HBM highlights the need for behaviour change communication strategies that not only increase awareness but also address perceived susceptibility, reduce barriers and frame food safety as a protective behaviour that yields tangible health benefits (Machava *et al.*, 2022).

2.1.2 Theory of Planned Behaviour (TPB)

The TPB posits that behaviour is guided by intentions, which are shaped by attitudes, subjective norms and perceived behavioural control (Ajzen, 1991; Parker *et al.*, 1995). This model is particularly useful for understanding how food safety practices are influenced by social expectations and structural constraints (Godin & Kok, 1996). In rural Zimbabwe, food preparation is often governed by longstanding cultural norms, some of which may undermine safe practices. For instance, it is common to reuse cooking oil or to ferment milk in unwashed containers, practices viewed as traditional but potentially risky. Subjective norms are reinforced by family members and peers who may discourage deviation from accepted practices, even when safer alternatives are available (Laursen & Veenstra, 2021; Capasso *et al.*, 2023). Moreover, perceived behavioural control is often low due to lack of access to clean water, time-saving equipment, or food safety training. In such contexts, interventions that focus solely on changing attitudes may fail unless accompanied by efforts to enhance behavioural control through infrastructure, education and supportive community norms.

2.1.3 Socio-Ecological Model (SEM)

The SEM conceptualises behaviour as influenced by factors at multiple levels: individual, interpersonal, community, institutional and policy (Owen *et al.*, 2008). At the individual level, education, risk perception and health literacy play a central role. At the interpersonal level, household dynamics, including gender roles, dictate who makes decisions and performs food preparation tasks. In most rural households in Zimbabwe, women are the primary food handlers but may lack decision-making authority and access to resources that facilitate safe practices (Moyo *et al.*). Community-level influences include norms around market practices, street vending and communal eating. Institutional-level determinants encompass the availability and effectiveness of extension services, food inspections and health education programs. At the policy level, fragmented food safety legislation and weak enforcement systems contribute to persistent food safety gaps, particularly in informal food systems that dominate rural markets (Mugadza *et al.*, 2025). The SEM underscores the importance of multi-level interventions that address not only knowledge but also enabling environments and institutional structures.

2.1.4 Food Systems Framework

The Food Systems Framework broadens the scope of analysis by embedding food safety within the entire food chain, from production to consumption and linking it with environmental, social and policy dimensions (Fanzo *et al.*, 2017; Brouwer *et al.*, 2020; Clapp *et al.*, 2022). In this framework, food safety is not merely a consumer-level issue but a systemic outcome shaped by inputs like agrochemicals, postharvest handling practices, market infrastructure and regulatory oversight. Unsafe food may be contaminated at multiple points in the chain, including during harvesting, storage, transport, processing, retail and home preparation (Aworh, 2021).

In much of rural Africa, Zimbabwe included, food systems are largely informal and poorly regulated. Farmers often lack training on safe pesticide use; food is transported in open vehicles under high temperatures; and markets lack basic hygiene facilities (Omuse *et al.*, 2025; Tohonon *et al.*, 2025). Moreover, food labels, when available, are often poorly understood or ignored by consumers due to low literacy levels (Miller & Cassady, 2015). Integrating food safety into food system transformation requires policy coherence across agriculture, health, environment and trade sectors, as well as engagement with informal actors who dominate the rural food economy. This systems perspective aligns with the One Health approach, which recognises the interdependence of human, animal and environmental health.

2.2 The nexus between food safety and food and nutrition security

Food safety is interlinked with food and nutrition security, particularly in rural settings where vulnerability to health and environmental shocks is high. The widely accepted four dimensions of food and nutrition security, i.e., availability, access, utilisation and stability, are all influenced, either directly or indirectly, by the safety of food consumed. Unsafe food compromises dietary quality, increases the burden of disease, reduces nutrient absorption and weakens the productivity of affected individuals, especially children and immunocompromised populations (Afsana *et al.*, 2022).

In rural Zimbabwe and across Southern Africa, food safety-related illnesses such as diarrhoea, typhoid and cholera are recurrent and undermine nutrition outcomes, particularly among children under five. Studies have shown that repeated episodes of diarrhoeal disease contribute to chronic undernutrition, stunting and poor cognitive development (Fischer Walker *et al.*, 2012; Pinkerton *et al.*, 2016; Ugboko *et al.*, 2020). Malnutrition, in turn, weakens immunity and increases susceptibility to foodborne pathogens, creating a vicious cycle of poor health and reduced human capital.

The nutrition implications of unsafe food extend beyond microbiological risks. Contamination with chemical residues, such as aflatoxins and pesticide residues, has been linked to long-term health effects including liver cancer, immune suppression and micronutrient deficiencies (Ndemera *et al.*, 2020; Balan *et al.*, 2024). Aflatoxin exposure, for instance, has been associated with impaired growth in children and adverse pregnancy outcomes. This risk is particularly acute in rural areas where staple crops such as maize and groundnuts are frequently contaminated due to poor postharvest handling, lack of drying infrastructure and insufficient regulatory enforcement (Ndemera *et al.*, 2018; Ndemera *et al.*, 2020). Furthermore, access to safe food is critical for realising the potential benefits of food-based nutrition interventions. Biofortified crops, supplementary feeding programmes and diet diversification efforts can all be undermined if the food delivered or consumed is unsafe. For example, vitamin A-rich orange maize may still contribute to malnutrition if it is infested with mould or prepared using contaminated water (Nakuwa *et al.*, 2023). Thus, integrating food safety into nutrition-sensitive agriculture is essential for achieving meaningful improvements in dietary quality and health.

Food safety also affects economic access to food. Households burdened by healthcare costs due to foodborne illnesses have fewer resources for purchasing nutritious food (Agurs-Collins *et al.*, 2024). In Zimbabwe, health shocks are one of the major drivers of transitory food insecurity, with food safety-related illnesses often misclassified or underreported. Poor food safety also limits household income through its effect on productivity. Sick individuals are less able to work, attend school, or care for dependents, further entrenching poverty and food insecurity. Finally, stability of food and nutrition security, particularly in the face of climate change and economic shocks, is linked to the resilience of food systems to produce and distribute safe food (Naheed & Rukhsana, 2024). Droughts, floods and rising temperatures influence pathogen prevalence, water quality and storage conditions, thereby exacerbating food safety risks. As such, food safety is both a prerequisite and a pillar of food and nutrition security. It must be addressed holistically within food systems strategies, policy frameworks and programme designs aimed at improving rural health and livelihoods. Only by recognising and acting upon this nexus can governments and development partners effectively achieve SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being) and SDG 6 (Clean Water and Sanitation).

2.3 Use of Antibiotics and Antimicrobial Resistance (AMR)

2.3.1 Prevalence of antibiotic use in backyard and smallholder livestock production

In rural areas across Southern Africa, including Zimbabwe, the use of antibiotics in backyard and smallholder livestock production is widespread, primarily for growth promotion and disease prevention. Most livestock owners, including those keeping poultry, cattle and goats, often administer antibiotics without veterinary consultation, relying on informal advice or previous experience. Studies from Malawi (MacPherson *et al.*, 2023), Zambia (Mudenda *et al.*, 2022) and Zimbabwe (Mugoti & Munengwa, 2024) reported high prevalence of antibiotic use among smallholder farmers, with tetracyclines, sulfonamides and penicillins being the most commonly used classes. These drugs are frequently accessed through agro-vet shops or informal traders without prescription, posing serious public health concerns. The ease of access, combined with poor regulation and limited farmer training, has led to widespread misuse, including under-dosing, overuse and lack of adherence to withdrawal periods (Musuka *et al.*, 2025). In many instances, antibiotics are used prophylactically, especially during disease outbreaks, even when animals show no clinical symptoms (Manyi-Loh *et al.*, 2018). This routine application increases the selection pressure for antimicrobial-resistant bacteria in animals, which may then be transmitted to humans through direct contact, the food chain, or the environment (Uddin *et al.*, 2021).

2.3.2 AMR containment efforts in Zimbabwe and relevance to rural communities

Zimbabwe's National Action Plan on Antimicrobial Resistance (2017–2021), developed with support from the WHO and FAO, provided a roadmap for AMR containment. It includes objectives to strengthen surveillance, improve awareness, regulate antimicrobial use and enhance infection prevention. However, implementation in rural areas has been minimal due to funding limitations and weak decentralisation. Few rural communities are aware of the AMR strategy and there are limited mechanisms to enforce safe antibiotic use in livestock. Veterinary drugs remain readily accessible in agro-dealer shops without prescription and animal health services are underfunded and understaffed. These gaps undermine the effectiveness of national strategies at the grassroots level.

However, the Government of Zimbabwe has made some strides and there are emerging opportunities. Pilot projects in districts like Chiredzi and Gwanda have introduced community-based animal health workers trained in responsible antibiotic use and basic hygiene (FAO, 2022; Swiswa *et al.*, 2022). Additionally, NGOs and universities are partnering with government agencies to roll out AMR awareness campaigns through radio and farmer field schools. Regional collaboration through the Africa CDC AMR Framework and the Tripartite Alliance (WHO, FAO, WOAH) is also growing. These partnerships can support capacity building, data sharing and harmonised policies across borders. For rural Zimbabwe, integrating AMR awareness into agricultural extension, school curricula and local council health agendas is essential. To succeed, AMR containment must move beyond urban centres and hospitals to encompass the informal, rural contexts where the bulk of food is produced and consumed (Lubanga *et al.*, 2025). Bottom-up strategies, community empowerment and inclusive policy design will be key to safeguarding public health from the growing threat of antimicrobial resistance.

2.4 Use of Pesticides in Fruits and Vegetables

2.4.1 Common pesticide types used in rural horticulture

In rural Zimbabwe and across many parts of Southern Africa, smallholder farmers heavily depend on pesticides to protect fruit and vegetable crops from pests and diseases. Commonly used pesticide classes include organophosphates (e.g., dimethoate, chlorpyrifos), pyrethroids (e.g., cypermethrin, deltamethrin) and carbamates (e.g., carbaryl). These are frequently applied to tomatoes, cabbages, rape, onions and green beans, staples in both household diets and informal markets (Zimba & Zimudzi, 2016). Despite their effectiveness, many of these substances fall under WHO Hazard Class II (moderately hazardous), with potential for acute and chronic health effects if misused. In rural communities such as Mutoko, Murehwa and Gokwe South, pesticide application is often done manually using backpack sprayers, without protective gear or formal training. A similar pattern is observed in Malawi and Tanzania, where smallholder vegetable producers lack access to safer pest control technologies or alternative integrated pest management (IPM) strategies (FAO, 2021). The use of unregistered or counterfeit pesticides is also a concern. Farmers sometimes purchase products in unlabelled containers or expired packages from informal vendors. These products may be banned or misused, increasing environmental and food safety risks. Moreover, due to limited literacy, farmers may not be able to interpret label instructions or hazard symbols, leading to incorrect mixing, frequency and dosage.

2.4.2 Knowledge and attitudes towards safe pesticide application

Studies in Zimbabwe and neighbouring countries indicate that knowledge about safe pesticide application is generally low among smallholder farmers (Ocho *et al.*, 2016; Zimba & Zimudzi, 2016). Many apply pesticides based on peer advice or past experience rather than scientific guidance. Farmers often believe that higher doses or more frequent spraying lead to better pest control, which results in overuse and environmental contamination. In rural Zambia, similar misconceptions persist, where vegetables are harvested and sold shortly after spraying, with little regard for Pre-Harvest Intervals (PHI) (Mwanja *et al.*, 2017). Pre-Harvest Interval (PHI) is the minimum number of days that must pass between the last application of a pesticide and the harvesting of the crop for consumption. It is determined based on how long pesticide residues take to degrade to safe levels as defined by Maximum Residue Limits (MRLs) Although awareness of pesticide-related health risks is rising, it has not always translated into behavioural change. Economic pressures, such as the need to protect high-value crops or meet market demand, frequently override safety considerations (Zinyemba *et al.*, 2021). Effective knowledge transfer mechanisms, such as farmer field schools, participatory IPM training and community demonstrations, can help bridge the knowledge gap, particularly when delivered in local languages and through trusted intermediaries.

2.5 National food safety governance in Zimbabwe

2.5.1 Fragmentation and regulatory overlaps

Food safety governance in Zimbabwe is characterised by institutional fragmentation, resulting in overlapping mandates, regulatory inefficiencies and weak enforcement. The primary legislative instruments are the Food and Food Standards Act (Chapter 15:04) enacted in 1971, Public Health Act [Chapter 15:09] enacted in 1924 and revised in 2018, Animal Health Act [Chapter 19:01] enacted in 1961, Environmental Management Act [Chapter 20:27] enacted in 2002 and the Consumer Protection Act [Chapter 14:44] enacted in 2019. These legislations are supported by various statutory instruments and regulations. However, responsibility for food safety in Zimbabwe is shared across food safety responsibilities are shared across multiple government agencies, leading to a fragmented and often overlapping regulatory landscape. This multi-agency framework involves ministries, regulatory authorities, local governments and scientific institutions.

Examples include the Ministry of Health and Child Care (MoHCC), Ministry of Lands, Agriculture, Fisheries, Water and Rural Development (MLAFWRD), Ministry of Industry and Commerce, Ministry of Environment, Climate and Wildlife, Ministry of Local Government and Public Works and Ministry of Higher and Tertiary Education, Innovation, Science and Technology Development (MHTEISTD). According to Mugadza *et al.* (2025), this multiplicity of actors leads to policy incoherence and duplication of efforts, particularly in rural and peri-urban areas. This fragmentation is further complicated by the absence of a unified food control authority. Mugadza et al. (2025) further reported that Zimbabwe has more than 15 laws and over 30 related statutory instruments on food safety, many of which are outdated and conflict with each other. These include provisions related to food hygiene, labelling, import/export controls and use of agrochemicals. Despite the existence of the Food Control Bill, first drafted in September 2011, legislative reform has stagnated. As a result, food safety enforcement remains reactive and inspection-based, rather than preventive and risk-based. This stagnation has real-world consequences. Outdated laws fail to address contemporary challenges such as antimicrobial resistance (AMR), pesticide residues, genetically modified organisms and novel food technologies.

Additionally, Zimbabwe lacks a comprehensive national food safety policy (*consultation regarding a food safety policy are currently ongoing*) that articulates strategic priorities, institutional roles and a coordinated framework for implementation. The absence of such a policy has contributed to ad hoc responses to food safety issues, poor inter-agency collaboration and limited alignment with regional and global best practices. Without a guiding policy, efforts to mainstream food safety into broader public health, agricultural and trade agendas remain disjointed. Moreso, the lack of coordination affects surveillance systems and emergency response mechanisms for foodborne outbreaks. For example, there is no centralised foodborne illness reporting system linking hospitals, public health authorities and regulatory agencies. This undermines the country's capacity to manage emerging risks such as antimicrobial resistance (AMR) and pesticide residues. International best practices, such as the establishment of a single food safety authority as implemented in countries like South Africa and Kenya, have been shown to improve accountability and streamline enforcement (Grace, 2015).

2.6 Determinants of good food safety practices

Understanding the determinants of food safety practices is essential for addressing the persistent burden of foodborne diseases and malnutrition. These practices are shaped by socioeconomic, infrastructural, institutional, cultural and market-related factors that influence household decision-making and capacity to handle food safely. Exploring these drivers provides a basis for designing targeted, context-sensitive interventions that promote safer food environments.

2.6.1 Socioeconomic status, household income and education levels

Socioeconomic status and education are key determinants of food safety behaviours in rural households (Phan *et al.*, 2024). Lower-income households often face structural barriers to implementing safe food handling, storage and preparation practices. Limited access to soap, clean water, fuel and safe storage equipment constrains households' ability to adhere to recommended hygiene standards, even when knowledge is present (Grace, 2015). Education significantly influences risk perception, health-seeking behaviour and application of knowledge. Households headed by individuals with higher education levels are more likely to adopt hygienic practices, such as separating raw and cooked foods, reading expiry dates and using clean utensils. Income levels also affect dietary choices and coping strategies (Aunger *et al.*, 2016). Poorer households are more likely to consume unsafe food because they are unable to discard spoiled products due to economic constraints. They may also be forced to purchase cheaper food items from informal vendors with poor hygiene standards. Therefore, interventions must address the underlying structural inequalities that prevent safe practices, while promoting context-appropriate education and livelihoods support.

2.6.2 Availability of clean water, sanitation and waste disposal infrastructure

The availability of safe water, sanitation and hygiene (WASH) infrastructure is one of the strongest determinants of food safety. Clean water is required for handwashing, cleaning utensils, rinsing food items and cooking. Sanitation infrastructure, such as ventilated improved pit latrines, is essential for preventing environmental contamination and the spread of foodborne pathogens (WHO, 2024). Handwashing stations near kitchens, proper drainage systems and designated areas for waste disposal are critical but often missing in rural homes. Where water is scarce, priorities shift from hygiene to essential needs like drinking and irrigation. Consequently, multi-sectoral WASH interventions that link water access with nutrition and food safety outcomes are vital for improving rural health.

2.6.3 Access to health, agricultural and extension services

Health and agricultural extension services play an essential role in disseminating food safety information, promoting hygiene behaviours and building local capacity (Morse *et al.*, 2018). However, in most cases, access to these services is uneven and often constrained by distance, staff shortages and resource limitations (WHO, 2024). Strengthening links between local clinics, schools and agriculture offices can foster a more coordinated, One Health-oriented approach. To enhance access, governments and partners should invest in community-based extension platforms, mobile outreach and digital tools such as SMS campaigns or community radio broadcasts. These approaches can reach underserved populations and address misinformation while building trust and accountability.

2.6.4 Influence of local markets, food vendors and informal food chains

Local markets and informal food vendors are primary food sources for many rural households in Southern Africa. These markets are typically unregulated and operate without basic infrastructure such as clean water, refuse bins, or handwashing stations. Moreover, trust in informal food vendors can sometimes override concerns about safety. Lack of consumer awareness or bargaining power can prevent customers from demanding safer products. Interventions such as vendor training, provision of mobile cold storage and establishment of hygiene bylaws enforced through local councils can improve market safety without disrupting livelihoods.

2.6.5 Cultural norms, traditional beliefs and food taboos

Cultural norms and beliefs strongly influence food safety practices in rural communities. While some traditional norms promote beneficial behaviours, such as covering food or boiling water, others may hinder the adoption of safe practices. In settings with low literacy and weak regulatory enforcement, these beliefs fill an informational void and may persist even in the face of contradicting evidence (Lee *et al.*, 2022). To address these issues, food safety education must be framed in culturally resonant terms. Collaborating with traditional leaders, religious figures and community elders can help debunk harmful myths and promote protective practices. Behaviour change communication strategies that leverage storytelling, local proverbs and visual demonstrations are more effective than top-down directives. Therefore, understanding and addressing the socio-cultural context is essential for improving food safety outcomes. Rather than dismissing traditional beliefs, programs should build on local knowledge and co-develop safer practices that are culturally acceptable and practically achievable.

2.7 Summary of gaps and implications for research

Despite growing recognition of the importance of food safety in achieving health and food security goals, substantial gaps remain in both research and practice, particularly in rural and low-resource settings. Firstly, much of the available research focuses on individual knowledge and practices, with limited attention to structural and systemic determinants of unsafe food environments. As Mugadza et al. (2025) argue, addressing food safety at the household level without reforming the broader food system infrastructure is insufficient. Furthermore, informal markets, which dominate rural food systems, remain under-researched. The role of street vendors, community cooperatives and cross-border food trade in shaping food safety outcomes is critical but poorly documented. Existing legislation does not adequately regulate these spaces, nor does it build the capacity of informal actors to handle food safely.

Additionally, most interventions rely heavily on education and training without addressing feasibility or structural constraints. Behavioural change campaigns, while necessary, often fail when households lack access to clean water, refrigeration, or protective equipment. There is a need for context-sensitive approaches that combine education with service provision, economic empowerment and policy enforcement. Also, limited integration exists between food safety, nutrition and One Health programming. Research often treats food safety as a siloed issue, yet its intersections with antimicrobial resistance, zoonotic diseases and environmental contamination are profound. Grace et al. (2018) stress the importance of cross-sectoral collaboration, especially at the local government level, to address food safety in a holistic manner. To fill these gaps, research should adopt participatory, interdisciplinary and systems-based methodologies. These efforts will be crucial for achieving the SDGs and ensuring the right to safe and nutritious food for all.

CHAPTER 3 FINDINGS

The results presented in this chapter provides insights into the state of food safety knowledge, practices and risk behaviours at the household level, with specific attention to antimicrobial resistance (AMR), agrochemical use and engagement with food labelling. Descriptive statistics and multivariate regressions are used to examine how sociodemographic factors such as education, gender, religion, asset ownership, disability and region influence food safety outcomes. The findings support the design of risk communication, AMR awareness and consumer protection interventions aligned with the One Health framework and national development strategies.

3.1 Sociodemographic profile of households

Table 1 summarises the core demographic and socioeconomic characteristics of 17,974rural households in Zimbabwe, reflecting diverse household structures, education levels, religious affiliations and asset ownership. The mean age of household heads is 46 years (SD = 17.28), indicating a predominantly mature adult population responsible for household decisions. The age range spans from youth to elderly, with implications for knowledge transmission, risk perception and openness to behavioural change concerning food safety and health. **Table 1** shows that 64.4% of households were headed by males and 35.6% by females. The proportion of female-headed households is significant, especially in the context of food security and caregiving, as women are often primary food handlers.

Table 1 also show that education levels are skewed towards basic schooling, with 34% of household heads having primary education, 16.9% having reached Zimbabwe Junior Certificate (ZJC) and 37.0% attaining O' Level. Only 2.6% of respondents achieved post-secondary qualifications. This low level of formal education likely affects health literacy, comprehension of food labels and application of safe handling practices. Religion plays a prominent role, with Apostolic sects (37.3%) being the most common affiliation, followed by Pentecostal (11.5%), Zionist (10.8%) and Protestant (7.6%) faiths. About 15.4% reported no religious affiliation. This religious composition can have direct implications for attitudes towards health interventions and trust in formal knowledge systems.

On average, households comprised 3.89 members (SD = 1.71). The asset index, a proxy for economic status, averaged 6.36 (SD = 3.39), illustrating significant disparities in household wealth and material wellbeing. This heterogeneity across socioeconomic variables is essential for understanding differentiated food safety behaviours and potential interventions.

Table 1. Descriptive statistics for background characteristics

Background characteristics	Mean	Standard deviation
Characteristics of household head		
Household head age	46	17.281
Male-headed households	0.644	0.479
Female-headed households	0.356	0.479
Education level		
None	0.084	0.277
Primary level	0.340	0.474
ZJC level	0.169	0.375
O' level	0.370	0.483
A' level	0.014	0.116
Diploma/Certificate after primary	0.006	0.079
Diploma/Certificate after secondary	0.010	0.097
Graduate/postgraduate	0.006	0.077
Marital status		
Married living together	0.602	0.489
Married living apart	0.101	0.301
Divorced/separated	0.074	0.262
Widow/widower	0.197	0.398
Cohabiting	0.003	0.056
Religion		
Roman Catholic	0.070	0.255
Protestant	0.076	0.266
Pentecostal	0.115	0.320
Apostolic Sect	0.373	0.484
Zion	0.108	0.310
Other Christian	0.063	0.243
Islam	0.004	0.061
Traditional	0.023	0.151
Other religion	0.013	0.115
No religion	0.154	0.361
Household characteristics		
Household size	3.888	1.711
Asset index	6.363	3.389
Province		
Manicaland	0.117	0.321
Mashonaland Central	0.134	0.340
Mashonaland East	0.150	0.357
Mashonaland West	0.116	0.321
Matabeleland North	0.117	0.321
Matabeleland South	0.115	0.319
Midlands	0.134	0.340
Masvingo	0.118	0.322

The demographic and socioeconomic characteristics presented in **Table 1** provide important insights for interpreting rural households' engagement with food safety, antimicrobial practices and hygiene. Age plays a dual role; while older household heads may have experience and resilience, they may also exhibit cognitive rigidity or lower receptiveness to newer scientific information (Saez-Sanz *et al.*, 2025). The relatively high proportion of female-headed households reflects shifting family structures due to migration, mortality and social dynamics. Previous studies have shown that women in such settings often assume responsibility for child feeding and food preparation, which positions them as key stakeholders in food safety interventions (Chance & Sardi Abdoul, 2025).

The dominance of Apostolic and Pentecostal affiliations necessitates culturally sensitive strategies, as doctrinal beliefs may either inhibit or promote positive health behaviours depending on how aligned they are with biomedical advice (Wüthrich-Grossenbacher *et al.*, 2023). In addition, the presence of disabled or chronically ill individuals raises the importance of inclusivity in programming, as these households may need adaptive infrastructure or tailored messages. Furthermore, asset ownership may be an enabling factor as wealthier households are more likely to afford refrigeration, food storage and quality food products. Understanding these background dynamics is crucial for designing equitable and effective food safety and AMR interventions.

3.2 Determinants of food safety knowledge

Table 2 provides the determinants of food safety knowledge among rural households in Zimbabwe using five outcome variables: (1) general knowledge on health and nutrition practices and the likelihood of considering specific food safety factors, (2) brand/source, (3) expiry date, (4) nutritional content and (5) storage instructions, when buying food. Regarding general knowledge on health and nutrition practices, **Table 2** indicates that older household heads were slightly less likely to report higher food safety knowledge ($\beta = -0.001$, $p<0.05$), possibly reflecting generational gaps in exposure to modern food safety information. Female-headed households and marital status were not statistically significant predictors. Education emerged as a critical determinant. Although most coefficients were positive, none of the education categories (relative to no education) were statistically significant except at the tertiary level. Households whose heads had post-secondary education showed higher but non-significant coefficients, suggesting a positive trend.

Regarding religion, Protestants ($\beta = 0.061$, $p<0.01$), Other Christians ($\beta = 0.033$, $p<0.1$) and Muslims ($\beta = 0.100$, $p<0.1$) had higher knowledge scores, while Apostolic and Zion groups did not show significant effects. This may be due to different levels of health outreach engagement or educational exposure among denominations. Furthermore, household size (β = 0.010, $p<0.01$) and asset index (β = 0.018, $p<0.01$) were both positively and significantly associated with knowledge, indicating that wealthier and larger households may have better access to health information. However, households with disabled heads (β = -0.032, $p<0.05$) or those with chronic illness (β = 0.027, $p<0.05$) presented mixed effects, suggesting that illness may sometimes be a motivator for increased food safety awareness.

With respect to consideration of brand/source when buying food, **Table 2** reveals that educational attainment strongly predicted the likelihood of considering brand or source. All levels from primary through graduate were significant ($p<0.01$), with the highest being those with post-secondary diplomas (β = 0.237). This suggests that formal education enhances awareness of product origin and brand integrity. Households in Mashonaland Central, Mashonaland East and Midlands had higher likelihoods of checking brand/source. However, Matabeleland South and Masvingo scored negatively. Similarly, religious affiliations such as Traditional, Apostolic and Zion had negative and significant associations.

As for expiry/best before date, **Table 2** reveals this factor as the most sensitive food safety factor to education, as all education levels were positively and significantly associated with checking expiry dates. For instance, those with O' Level (β = 0.132, $p<0.01$) or Certificate/Diploma after secondary (β = 0.200, $p<0.01$) were most likely to read expiry labels. This trend affirms that literacy directly supports engagement with food labelling. Households with a person living with disability were more likely to check expiry dates (β = 0.097, $p<0.01$), possibly due to heightened health vulnerability. In addition, household wealth, as indicated by the asset index, also predicted better outcomes (β = 0.015, $p<0.01$).

With respect to consideration of nutritional content, **Table 2** indicates that higher educational attainment, especially graduate or post-secondary education, was strongly predictive of households checking for nutrition content. However, household head age had a small but negative association (β = -0.001, $p<0.01$) and male-headed households were significantly less likely to check this information. Disaggregating the results by province, Mashonaland East showed the highest positive effect (β = 0.122, $p<0.01$), suggesting active nutrition messaging.

Table 2. Regression analysis of food safety knowledge with background characteristics

VARIABLES	Knowledge on health and nutrition practices		Factors considered by households when buying food for the family, excluding price							
			Brand/source		Expiry /Best before date		Nutritional content		Storage instructions	
	coef	se	coef	se	coef	se	coef	se	coef	se
Characteristics of household head										
Household head age	-0.001	(0.000)**	-0.000	(0.000)	-0.001	(0.000)***	-0.000	(0.000)	0.000	(0.000)
Female-headed household	-0.006	(0.012)	0.005	(0.012)	0.007	(0.011)	0.034	(0.009)***	0.003	(0.007)
Education level										
Primary level	0.006	(0.014)	0.069	(0.013)***	0.051	(0.014)***	0.017	(0.010)*	0.030	(0.007)***
ZJC level	-0.011	(0.016)	0.105	(0.015)***	0.100	(0.016)***	0.042	(0.012)***	0.040	(0.009)***
O' level	0.013	(0.015)	0.139	(0.015)***	0.132	(0.015)***	0.053	(0.011)***	0.055	(0.008)***
A' level	-0.001	(0.035)	0.184	(0.035)***	0.155	(0.032)***	0.081	(0.028)***	0.070	(0.022)***
Diploma/Certificate after primary	0.028	(0.045)	0.190	(0.048)***	0.170	(0.040)***	0.081	(0.040)**	-0.006	(0.024)
Diploma/Certificate after secondary	0.022	(0.038)	0.237	(0.039)***	0.200	(0.033)***	0.156	(0.037)***	0.118	(0.030)***
Graduate/Postgraduate	0.045	(0.047)	0.187	(0.050)***	0.116	(0.045)**	0.222	(0.048)***	0.140	(0.040)***
Marital status										
Married living apart	0.020	(0.014)	0.029	(0.014)**	0.024	(0.013)*	-0.012	(0.011)	0.008	(0.009)
Divorced/separated	0.003	(0.017)	-0.008	(0.017)	-0.017	(0.016)	-0.023	(0.013)*	0.021	(0.011)**
Widow/widower	0.020	(0.015)	-0.004	(0.014)	-0.024	(0.014)*	-0.038	(0.011)***	0.001	(0.009)
Cohabiting	0.035	(0.066)	-0.129	(0.062)**	-0.291	(0.065)***	-0.112	(0.043)***	-0.028	(0.039)
Never married	-0.060	(0.026)**	0.078	(0.026)***	0.019	(0.023)	0.065	(0.022)***	0.016	(0.017)
Religion										
Protestant	0.061	(0.019)***	0.016	(0.019)	-0.059	(0.018)***	-0.054	(0.015)***	-0.055	(0.012)***
Pentecostal	0.017	(0.017)	0.004	(0.018)	-0.004	(0.016)	-0.018	(0.014)	-0.044	(0.012)***
Apostolic Sect	0.011	(0.015)	-0.042	(0.015)***	-0.035	(0.014)**	-0.046	(0.013)***	-0.031	(0.011)***

Zion	0.020	(0.018)	-0.041	(0.018)**	-0.012	(0.017)	-0.019	(0.014)	-0.021	(0.012)*
Other Christian	0.033	(0.020)*	-0.009	(0.020)	0.047	(0.018)**	0.024	(0.017)	-0.015	(0.014)
Islam	0.100	(0.059)*	-0.028	(0.061)	0.011	(0.056)	0.008	(0.052)	-0.011	(0.041)
Traditional	0.021	(0.028)	-0.131	(0.026)***	0.020	(0.026)	-0.048	(0.021)**	-0.033	(0.017)*
Other religion	-0.002	(0.034)	0.113	(0.034)***	0.040	(0.031)	-0.040	(0.028)	-0.071	(0.020)***
No religion	-0.020	(0.017)	-0.020	(0.017)	-0.061	(0.016)***	-0.062	(0.014)***	-0.048	(0.011)***
Household characteristics										
Household size	0.010	(0.002)***	-0.011	(0.002)***	-0.006	(0.002)***	-0.013	(0.002)***	-0.006	(0.001)***
Household head disability	-0.032	(0.015)**	0.008	(0.014)	0.097	(0.014)***	0.042	(0.012)***	0.023	(0.009)**
Household head chronic condition	0.027	(0.011)**	-0.032	(0.010)***	-0.038	(0.010)***	-0.031	(0.008)***	-0.030	(0.006)***
Asset index	0.018	(0.001)***	0.009	(0.001)***	0.015	(0.001)***	0.009	(0.001)***	0.008	(0.001)***
Province										
Mashonaland Central	-0.031	(0.014)**	0.135	(0.015)***	0.012	(0.014)	0.045	(0.011)***	0.065	(0.009)***
Mashonaland East	-0.029	(0.014)**	0.062	(0.014)***	0.063	(0.013)***	0.122	(0.011)***	0.092	(0.009)***
Mashonaland West	-0.129	(0.015)***	-0.053	(0.015)***	-0.135	(0.015)***	-0.011	(0.011)	0.011	(0.008)
Matabeleland North	-0.028	(0.015)*	-0.006	(0.015)	-0.125	(0.015)***	-0.007	(0.011)	0.047	(0.009)***
Matabeleland South	-0.160	(0.016)***	-0.060	(0.015)***	0.087	(0.015)***	0.050	(0.012)***	0.080	(0.009)***
Midlands	-0.156	(0.014)***	0.014	(0.015)	-0.004	(0.014)	0.054	(0.011)***	0.047	(0.008)***
Masvingo	-0.049	(0.015)***	-0.031	(0.015)**	0.010	(0.015)	-0.042	(0.010)***	-0.028	(0.007)***
Constant	0.518	(0.029)***	0.287	(0.029)***	0.561	(0.028)***	0.130	(0.022)***	0.010	(0.017)
Observations	17,895		17,895		17,895		17,895		17,895	
R-squared	0.039		0.039		0.059		0.043		0.035	

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Lastly, for storage instructions, education remained significant across all levels. For example, households headed by individuals with diploma after secondary education (β = 0.118, p<0.01) or graduate-level education (β = 0.140, p<0.01) were more likely to consider storage information, reinforcing the importance of education in interpreting food handling guidelines. As expected, asset index had a positive effect (β = 0.008, p<0.01) and household heads with chronic illness or disabilities were significantly more likely to consider storage instructions, perhaps reflecting greater risk perception and food sensitivity. Religiously, most denominations (e.g., Apostolic, Zion and No Religion) had negative coefficients. This indicates possible gaps in health and nutrition messaging in communities affiliated with these groups.

The above findings confirm education and socioeconomic status as key drivers of food label literacy in rural Zimbabwe. Prior studies from similar contexts, such as Unusan (2007) in Turkey and (Nigussie *et al.*, 2017) in Ethopia, similarly found that formal education significantly enhances the ability to interpret and act upon nutritional and safety information. The asset index effect confirms that economic empowerment enables households to prioritise safety and quality over cost when purchasing food. Wealthier households may also have better exposure to markets where such information is displayed more prominently. Regional disparities also align with access to markets, NGOs and extension services. For instance, Matabeleland North has benefited from community-based nutrition programs, which may account for the higher engagement levels. Together, these results highlight the need for stratified messaging, targeting less-educated, poorer and religiously conservative populations with tailored, accessible information. Labelling policy reform should consider both format and dissemination strategies that account for socioeconomic and cultural contexts to improve food safety knowledge nationally.

3.3 Determinants of household food handling practices

Table 3 provides household-level determinants of five essential food handling and hygiene practices: (1) using clean and fresh utensils, (2) keeping food at correct temperatures, (3) keeping food covered, (4) separating raw and cooked foods and (5) cooking food thoroughly. These practices are key in preventing foodborne illnesses and controlling microbial contamination.

Results in **Table 3** indicate that age of household head was significantly and positively associated with all five practices ($p < 0.001$). This implies that older household heads are more likely to implement safe food handling procedures, possibly due to accumulated experience or adherence to traditional hygiene practices. Female-headed households were also more likely to adopt all five behaviours, with a particularly strong association observed in ensuring food was thoroughly cooked ($p < 0.05$). This aligns with literature highlighting the central role of women in household food preparation in rural contexts

(Roesel & Grace, 2014). Moreso, education was a consistent predictor across all practices. Households with O' Level or higher qualifications were more likely to implement all five food safety practices. For example, O' Level education was associated with a 5.4 percentage point increase in separating raw and cooked foods and a 6.9-point increase in keeping food covered ($p < 0.01$). Higher education levels such as A' Level and diploma showed even stronger effects.

Religious affiliation had mixed effects. Protestant and Pentecostal affiliations were positively associated with thorough cooking and use of clean utensils, while Apostolic and Traditional affiliations were negatively associated with some practices, such as separation of raw and cooked foods. This pattern may reflect doctrinal beliefs or differing access to health education.

Table 3 also reveals that disability status was a statistically significant predictor in some models. Households with disabled members were more likely to keep food covered and clean utensils, potentially due to greater sensitivity to health risks. In contrast, households with chronically ill members had a reduced probability of engaging in temperature control and separation of raw and cooked foods, likely due to caregiving burdens or economic constraints.

Geographic effects were evident, with households in Matabeleland North and Mashonaland East displaying better hygiene practices compared to the reference province, Mashonaland West.

Table 3. Regression analysis of food safety practices with background characteristics

VARIABLES	Use clean and fresh utensils		Keep food at correct temperatures		Keep food closed or covered		Separate raw and cooked food		Cook food completely and not leave any part raw	
	coef	se	coef	se	coef	se	coef	se	coef	se
Characteristics of household head										
Household head age	0.000	(0.000)	-0.000	(0.000)	-0.001	(0.000)***	-0.000	(0.000)*	-0.000	(0.000)
Female-headed household	0.010	(0.009)	0.001	(0.011)	0.013	(0.012)	-0.008	(0.012)	-0.018	(0.011)*
Education level										
Primary level	0.035	(0.012)***	-0.001	(0.014)	0.061	(0.014)***	0.051	(0.013)***	0.019	(0.012)
ZJC level	0.049	(0.013)***	0.005	(0.015)	0.036	(0.016)**	0.049	(0.015)***	0.032	(0.014)**
O' level	0.052	(0.013)***	0.003	(0.015)	0.046	(0.015)***	0.054	(0.014)***	0.042	(0.013)***
A' level	0.090	(0.026)***	0.031	(0.034)	0.081	(0.033)**	0.098	(0.034)***	0.028	(0.031)
Diploma/Certificate after primary	0.042	(0.038)	0.055	(0.047)	0.064	(0.047)	0.046	(0.047)	0.041	(0.043)
Diploma/Certificate after secondary	0.069	(0.031)**	0.150	(0.041)***	0.139	(0.036)***	0.139	(0.041)***	0.075	(0.038)**
Graduate/postgraduate	0.079	(0.036)**	0.124	(0.052)**	0.145	(0.044)***	0.130	(0.051)**	0.074	(0.046)
Marital status										
Married living apart	-0.017	(0.011)	0.010	(0.013)	-0.001	(0.013)	0.030	(0.014)**	-0.002	(0.013)
Divorced/separated	-0.016	(0.013)	0.011	(0.016)	0.016	(0.016)	0.020	(0.016)	0.008	(0.015)
Widow/widower	-0.032	(0.012)***	-0.014	(0.014)	0.012	(0.014)	0.008	(0.014)	0.017	(0.013)
Cohabiting	0.061	(0.045)	-0.109	(0.061)*	-0.060	(0.068)	-0.106	(0.066)	0.087	(0.067)
Never married	-0.070	(0.022)***	-0.002	(0.025)	-0.061	(0.026)**	-0.031	(0.024)	-0.016	(0.023)
Religion										
Protestant	-0.003	(0.015)	-0.020	(0.019)	0.047	(0.019)**	0.087	(0.019)***	0.131	(0.018)***
Pentecostal	0.028	(0.014)**	-0.022	(0.017)	0.052	(0.018)***	0.007	(0.017)	0.039	(0.016)**
Apostolic Sect	-0.005	(0.012)	-0.007	(0.015)	0.043	(0.015)***	0.028	(0.015)*	0.030	(0.014)**
Zion	-0.011	(0.014)	-0.016	(0.017)	0.034	(0.018)*	0.036	(0.018)**	0.043	(0.016)***
Other Christian	0.037	(0.016)**	-0.056	(0.019)***	-0.067	(0.020)***	-0.099	(0.019)***	-0.079	(0.017)***
Islam	-0.017	(0.048)	0.013	(0.060)	0.085	(0.062)	0.051	(0.057)	0.151	(0.060)**
Traditional	-0.086	(0.024)***	0.034	(0.027)	0.145	(0.026)***	-0.072	(0.026)***	-0.061	(0.023)***
Other religion	-0.041	(0.029)	-0.092	(0.032)***	-0.012	(0.034)	-0.117	(0.032)***	-0.055	(0.030)*
No religion	-0.033	(0.014)**	-0.034	(0.017)**	0.042	(0.017)**	0.015	(0.017)	0.038	(0.015)**
Household										

characteristics										
Household size	-0.006	(0.002)***	0.004	(0.002)*	0.016	(0.002)***	0.012	(0.002)***	0.009	(0.002)***
Household head disability	0.064	(0.010)***	0.006	(0.014)	-0.031	(0.015)**	-0.002	(0.014)	0.004	(0.014)
Household head chronic condition	0.007	(0.008)	-0.003	(0.010)	0.019	(0.010)*	0.004	(0.010)	0.021	(0.010)**
Asset index	0.004	(0.001)***	0.007	(0.001)***	0.014	(0.001)***	0.012	(0.001)***	0.009	(0.001)***
Province										
Mashonaland Central	0.126	(0.012)***	0.054	(0.015)***	0.070	(0.014)***	-0.025	(0.014)*	-0.044	(0.014)***
Mashonaland East	0.049	(0.012)***	0.098	(0.014)***	0.065	(0.014)***	0.161	(0.014)***	0.076	(0.014)***
Mashonaland West	-0.012	(0.013)	0.031	(0.015)**	-0.066	(0.015)***	-0.103	(0.014)***	-0.169	(0.013)***
Matabeleland North	0.135	(0.011)***	-0.079	(0.014)***	0.021	(0.015)	0.105	(0.015)***	-0.030	(0.014)**
Matabeleland South	0.065	(0.013)***	0.138	(0.016)***	0.053	(0.015)***	0.159	(0.015)***	0.142	(0.015)***
Midlands	-0.004	(0.013)	0.014	(0.014)	-0.073	(0.015)***	0.000	(0.014)	-0.076	(0.013)***
Masvingo	-0.017	(0.013)	-0.044	(0.014)***	0.017	(0.015)	-0.030	(0.015)**	-0.083	(0.014)***
Constant	0.718	(0.024)***	0.283	(0.028)***	0.439	(0.029)***	0.168	(0.028)***	0.161	(0.026)***
Observations	17,895		17,895		17,895		17,895		17,895	
R-squared	0.030		0.025		0.035		0.052		0.055	

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

3.4 Descriptives on unsafe food consumption practices

Table 4 presents two key indicators on antimicrobial resistance (AMR) awareness and related food safety risks across rural households in Zimbabwe's provinces. These indicators include the proportion of households aware of AMR and the proportion of households that consumed meat from animals still under antibiotic treatment before observing the mandatory withdrawal period. Moreover, **Table 4** presents the proportion of rural households across Zimbabwe's eight provinces that reported consuming fruits or vegetables that had been sprayed with pesticides before the mandatory withdrawal period was completed. The withdrawal period refers to the time interval that must elapse between pesticide application and the harvesting or consumption of treated produce, in order to allow chemical residues to degrade to levels considered safe for human health. Failure to observe this interval poses significant food safety risks, including acute toxicity, long-term exposure to hazardous chemicals and increased risk of non-communicable diseases.

Nationally, only 18.3% of rural households demonstrated any awareness of AMR, a concerningly low figure considering the rising global threat posed by antimicrobial resistance. There is, however, considerable provincial variability. The highest awareness was recorded in Mashonaland Central (25.3%) and Matabeleland North (23.2%), while the lowest was in Mashonaland West (8.2%) and Mashonaland East (16.5%). Manicaland, one of the more densely populated provinces, had a moderate awareness level of 20%.

Table 4. Knowledge of antimicrobial resistance and adherence to pre-harvest intervals and antimicrobial resistance.

Province	Proportion of households with knowledge of antimicrobial resistance	Households that consumed any meat from an animal on antimicrobial treatment before the withdrawal period was over	Unsafe fruit and vegetable consumption in Zimbabwean Rural Households
Manicaland	20.0	4.5	9.6
Mashonaland Central	25.3	4.8	7.3
Mashonaland East	16.5	5.4	10.0
Mashonaland West	8.2	5.0	6
Matabeleland North	23.2	7.0	4.4
Matabeleland South	15.0	2.5	6.6
Midlands	15.5	7.7	6.0
Masvingo	22.3	8.2	7.8
National	**18.3**	**5.7**	**7.3**

In addition, **Table 4** indicates that unsafe consumption practices, specifically, consuming meat from animals that had not yet completed their antibiotic withdrawal period, were also widespread. The highest incidences were reported in Masvingo (8.2%), Midlands (7.7%) and Matabeleland North (7.0%). In contrast, lower prevalence rates were observed in Matabeleland South (2.8%) and Manicaland (4.5%). These values suggest a troubling disconnect between awareness and behaviour. In some provinces such as Matabeleland North, relatively higher awareness did not necessarily correlate with safer practices. These findings provide a geographic map of vulnerability. In provinces such as Mashonaland West, low awareness and moderate consumption of contaminated meat coincide, raising alarm for public health authorities. On the other hand, in provinces like Matabeleland South, low consumption despite low awareness may reflect other mitigating factors such as limited access to veterinary drugs or stricter local norms.

Regarding unsafe consumption of fruit and vegetables, Table 4 indicates that at the national level, 7.3% of rural households reported consuming produce before the pesticide withdrawal period had elapsed. While this may appear to be a moderate prevalence, it is cause for concern, especially given that actual exposure may be higher due to underreporting, misclassification, or lack of awareness of what a withdrawal period entails. Provincially, Mashonaland East recorded the highest prevalence of unsafe produce consumption at 10.0%, followed closely by Manicaland at 9.6% and Masvingo at 7.8%. Mashonaland Central (7.3%), Matabeleland South (6.6%) and Mashonaland West (6.0%) fell near or below the national average. The relatively lower prevalence in Mashonaland West may be associated with less intensive horticultural production or potentially better farmer education and regulation through extension services. Conversely, in Matabeleland North, the proportion was the lowest nationally at 4.4%, possibly due to limited pesticide use, lower production volumes of fruits and vegetables, or greater reliance on organic or traditional pest control methods.

The overall findings suggest that unsafe consumption of pesticide-treated produce is a widespread but geographically variable practice, driven by a combination of knowledge deficits, structural barriers to compliance and regulatory gaps. These results underscore the need for farmer training on pre-harvest intervals, strengthened extension and monitoring systems and community-level food safety education targeted at both producers and consumers. Moreover, agro-dealer regulation and pesticide labelling must be improved to enhance comprehension and observance of safe pesticide application guidelines across rural Zimbabwe.

The findings in **Table 4** underscore the need to scale up AMR awareness in rural Zimbabwe, particularly through provincial strategies that account for geographic disparities. AMR awareness is a cornerstone of antimicrobial stewardship, and its low prevalence aligns with observations in similar rural African contexts (Elton *et al.*, 2020; Kariuki *et al.*, 2022). The weak linkage between AMR knowledge and safer meat consumption practices may indicate that knowledge alone is insufficient and structural and behavioural barriers must also be addressed. The consumption of meat from animals still on antibiotics before the withdrawal period presents multiple public health risks. It facilitates direct human exposure to drug residues, which can cause allergic reactions and accelerate resistance development (Muriuki *et al.*, 2001). Moreover, rural communities often lack adequate regulatory enforcement, further compounding these risks.

3.5 Descriptives on use of antibiotics and practices

Table 5 presents behavioural indicators on the use of antibiotics in livestock among rural Zimbabwean households. These indicators directly relate to the potential entry of antimicrobial residues into the food chain and thus to public health risks and the spread of antimicrobial resistance (AMR). The results, disaggregated by response frequencies, show extremely low adherence to safe antibiotic use practices.

The results in **Table 5** review that only 0.9% of households always used antibiotics to treat their livestock, while 2.5% always read the instructions regarding withdrawal periods. A mere 1.9% always continued administering the medication for the recommended duration and only 3.1% always observed the withdrawal period before selling the animals. Furthermore, just 3.8% reported always observing the withdrawal period before consuming meat from treated animals. On the other hand, 90.9% of households “never” read withdrawal instructions, 92.5% stopped giving antibiotics as soon as the animal appeared to recover and 91.6% did not observe withdrawal periods prior to slaughter for sale or household consumption (89.9%).

Table 5. Use of antimicrobials and practices

Variable	Responses (%)				
	Never	Rarely	Sometimes	Often	Always
1. Households use antibiotics to treat their livestock	93.1	3.2	2.3	0.6	0.9
2. Households read the instructions regarding withdrawal periods when using medicine to treat their livestock	90.9	3.0	2.6	1.0	2.5
3. Households continue giving the livestock medication for the full prescribed duration, even when they no longer appear sick	92.5	2.8	1.9	0.9	1.9
4. Households observe the prescribed withdrawal periods before selling the livestock treated with antibiotics	91.6	2.3	1.7	1.3	3.1
5. Households follow the prescribed withdrawal period before consuming meat, milk and eggs from treated livestock	89.9	2.6	2.1	1.6	3.8

These figures illustrate a high level of non-compliance and suggest that antimicrobial misuse is widespread. While the percentage of households using antibiotics is itself low (only 0.9% reported "always" doing so), this likely reflects lack of access rather than an intentional avoidance. The most shocking finding is the failure to comply with withdrawal period recommendations, which may be attributed to either due to lack of awareness, low risk perception, or absence of veterinary guidance. Improper antibiotic use in livestock, including premature cessation and ignoring withdrawal periods, allows for the accumulation of drug residues in meat and milk, increasing human exposure to sub-therapeutic antimicrobial levels. These behaviours, if left unchecked, pose a dual threat, that is, compromising food safety and accelerating AMR through indirect ingestion of residues.

The behavioural profile in **Table 5** mirrors findings from other low- and middle-income countries, where veterinary drug misuse is often rooted in informal systems of livestock management (Orwa *et al.*, 2017). The prevalence of unsafe practices such as discontinuing antibiotics prematurely and neglecting withdrawal periods suggests systemic gaps in awareness, regulation and access to veterinary care. The results in **Table 5** also revealed that while only a small fraction of households routinely used antibiotics, those that did rarely followed safe use guidelines. This poses a serious food safety threat, particularly in informal food markets where meat is often traded without inspection. As per WHO (2022), antimicrobial residues in meat can cause allergic reactions, gut microbiota disruption and long-term resistance selection pressures. Additionally, animals not treated under veterinary supervision are more likely to be improperly dosed, increasing the risk of treatment failure and disease persistence. Addressing these challenges requires a One Health approach that integrates human health, animal health and environmental safety, as promoted in the FAO-OIE-WHO tripartite frameworks. Strengthening veterinary services, training para-veterinarians and community-level enforcement of withdrawal periods are key strategies to mitigate these public health risks.

3.6 Factors associated with knowledge of Antimicrobial Resistance (AMR)

Table 6 presents multivariate regression estimates examining the determinants of household-level knowledge on antimicrobial resistance (AMR) in rural Zimbabwe. The model includes demographic, socio-economic, religious and provincial variables. The outcome variable is binary, indicating whether a household reported any awareness of AMR. The results are reported as marginal effects, which reflect the change in the probability of AMR knowledge associated with each predictor, holding all other variables constant.

Table 6. Regression analysis of knowledge about antimicrobial resistance with background characteristics

Variables	**Knowledge about antimicrobial resistance**	
	coef	**se**
Characteristics of household head		
Household head age	0.000	(0.000)
Female-headed household	-0.011	(0.009)
Education level		
Primary level	0.035	(0.010)***
ZJC level	0.029	(0.012)**
O' level	0.034	(0.011)***
A' level	0.097	(0.030)***
Diploma/Certificate after primary	0.022	(0.041)
Diploma/Certificate after secondary	0.083	(0.034)**
Graduate/postgraduate	0.050	(0.043)
Marital Status		
Married living apart	0.014	(0.011)
Divorced/separated	0.002	(0.013)
Widow/widower	-0.005	(0.012)
Cohabiting	-0.054	(0.038)
Never married	-0.030	(0.018)*
Religion		
Protestant	0.044	(0.016)***
Pentecostal	0.026	(0.014)*
Apostolic Sect	0.009	(0.012)
Zion	0.011	(0.014)
Other Christian	-0.026	(0.015)*
Islam	-0.077	(0.038)**
Traditional	0.020	(0.021)
Other religion	0.059	(0.029)**
No religion	-0.004	(0.013)
Household characteristics		
Household size	-0.003	(0.002)*
Household head disability	0.052	(0.012)***
Household head chronic condition	-0.029	(0.008)***
Asset index	0.015	(0.001)***
Province		
Mashonaland Central	0.056	(0.013)***
Mashonaland East	-0.034	(0.011)***
Mashonaland West	-0.109	(0.011)***
Matabeleland North	0.024	(0.013)*
Matabeleland South	-0.048	(0.013)***
Midlands	-0.036	(0.012)***
Masvingo	0.015	(0.013)
Constant	0.066	(0.023)***
Observations	17,785	
R-squared	0.042	

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The findings presented in **Table 6** indicate that education is the most consistent and significant predictor of AMR awareness. Compared to household heads with no formal education, those with primary education were 3.5 percentage points more likely to report AMR knowledge ($p < 0.01$), those with ZJC had a 2.9-point increase ($p < 0.05$), O' Level raised awareness by 3.4 points ($p < 0.01$), A' Level by 9.7 points ($p < 0.01$) and diploma-level education increased the likelihood by 8.3 points ($p < 0.05$). This finding underscores the pivotal role of formal schooling in health literacy. Among religious groups, Protestant households had a 4.4 percentage point higher probability of AMR awareness compared to non-affiliated households ($p < 0.01$). Furthermore, the presence of a person with a disability in the household increased AMR awareness by 5.2 points ($p < 0.01$), while households with a member suffering from a chronic illness had a reduced probability ($\beta = -0.029$, $p < 0.01$). Household size also showed a small but significant negative association ($\beta = -0.003$, $p < 0.05$), indicating that larger households were marginally less likely to be aware of AMR. Provincial disparities were also evident. Compared to the base province of Mashonaland West, households in Matabeleland North ($\beta = 0.043$, $p < 0.01$) and Mashonaland Central ($\beta = 0.045$, $p < 0.01$) were significantly more likely to report AMR awareness. Additionally, socioeconomic status, proxied by the asset index, was positively associated with AMR awareness ($\beta = 0.015$, $p < 0.01$).

The regression results from **Table 6** provide robust empirical support for targeted interventions to improve AMR awareness in Zimbabwe's rural areas. The significant influence of education observed is consistent with findings from other LMICs, such as Nigeria (Popoola et al., 2024) and Malawi (Mudenda et al., 2022), where formal schooling was a key enabler of AMR knowledge and responsible antimicrobial use (Popoola et al., 2024; Mshana et al., 2013). This underscores the need for integrating AMR content into both formal and non-formal adult education and farmer training curricula. The increased awareness among households with disabled members might reflect more frequent interaction with the healthcare system, while the negative effect of chronic illness could stem from burdened caregiving roles that leave less capacity for preventive learning. The negative association with household size supports theories of cognitive and resource dilution, where larger families may struggle to process and act on health information (Mberu et al., 2016). Geographic targeting is also warranted, as provinces such as Mashonaland West and Midlands lag behind others. Collectively, these findings support a multi-sectoral strategy integrating education, disability inclusion, faith-based engagement and regional equity to enhance AMR knowledge across rural Zimbabwe.

3.7 Determinants for livestock antibiotic use and compliance with withdrawal practices.

Table 7 presents regression estimates evaluating household-level determinants of five key behaviours relating to livestock antibiotic practices: (1) use of antibiotics, (2) reading withdrawal instructions, (3) completing medication duration, (4) observing withdrawal periods before selling animals and (5) observing withdrawal periods before consumption. These practices are essential to prevent antimicrobial residues in food and mitigate the spread of antimicrobial resistance (AMR). **Table 7** revealed that age of the household head was a consistent positive predictor across several behaviours. Older individuals were significantly more likely to use antibiotics appropriately ($\beta = 0.002$, $p < 0.05$), adhere to the full treatment regimen ($\beta = 0.002$, $p < 0.1$) and observe withdrawal periods before selling animals ($\beta = 0.002$, $p < 0.05$). In addition, education exhibited a slight influence on behaviour. While primary, ZJC and O' Level education showed no significant effects across most antibiotic practices, respondents with graduate or postgraduate education were significantly less likely to engage in indiscriminate antibiotic use ($\beta = -0.129$, $p < 0.01$) and more likely to complete the full course of medication ($\beta = -0.120$, $p < 0.05$). Religious affiliation significantly influenced antibiotic use and compliance. Members of the Zionist sect were more likely to read withdrawal instructions ($\beta = 0.162$, $p < 0.05$), complete the medication regimen ($\beta = 0.143$, $p < 0.01$) and observe both withdrawal periods before sale ($\beta = 0.134$, $p < 0.1$) and consumption ($\beta = 0.188$, $p < 0.05$). These findings suggest that religious norms and guidance within certain faith communities may reinforce adherence to safe food and health practices.

Table 7 also showed that wealth, measured using an asset index, was a significant positive predictor across most antibiotic practices. Wealthier households were more likely to read instructions ($\beta = 0.011$, $p < 0.05$), observe withdrawal periods before sale ($\beta = 0.012$, $p < 0.05$) and generally comply with safe use practices. These results underscore the role of economic capacity in enabling better access to veterinary services, storage infrastructure and formal drug markets, as well as health literacy. Moreso, household size, although not statistically significant, exhibited negative associations with several behaviours, including medication adherence ($\beta = -0.003$) and instruction reading ($\beta = 0.007$). Geographic location also influenced compliance as households in Matabeleland South consistently demonstrated lower compliance with safe practices. Respondents from this province were significantly less likely to read withdrawal instructions ($\beta = -0.135$, $p < 0.05$), complete treatment ($\beta = -0.192$, $p < 0.01$) and observe withdrawal periods before consumption ($\beta = -0.273$, $p < 0.01$). In contrast, Matabeleland North showed higher levels of antibiotic use ($\beta = 0.120$, $p < 0.01$) and instruction reading ($\beta = 0.141$, $p < 0.05$), suggesting possible differences in access to veterinary services, local governance, or cultural norms.

Other variables such as sex of the household head, disability status and chronic illness did not show significant associations with antibiotic-related behaviours. This suggests that structural and informational factors, rather than demographic or biological characteristics, play a more central role in shaping antimicrobial use and compliance in rural settings. These findings support the need for targeted, context-specific interventions that combine health education, faith-based outreach and economic support to improve antibiotic stewardship and reduce AMR risks in Zimbabwe's rural livestock systems.

Table 7. Regression analysis for livestock practices/consumption with background characteristics

	Use antibiotics to treat your livestock		Read the instructions regarding withdrawal periods when you use medicine to treat		Continue giving the livestock medication for the full prescribed duration even		Observe the prescribed withdrawal periods before selling the livestock treated w		Follow the prescribed withdrawal period before consuming meat	
VARIABLES	**coef**	**se**	**coef**	**se**	**coef**	**se**	**coef**	**se**		**se**
Household head age	0.002	(0.001)**	0.001	(0.001)	0.002	(0.001)*	0.002	(0.001)**	0.001	(0.001)
Female-headed household	-0.028	(0.031)	-0.024	(0.040)	-0.021	(0.037)	-0.020	(0.044)	0.019	(0.047)
Primary level	0.011	(0.037)	0.011	(0.051)	0.025	(0.045)	0.008	(0.058)	-0.002	(0.062)
ZJC level	0.027	(0.041)	0.006	(0.054)	0.025	(0.048)	-0.000	(0.061)	-0.041	(0.065)
O' level	0.019	(0.039)	-0.015	(0.052)	0.022	(0.048)	-0.034	(0.060)	-0.064	(0.064)
A' level	0.111	(0.087)	0.179	(0.129)	0.164	(0.119)	0.098	(0.129)	0.042	(0.135)
Diploma/Certificate after primary	-0.143	(0.049)***	0.156	(0.225)	0.033	(0.124)	-0.020	(0.182)	0.028	(0.203)
Diploma/Certificate after secondary	-0.075	(0.051)	0.044	(0.166)	0.086	(0.146)	-0.108	(0.133)	-0.183	(0.136)
Graduate/postgraduate	-0.129	(0.047)***	-0.060	(0.137)	-0.120	(0.054)**	-0.127	(0.118)	-0.013	(0.198)
Married living apart	0.013	(0.035)	-0.013	(0.046)	-0.048	(0.039)	-0.019	(0.050)	-0.070	(0.055)
Divorced/separated	0.034	(0.040)	0.008	(0.050)	-0.031	(0.045)	-0.013	(0.054)	-0.059	(0.059)
Widow/widower	-0.005	(0.042)	-0.007	(0.057)	-0.018	(0.052)	-0.029	(0.062)	-0.074	(0.067)
Cohabiting	-0.102	(0.028)***	-0.167	(0.037)***	-0.174	(0.035)***	-0.187	(0.039)***	-0.247	(0.041)***
Never married	0.096	(0.063)	0.145	(0.083)*	0.154	(0.080)*	0.135	(0.084)	0.132	(0.090)
Protestant	0.082	(0.064)	0.205	(0.087)**	0.216	(0.076)***	0.138	(0.090)	0.175	(0.100)*
Pentecostal	-0.065	(0.036)*	-0.030	(0.050)	0.029	(0.038)	-0.034	(0.060)	-0.015	(0.066)
Apostolic Sect	0.005	(0.036)	0.053	(0.046)	0.088	(0.033)***	0.028	(0.057)	0.031	(0.061)
Zion	0.063	(0.050)	0.162	(0.066)**	0.143	(0.051)***	0.134	(0.077)*	0.188	(0.085)**
Other Christian	0.071	(0.053)	0.079	(0.063)	0.136	(0.053)***	0.079	(0.073)	0.082	(0.079)
Islam	0.003	(0.101)	-0.071	(0.097)	0.088	(0.174)	-0.031	(0.180)	-0.067	(0.183)
Traditional	0.053	(0.061)	0.187	(0.108)*	0.240	(0.105)**	0.142	(0.119)	0.162	(0.123)
Other religion	0.187	(0.148)	0.122	(0.153)	0.213	(0.147)	0.096	(0.155)	0.065	(0.156)
No religion	-0.009	(0.039)	-0.002	(0.049)	0.031	(0.035)	-0.036	(0.059)	-0.032	(0.064)

Household size	-0.006	(0.007)	0.007	(0.009)	-0.003	(0.008)	0.004	(0.010)	0.001	(0.011)
Household head disability	0.061	(0.055)	0.098	(0.072)	0.098	(0.067)	0.096	(0.079)	0.069	(0.084)
Household head chronic condition	0.020	(0.031)	-0.012	(0.038)	0.017	(0.035)	0.020	(0.043)	-0.002	(0.046)
Asset index	0.010	(0.004)***	0.011	(0.005)**	0.006	(0.004)	0.012	(0.006)**	0.010	(0.006)
Mashonaland Central	0.009	(0.032)	-0.064	(0.051)	-0.036	(0.048)	-0.075	(0.057)	-0.170	(0.063)***
Mashonaland East	0.021	(0.036)	-0.034	(0.054)	0.008	(0.053)	-0.027	(0.060)	-0.101	(0.067)
Mashonaland West	-0.037	(0.030)	-0.112	(0.052)**	-0.120	(0.047)**	-0.130	(0.056)**	-0.186	(0.065)***
Matabeleland North	0.120	(0.046)***	0.141	(0.071)**	0.057	(0.061)	0.126	(0.077)	0.008	(0.082)
Matabeleland South	-0.102	(0.033)***	-0.135	(0.057)**	-0.192	(0.049)***	-0.180	(0.060)***	-0.273	(0.069)***
Midlands	0.041	(0.037)	-0.079	(0.054)	-0.046	(0.050)	-0.081	(0.061)	-0.155	(0.070)**
Masvingo	0.069	(0.048)	0.006	(0.068)	-0.021	(0.059)	-0.051	(0.069)	-0.134	(0.077)*
Constant	0.996	(0.074)***	1.066	(0.100)***	1.026	(0.088)***	1.106	(0.118)***	1.295	(0.126)***
Observations	3,940		3,940		3,940		3,940		3,940	
R-squared	0.026		0.025		0.026		0.022		0.020	

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.

3.8 Household engagement with food safety labels and purchasing decisions

Table 8 presents data on rural household interactions with food packaging information and the criteria they consider when purchasing food. These behaviours are key proxies for food safety awareness and consumer decision-making in informal markets.

Table 8. Food safety understanding and practices

Food safety practice	**Proportion (%) of surveyed rural households**
1. Households that read information on the food package when purchasing food	
All the time	9.5
Sometimes	57.3
No	33.2
2. Factors considered by households when buying food for the family, excluding price	
Brand/source	38.6
Expiry /Best before date	64.1
Nutritional content	17.1
Storage instructions	10.0
Other	2.7
No other consideration	22.1
3. Methods used by households to ensure food is safe	
Use clean and fresh utensils	80.7
Keep food at correct temperatures	34.2
Keep food closed or covered	62.9
Separate raw and cooked food	37.2
Cook food completely and not leave any part raw	28.4
Other	0.8

Row 1 shows results on the frequency with which households read information printed on food packaging. Only 9.5% of households reported reading packaging information "all the time", 57.3% indicated that they "sometimes" do so and a substantial 33.2% admitted to never reading food packaging information. These figures highlight limited engagement with labelling information in rural settings. Row 2 indicate specific factors considered during food purchases. The most frequently cited consideration was expiry date (64.1%), followed by the source or brand of the food item (38.6%). Nutritional content (17.1%) was less frequently mentioned, while storage instructions were least cited (10.0%). At least 22.1% of households reported that they do not consider any food safety-related factor when buying food, suggesting that affordability and accessibility may override safety considerations. These findings indicate both awareness gaps and structural barriers. While a majority (66.8%) of households engage with label information at least occasionally, only a small minority do so consistently. The heavy reliance on expiry dates reflects an intuitive understanding of spoilage risk, while the low attention to nutritional information and storage guidance suggests limited health literacy.

Findings in Row 3 of **Table 8** revealed use of clean and fresh utensils (80.7%) as the most frequently reported practice, indicating widespread adoption of visible hygiene behaviours. Keeping food covered or closed was also common (62.9%), reflecting practical efforts to protect food from contamination by dust, insects, or animals. In contrast, more technical or knowledge-intensive practices were less frequently reported. Only 34.2% of households indicated that they kept food at correct temperatures, highlighting potential gaps in awareness or access to refrigeration. Similarly, only 28.4% reported thoroughly cooking food to avoid undercooked portions, raising concerns about microbial risks, particularly from meat and poultry. At least 37.2% of households reported separating raw and cooked food, a critical practice for preventing cross-contamination. While basic hygiene practices are widely adopted, key food safety measures that require specific knowledge or infrastructure, such as temperature control, thorough cooking and separation, are less common. This indicates the need for targeted food safety education and support to promote comprehensive risk-reduction behaviours in rural households.

Overall, the results in **Table 8** point to a need for intensified consumer education to promote label literacy and informed food choices. Similar patterns have been observed in other sub-Saharan contexts. For instance, a study by Kwabena-Osei *et al.* (2024) in Ghana found that while many rural consumers valued expiry dates, they were less attentive to nutritional information or storage advice, particularly when food was sourced from informal markets. Interventions must therefore move beyond information provision. Labelling standards should adopt simplified and pictorial formats, especially for populations with low literacy. Community nutrition programming, school curricula and media campaigns can reinforce these messages.

3.9 Conformance to food labelling regulation

Figure 2 illustrates the general status of food labelling compliance across different food categories assessed using qualitative methods during the 2025 RLA. Overall, food products demonstrated acceptable adherence to core labelling components, including the product name, manufacturer address, net weight and expiry date, requirements stipulated under the Food Labelling Regulations SI 265 of 2002 and SI 236 of 2019. However, **Figure 2** also highlights a substantial lack of compliance to key public health-related elements, particularly allergen declarations, nutrition labelling and product origin. Milk products and edible oils exhibited the highest overall compliance with most labelling components. In contrast, maize meal and agrochemical products displayed significant inconsistencies. For example, while nearly all milk products featured product name and expiry dates, only a minority included allergen or origin information. Similarly, a large proportion of maize meal packages observed had no nutrition composition information or allergen warnings.

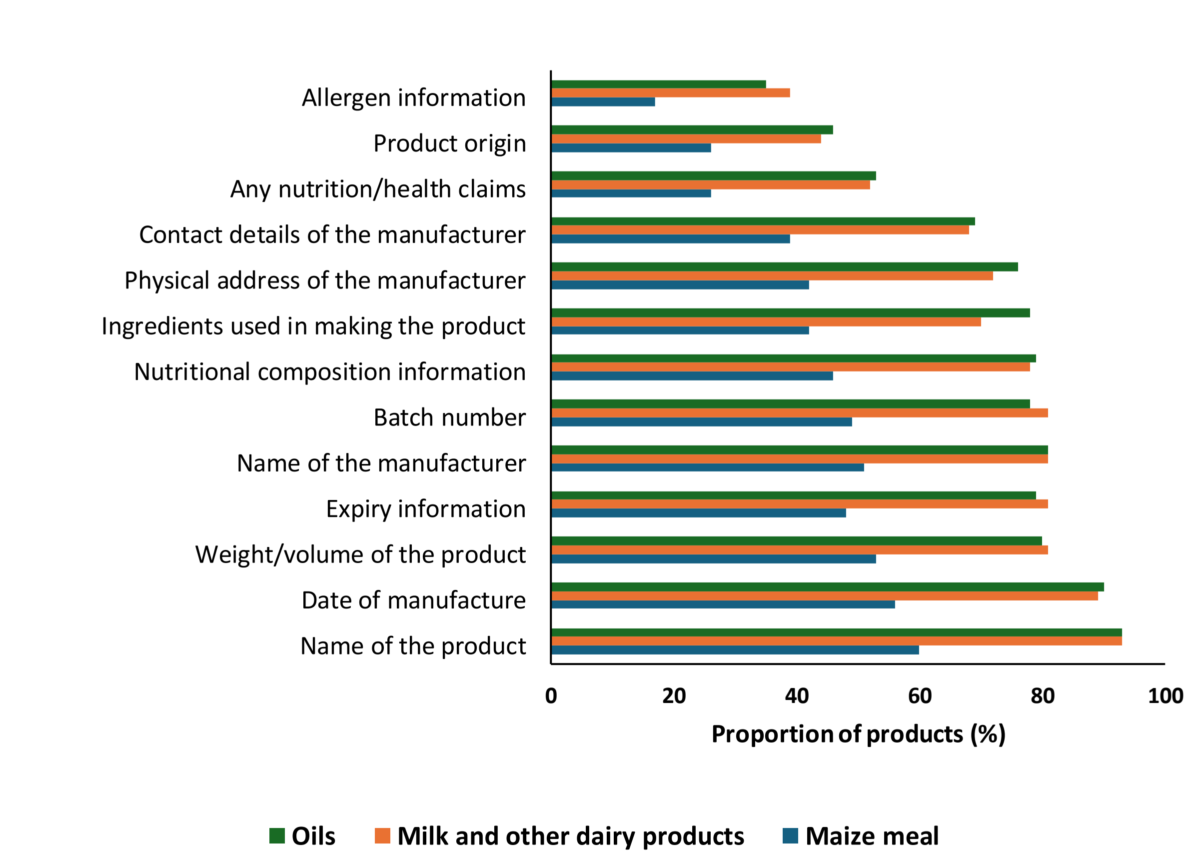

Figure 2. Overall food labelling compliance

These results mab be compounded by consumer behaviour as the results earlier presented in **Table 8** showed that only 9.5% of rural households reported reading food labels before purchasing a product. This critical gap between available information and consumer utilisation of that information undermines the protective role of food labels in ensuring dietary safety and informed food choices. The findings suggest that while formal manufacturers are making efforts to comply with basic packaging laws, the enforcement of more comprehensive food labelling regulations is either weak or under-prioritised.

Informal markets, in particular, appear to be neglected in regulatory oversight, despite serving as the main food access points for rural populations. Policy responses should therefore prioritise monitoring informal points of sale, enforcing package integrity requirements and strengthening public education. Government-led initiatives could also partner with producers to introduce tamper-proof packaging and traceable QR codes that provide origin and safety data. Without these safeguards, efforts to improve dietary quality through fortification and oil regulation may be undermined, especially for the rural poor.

3.10 Agrochemical labelling compliance

Figure 3 presents the results of agrochemical labelling compliance as observed in the 2025 Rural Livelihoods Assessment. Agrochemical labelling in Zimbabwe is governed by the Environmental Management Act (Hazardous Substances, Pesticides and Other Toxic Substances Regulations, 2007) and the Fertilizers, Farm Feeds and Remedies Act (Chapter 18:12). These legislations require comprehensive labelling that includes the product name, active ingredients, pests controlled, directions for use, health warnings, first aid instructions, expiry date, batch number and the manufacturer's contact information. Additional components such as registration numbers and colour-coded toxicity indicators are mandated to aid users in identifying chemical hazards.

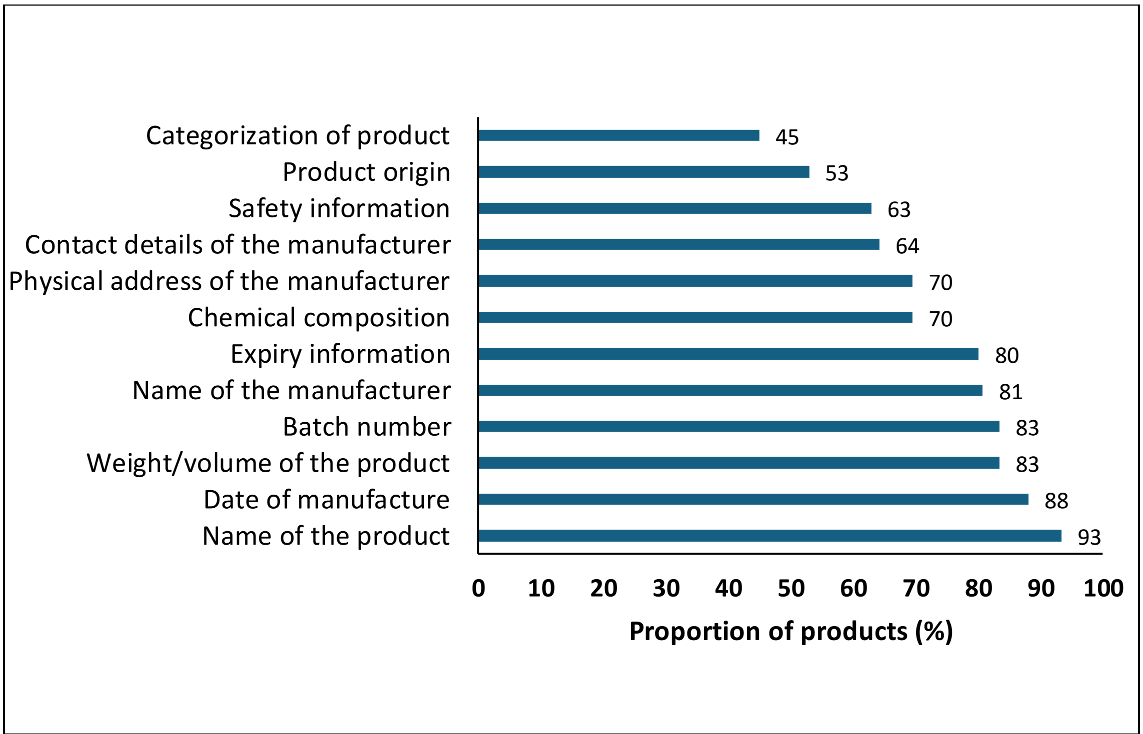

Figure 3. Labelling of agro-chemicals

The results in **Figure 3** indicate that most agro-chemical products sampled, particularly those sold through formal agro-dealers and licensed vendors, displayed strong compliance with core regulatory requirements. Over 80% of the products included key details such as the product name, expiry date, manufacturer identity and instructions for use. This high compliance level suggests that the agrochemical sector, possibly due to the inherent risks associated with pesticides and veterinary drugs, is subject to more rigorous enforcement and industry self-regulation than the food sector.

However, the figure also reveals some critical deficiencies. Notably, 45% of agrochemical products lacked product categorisation using the prescribed colour coding system that indicates toxicity levels. The absence of this information compromises the ability of end-users, particularly rural farmers with limited literacy or chemical training, to make safe usage decisions. Furthermore, a portion of the products did not include antidote instructions or emergency contact numbers, which are essential for reducing morbidity in the event of accidental exposure. The widespread use of agrochemicals in Zimbabwe's agricultural sector, especially in high-input crops like tobacco and maize, heightens the risk of improper use, contamination and long-term environmental damage.

The findings in **Figure 3** suggests that while Zimbabwe's regulatory framework for agrochemicals is relatively well-developed, enforcement and compliance remain uneven, particularly in non-mandatory or semi-voluntary components like colour-coded toxicity indicators. Similar findings have been reported in Tanzania and Ethiopia, where colour coding and first aid information are inconsistently presented on agrochemical packaging, particularly for imported or substandard products (Aghababaeian *et al.*, 2021). The lack of visual hazard identification tools disproportionately affects smallholder farmers, who may not fully understand written warnings or technical terminology. To address these gaps, regulatory authorities must ensure that all agrochemical products, whether imported or locally produced, adhere to a full suite of labelling standards. Outreach and training for agro-dealers and smallholder farmers on how to interpret these labels are also critical. Given the overlap between human, animal and environmental exposure pathways, improving agrochemical labelling is a cornerstone of the One Health approach to sustainable agriculture and public safety.

3.11 Overall discussion

Th findings presented in the previous chapter provide new evidence on the knowledge and practices surrounding AMR in livestock systems among rural households in Zimbabwe. The findings indicate widespread gaps in awareness and in adherence to recommended practices for antibiotic use and withdrawal periods. Moreover, the study identifies key demographic, socioeconomic and geographic determinants that shape household-level behaviours, with significant implications for public health and food safety. Despite growing global concern on AMR, knowledge of AMR among Zimbabwean rural households remains low, with only 18.3% reporting awareness. These findings are consistent with earlier research in sub-Saharan Africa, where awareness of AMR among the general population has been reported as low due to limited access to information, lack of health education and poor integration of AMR messages into primary healthcare and agricultural extension (Mshana *et al.*, 2013; Jorge *et al.*, 2019; Mdegela *et al.*, 2021). In rural settings, particularly, AMR communication is often fragmented and not mainstreamed into routine livestock or human health outreach programmes, further exacerbating the challenge (Fuller *et al.*, 2023). According to Kallu *et al.* (2024) and Sadiq *et al.* (2018), low awareness impairs informed decision-making around the use of antimicrobials, contributing to misuse and overuse, both of which are key drivers of resistance.

In addition, the study reveals low compliance with prescribed withdrawal periods for meat, milk and eggs from livestock treated with antibiotics. Only 3.8% of households indicted they always follow withdrawal period guidelines, either before selling or consuming animal products. This is consistent with studies in Ethiopia (Woyessa *et al.*, 2020), Ghana (Johnson *et al.*, 2019) and Nigeria (Njoga *et al.*, 2021), where non-observance of withdrawal periods was linked to inadequate veterinary supervision, limited awareness and informal drug distribution systems. Moreover, self-treatment without appropriate veterinary guidance is common in many African settings, where veterinary services are scarce or unaffordable (Alhaji & Isola, 2018). In this study, AMR knowledge was significantly associated with both improved access to veterinary services and higher satisfaction with veterinary care, reinforcing the role of extension and animal health systems in improving responsible antimicrobial use.

Education emerged as a strong and consistent predictor of knowledge on AMR. Respondents with primary, secondary and post-secondary education were significantly more likely to report awareness of AMR. This reflects similar findings from Nigeria and India, where literacy and school attendance were linked to improved hygiene, food safety and antimicrobial stewardship (King *et al.*, 2016; Popoola *et al.*, 2024). Higher asset ownership was also positively associated with knowledge and better practices, suggesting that wealthier households may have better access to services and information. Interestingly, religious affiliation influenced both knowledge and practice.

Protestant and Pentecostal households were more likely to be aware of AMR and comply with withdrawal guidelines, while some faith groups, such as Apostolic sects, showed mixed effects. These findings are consistent with qualitative work in Southern Africa that shows religious beliefs influence health-seeking behaviour, especially in rural communities (Lopes Ibanez-Gonzalez & Tollman, 2015). Geographic disparities were also notable as households in Matabeleland North consistently performed better in terms of both knowledge and compliance, while Mashonaland West and Matabeleland South performed poorly. This may reflect differential access to veterinary services, presence of NGOs, or historical investment in animal health systems (Catley *et al.*, 2012).

It is important to view these findings in relation to the One Health perspective, which underscores the interconnectedness of human, animal and environmental health. Anti-microbial resistance is a clear example of a One Health issue because it affects people, animals and the environment all at the same time (Robinson *et al.*, 2016). The low level of awareness and practice of food safety observed in the present study suggests the need to integrate food safety with AMR awareness in training programs. Adopting the One Health framework in educating stakeholders about food safety if therefore important in Zimbabwe and beyond, as this can help strengthen measures to prevent the spread of AMR, particularly in informal food environments where regulations and oversight tend to be weak. This suggestion is consistent with calls from organizations such as the World Health Organization (WHO) and Africa Centres for Disease Control and Prevention (Africa CDC), which have emphasized the importance of multidiscipline collaboration as well as data and community awareness the improvements (Varma *et al.*, 2018; WHO, 2022).

3.12 Implications for policy and practice

The strong link between education and AMR awareness suggests that targeted education campaigns can be impactful. Ministries of Health and Agriculture should mainstream AMR sensitisation and training into decentralised extension services, school curricula and farmer field schools, prioritising districts with low uptake of awareness-raising. Simple, culturally adapted messages, which have been translated into the local languages, can be efficiently transmitted through community-based distribution systems such as Community Health Workers, agricultural extension officers and para-veterinarians. These should also be based on the One Health approach, recognising the interface between human, animal and environmental health and allowing coordinated messaging on AMR, zoonoses and food safety hazards.

In addition, policy tools are required to enforce drug withdrawal intervals to enhance food safety, with respect to the informal and smallholder livestock production contexts with less veterinary knowledge. Low-cost and quick testing kits of antibiotic residue. In addition, farmer cooperatives and producer groups can be induced to assume selfregulating roles through certification schemes, preferential market entry (premium market access), or subsidies for compliance. Finally, the informal food sector, which is the predominant route for the distribution of animal-sourced foods in much of rural and peri-urban settings, will need to be monitored and formalised. Not only would these efforts strengthen public health, but they would also increase consumer confidence, avoid food waste from rejected products and support broader AMR containment and food system resilience objectives.

CHAPTER 4 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

This study provides nationally representative evidence on antimicrobial resistance (AMR) knowledge and food safety practices among rural households in Zimbabwe. Results show that the level of awareness on AMR is alarmingly low and that a wide medium-low spread non-compliance to essential food safety behaviours is present, such observing antibiotic withdrawal periods in food animal production systems. Such practices have potentially serious public health implications, in countries where informal food systems are predominant. Level of education, socio-economic status, religion, disability status and geographic location were identified as key determinants of awareness and adherence, indicating the multilayered nature of behavioural change.

The primary strength of the study is its large, representative sample of 17,974 households among the 60 rural districts, which applied robust statistical procedures for determining significant predictors of AMR-related outcomes. This large sample size increases the generalisability of results and their implications for national policy and interventions. However, the study has several limitations. The research supplies important findings to support Zimbabwe's One Health efforts and to guide interventionists wishing to design targeted, culturally appropriate activities. Integrating AMR messaging into community-level platforms and formalising informal food systems are essential next steps toward sustainable food safety and public health. More so, future studies should explore AMR transmission pathways in informal food markets and evaluate the impact of training interventions.

4.2 Recommendations

Based on the findings presented in this report, the following recommendations are put forward to help strengthen food safety management in rural households in Zimbabwe.

i. Develop and implement a comprehensive National Food Safety Policy

Zimbabwe urgently needs to develop a standalone **National Food Safety Policy** that integrates food safety, public health, nutrition, agriculture and trade. The current fragmentation, where responsibility is split between ministries (e.g., Health, Agriculture, Higher and Tertiary Education, Industry), creates enforcement gaps and regulatory incoherence.

Action Points

- Establish a Food Safety Authority or inter-ministerial Food Safety Committee.
- Incorporate Codex Alimentarius guidelines and One Health principles.
- Develop risk-based surveillance protocols and foodborne disease monitoring systems.

ii. Enhance community-based food safety education

Evidence from the report highlights significant knowledge gaps among rural households regarding microbial contamination, antimicrobial resistance (AMR) and safe food handling. These knowledge deficits, particularly among women and youth who are primary caregivers, increase vulnerability to foodborne risks.

Action Points

- Develop and disseminate context-specific, pictogram-based training materials to improve understanding of invisible risks such as cross-contamination and AMR transmission.
- Integrate food safety modules into existing agricultural extension, school feeding programmes and community health platforms, with targeted outreach to women and youth as key food preparers.
- Promote participatory and culturally sensitive learning approaches that leverage local knowledge systems while introducing scientific best practices.

iii. Strengthen farmer and consumer education on agrochemical and AMR risks

The findings revealed low awareness and poor adherence to safe pesticide withdrawal periods and AMR guidelines. Given the reliance on informal agricultural extension and agro-dealers, especially in communal farming areas, targeted educational interventions are critical.

Action Points

- Scale up community-based pesticide and antibiotic safety campaigns.
- Integrate food safety into Farmer Field Schools and agricultural training institutes.
- Train agro-dealers and veterinary drug suppliers on safe dispensing practices.

iv. Mandate and enforce clear labelling on agrochemical and processed food products

Evidence from the regression analysis and household responses shows poor utilisation of food label information, particularly expiry dates, nutritional content and storage instructions, due to low literacy and poorly labelled products.

Action Points

- Require agrochemical labels to include clear withdrawal periods, toxicity indicators and pictograms.
- Enforce mandatory labelling of processed food products sold in informal markets.
- Promote use of visual aids and local languages in labels to improve accessibility.

v. Promote gender-responsive food safety interventions

Regression results indicate that female-headed households are more likely to adopt safe food handling practices, particularly in cooking. However, women often face structural inequalities that limit their ability to access food safety information or technologies.

Action Points

- Design women-targeted training programmes on food hygiene, AMR and agrochemical safety.
- Involve women's groups, health volunteers and nutrition clubs in local food safety campaigns.
- Provide financial and technical support to women-led microenterprises in food processing and vending.

vi. Build institutional capacity for risk surveillance and enforcement

The report underscores Zimbabwe's lack of a national foodborne illness surveillance system, weak laboratory infrastructure and limited capacity for monitoring AMR and chemical contaminants. This governance vacuum allows unsafe practices to persist unchecked.

Action Points

- Equip provincial laboratories to test for pesticide residues, microbial pathogens and AMR markers.
- Develop an integrated data management system linking health, agriculture and veterinary sectors.
- Train Environmental Health Technicians (EHTs) and veterinary officers in risk-based inspections.

vii. Formalise and regulate informal food markets

The informal food economy dominates rural Zimbabwe but operates outside formal regulation. Unsafe practices such as the sale of expired goods, improper storage and unlabelled pesticides are prevalent.

Action Points

- Require registration and training of informal food vendors and agrochemical retailers.
- Introduce low-cost certification schemes for compliance with basic hygiene and labelling standards.

viii. Embed food safety into broader rural development and nutrition strategies

Food safety should be mainstreamed into Zimbabwe's rural development, resilience and nutrition policies. Unsafe food undermines not only public health but also national goals on food and nutrition security.

Action Points

- Include more food safety indicators in Urban and Rural Likelihood Assessments and other relevant national surveys.
- Align food safety targets with SDG 2 (Zero Hunger), SDG 3 (Good Health) and SDG 6 (Clean Water and Sanitation), NDS2.
- Promote nutrition-sensitive agriculture that reduces dependence on chemical inputs and encourages indigenous pest control practices.

ix. Adopt a One Health Approach to Food Safety and AMR

The interconnected risks of unsafe food, zoonotic pathogens and antimicrobial resistance require a One Health approach, as called for by the WHO, FAO, WOAH and Africa CDC. The low AMR awareness in rural households and misuse of veterinary antibiotics highlighted in the report underscores this need.

Action Points

- Update and operationalise the Zimbabwe National Action Plan on AMR at ward and district levels.
- Establish One Health coordination platforms at provincial level to guide surveillance and response.
- Launch joint campaigns by veterinarians, doctors and extension officers to promote safe antibiotic use.

x. Conduct further research and surveillance

The absence of robust data systems on foodborne illness and antimicrobial resistance significantly hampers targeted policy responses. The literature and findings underscore the importance of regular monitoring to guide adaptive and risk-based programming.

Action Points

- Establish surveillance sites in rural districts to monitor foodborne diseases, AMR prevalence and high-risk practices within households and local markets.
- Conduct periodic household-level assessments to track shifts in food safety knowledge, behaviours and exposure to chemical and microbial hazards.
- Build capacity in local academic and public health institutions to conduct operational research, analyse risks and publish findings that inform national food safety policy reforms.

Improving food safety in rural Zimbabwe demands a coordinated, inclusive and multi-sectoral approach that addresses knowledge, behaviour and systemic governance challenges. The recommendations above provide a roadmap for policymakers, development partners and researchers to reduce foodborne risks, build resilience and enhance public health. If effectively implemented, these actions will significantly contribute to national goals on food security, AMR containment and rural development.

References

Afsana, K., Jolly, S. P., & Akter, F. (2022). Nutrition, food safety and global health. In *Handbook of global health* (pp. 1-28). Springer.

Aghababaeian, H., Ostadtaghizadeh, A., Ardalan, A., Asgary, A., Akbary, M., Yekaninejad, M. S., & Stephens, C. (2021). Global Health Impacts of Dust Storms: A Systematic Review. *Environmental Health Insights*, *15*, 11786302211018390. https://doi.org/10.1177/11786302211018390

Agurs-Collins, T., Alvidrez, J., ElShourbagy Ferreira, S., Evans, M., Gibbs, K., Kowtha, B., Pratt, C., Reedy, J., Shams-White, M., & Brown, A. G. M. (2024). Perspective: Nutrition Health Disparities Framework: A Model to Advance Health Equity. *Advances in Nutrition*, *15*(4), 100194. https://doi.org/https://doi.org/10.1016/j.advnut.2024.100194

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, *50*(2), 179-211.

Akhtar, S., Sarker, M. R., & Hossain, A. (2014). Microbiological food safety: a dilemma of developing societies. *Critical reviews in microbiology*, *40*(4), 348-359.

Alhaji, N. B., & Isola, T. O. (2018). Antimicrobial usage by pastoralists in food animals in North-central Nigeria: The associated socio-cultural drivers for antimicrobials misuse and public health implications. *One Health*, *6*, 41-47.

Alyafei, A., & Easton-Carr, R. (2024). The health belief model of behavior change. *StatPearls*.

Aunger, R., Greenland, K., Ploubidis, G., Schmidt, W., Oxford, J., & Curtis, V. (2016). The determinants of reported personal and household hygiene behaviour: A multi-country study. *PLoS One*, *11*(8), e0159551.

Aworh, O. C. (2021). Food safety issues in fresh produce supply chain with particular reference to sub-Saharan Africa. *Food Control*, *123*, 107737.

Balan, B., Dhaulaniya, A. S., Kumar, M., Kumar, M., & Kumar, P. (2024). Aflatoxins in food: Prevalence, health effects and emerging trends in its mitigation—An updated review. *Food Safety and Health*, *2*(1), 39-71. https://doi.org/https://doi.org/10.1002/fsh3.12030

Brouwer, I. D., McDermott, J., & Ruben, R. (2020). Food systems everywhere: Improving relevance in practice. *Global food security*, *26*, 100398. https://doi.org/https://doi.org/10.1016/j.gfs.2020.100398

Bukachi, S. A., Ngutu, M., Muthiru, A. W., Lépine, A., Kadiyala, S., & Domínguez-Salas, P. (2021). Consumer perceptions of food safety in animal source foods choice and consumption in Nairobi's informal settlements. *BMC Nutrition*, *7*(1), 35.

Capasso, M., Califano, G., Caracciolo, F., & Caso, D. (2023). Only the best for my kids: An extended TPB model to understand mothers' use of food labels. *Appetite*, *191*, 107040. https://doi.org/https://doi.org/10.1016/j.appet.2023.107040

Catley, A., Alders, R. G., & Wood, J. L. N. (2012). Participatory epidemiology: Approaches, methods, experiences. *The Veterinary Journal*, *191*(2), 151-160. https://doi.org/https://doi.org/10.1016/j.tvjl.2011.03.010

Chance, E. A., & Sardi Abdoul, I. (2025). The roles and contributions of women to the health of their families and household economics in rural areas in the district of Mbe, Cameroon. *Social Sciences & Humanities Open*, *11*, 101456. https://doi.org/https://doi.org/10.1016/j.ssaho.2025.101456

Chimuti, S., Mugadza, D., Ntuli, V., & Njage, P. (2024). Contribution of farm-level hygiene and handling practices to microbial safety profiles in the informal dairy sector in Zimbabwe. *Journal of Food Protection*, *87*(8), 100313.

Clapp, J., Moseley, W. G., Burlingame, B., & Termine, P. (2022). Viewpoint: The case for a six-dimensional food security framework. *Food policy*, *106*, 102164. https://doi.org/https://doi.org/10.1016/j.foodpol.2021.102164

Devleesschauwer, B., Haagsma, J. A., Mangen, M.-J. J., Lake, R. J., & Havelaar, A. H. (2018). The global burden of foodborne disease. In *Food safety economics: Incentives for a safer food supply* (pp. 107-122). Springer.

Elton, L., Thomason, M. J., Tembo, J., Velavan, T. P., Pallerla, S. R., Arruda, L. B., Vairo, F., Montaldo, C., Ntoumi, F., Abdel Hamid, M. M., Haider, N., Kock, R., Ippolito, G., Zumla, A., McHugh, T. D., & the, P.-I. D. N. E. T. c. (2020). Antimicrobial resistance preparedness in sub-Saharan African countries. *Antimicrobial Resistance & Infection Control*, *9*(1), 145. https://doi.org/10.1186/s13756-020-00800-y

Fanzo, J., Arabi, M., Burlingame, B., Haddad, L., Kimenju, S., Miller, G., Nie, F., Recine, E., Serra-Majem, L., & Sinha, D. (2017). Nutrition and food systems. *A report by the high level panel of experts on food security and nutrition of the committee on world food security*.

Fanzo, J., & Swartz, H. (2019). Attaining a healthy and sustainable diet. In *Sustainable diets: linking nutrition and food systems* (pp. 99-112). CABI Wallingford UK.

FAO. (2022). *STRENGTHENING THE ANIMAL HEALTH SYSTEMS IN ZIMBABWE* (T C P / Z I M/ 3704). https://openknowledge.fao.org/server/api/core/bitstreams/a31bd00b-53ff-45c8-9cf2-7b87468c6a0c/content

Fischer Walker, C. L., Lamberti, L., Adair, L., Guerrant, R. L., Lescano, A. G., Martorell, R., Pinkerton, R. C., & Black, R. E. (2012). Does childhood diarrhea influence cognition beyond the diarrhea-stunting pathway? *PLoS One*, *7*(10), e47908.

Fuller, W., Kapona, O., Aboderin, A. O., Adeyemo, A. T., Olatunbosun, O. I., Gahimbare, L., & Ahmed, Y. A. (2023). Education and awareness on antimicrobial resistance in the WHO African region: a systematic review. *Antibiotics*, *12*(11), 1613.

Gichohi-Wainaina, W. N., Kumwenda, N., Zulu, R., Munthali, J., & Okori, P. (2021). Aflatoxin contamination: Knowledge disparities among agriculture extension officers, frontline health workers and small holder farming households in Malawi. *Food Control*, *121*, 107672.

Godin, G., & Kok, G. (1996). The theory of planned behavior: a review of its applications to health-related behaviors. *American journal of health promotion*, *11*(2), 87-98.

Grace, D. (2015). Food safety in low and middle income countries. *International journal of environmental research and public health*, *12*(9), 10490-10507.

Grace, D. (2023). Burden of foodborne disease in low-income and middle-income countries and opportunities for scaling food safety interventions. *Food Security*, *15*(6), 1475-1488.

Johnson, S., Bugyei, K., Nortey, P., & Tasiame, W. (2019). Antimicrobial drug usage and poultry production: case study in Ghana. *Animal Production Science*, *59*(1), 177-182.

Jorge, P., Magalhães, A. P., Grainha, T., Alves, D., Sousa, A. M., Lopes, S. P., & Pereira, M. O. (2019). Antimicrobial resistance three ways: healthcare crisis, major concepts and the relevance of biofilms. *FEMS Microbiology Ecology*, *95*(8), fiz115.

Kallu, S. A., Kebede, N., Kassa, T., Wubaye, A. M., Kainga, H., Mekonnen, H., & Simuunza, M. C. (2024). Knowledge, attitudes, practicesand risk perception of antimicrobial use and antimicrobial resistance among dairy farm owners/workers in Addis Ababa, Ethiopia. *Infection and Drug Resistance*, 1839-1861.

Kariuki, S., Kering, K., Wairimu, C., Onsare, R., & Mbae, C. (2022). Antimicrobial Resistance Rates and Surveillance in Sub-Saharan Africa: Where Are We Now? *Infection and Drug Resistance*, *15*(null), 3589-3609. https://doi.org/10.2147/IDR.S342753

King, S., Exley, J., Taylor, J., Kruithof, K., Larkin, J., & Pardal, M. (2016). Antimicrobial stewardship: The effectiveness of educational interventions to change risk-related behaviours in the general population: A systematic review. *Rand health quarterly*, *5*(3), 2.

Kwabena-Osei, P., Ampong Domfe, C., & Kojo Anderson, A. (2024). Consumer Awareness, Knowledge, Understandingand Use of Nutrition Labels in Africa: A Systematic Narrative Review. *SAGE Open*, *14*(2), 21582440241241982. https://doi.org/10.1177/21582440241241982

Laursen, B., & Veenstra, R. (2021). Toward understanding the functions of peer influence: A summary and synthesis of recent empirical research. *J Res Adolesc*, *31*(4), 889-907. https://doi.org/10.1111/jora.12606

Lee, J., Pelto, G. H., & Nordhagen, S. (2022). Beliefs, valuesand sociocultural patterns related to food safety in low-and middle-income countries: a synthesis of the descriptive ethnographic literature. *Appetite*, *178*, 106265.

Lopes Ibanez-Gonzalez, D., & Tollman, S. M. (2015). Clinics and Churches: lifeworlds and health-seeking practices of older women with noncommunicable disease in rural South Africa. *BMC International Health and Human Rights*, *15*(1), 12.

Lubanga, A. F., Bwanali, A. N., Kondowe, S., Nzima, E., Masi, A., Njikho, Y., Chitule, C., Harawa, G., Mudenda, S., Mwale, G., Makole, T., Mpinganjira, S., Nyirenda, T., & Mitambo, C. (2025). Strengthening antimicrobial stewardship in public health facilities in Malawi through a participatory epidemiology approach. *JAC Antimicrob Resist*, *7*(3), dlaf103. https://doi.org/10.1093/jacamr/dlaf103

Machava, N. E., Mulaudzi, F. M., & Salvador, E. M. (2022). Household Factors of Foodborne Diarrhea in Children under Five in Two Districts of Maputo, Mozambique. *Int J Environ Res Public Health*, *19*(23). https://doi.org/10.3390/ijerph192315600

MacPherson, E. E., Mankhomwa, J., Dixon, J., Pongolani, R., Phiri, M., Feasey, N., O'Byrne, T., Tolhurst, R., & MacPherson, P. (2023). Household antibiotic use in Malawi: A cross-sectional survey from urban and peri-urban Blantyre. *PLOS Glob Public Health*, *3*(8), e0001946. https://doi.org/10.1371/journal.pgph.0001946

Manyi-Loh, C., Mamphweli, S., Meyer, E., & Okoh, A. (2018). Antibiotic Use in Agriculture and Its Consequential Resistance in Environmental Sources: Potential Public Health Implications. *Molecules*, *23*(4). https://doi.org/10.3390/molecules23040795

Mberu, B. U., Haregu, T. N., Kyobutungi, C., & Ezeh, A. C. (2016). Health and health-related indicators in slum, ruraland urban communities: a comparative analysis. *Global health action*, *9*(1), 33163.

Mdegela, R. H., Mwakapeje, E. R., Rubegwa, B., Gebeyehu, D. T., Niyigena, S., Msambichaka, V., Nonga, H. E., Antoine-Moussiaux, N., & Fasina, F. O. (2021).

Antimicrobial use, residues, resistance and governance in the food and agriculture sectors, Tanzania. *Antibiotics*, *10*(4), 454.

Miller, L. M., & Cassady, D. L. (2015). The effects of nutrition knowledge on food label use. A review of the literature. *Appetite*, *92*, 207-216. https://doi.org/10.1016/j.appet.2015.05.029

Morse, T. D., Masuku, H., Rippon, S., & Kubwalo, H. (2018). Achieving an integrated approach to food safety and hygiene—Meeting the sustainable development goals in sub-saharan Africa. *Sustainability*, *10*(7), 2394.

Motsi, E. (2021). Food processing, handling and marketing in Zimbabwe. In *Environmental Resilience: Food and the City—Zimbabwe* (pp. 47-67). Springer.

Moyo, F., Dube, Z. L., Nkala, P., Ncube, V., Mathe, T. T., Murai, T., Ndlovu, T., Mamba, F. S., Ncube, M., Ndlovu, S., Ndlovu, N., & Ndlovu, A. Climate-Change Resilience and Women's Participation in Food-Security Initiatives. A Review of Amalima-Loko Programmes in Nkayi, Zimbabwe. *Journal of Asian and African Studies*, *0*(0), 00219096251313536. https://doi.org/10.1177/00219096251313536

Mshana, S. E., Matee, M., & Rweyemamu, M. (2013). Antimicrobial resistance in human and animal pathogens in Zambia, Democratic Republic of Congo, Mozambique and Tanzania: an urgent need of a sustainable surveillance system. *Annals of clinical microbiology and antimicrobials*, *12*(1), 28.

Mudenda, S., Mukosha, M., Godman, B., Fadare, J., Malama, S., Munyeme, M., Hikaambo, C. N., Kalungia, A. C., Hamachila, A., Kainga, H., Bumbangi, F. N., Daka, V., Mfune, R. L., Mainda, G., Mufwambi, W., Mpundu, P., Kasanga, M., Saad, S. A. M., & Muma, J. B. (2022). Knowledge, Attitudes and Practices of Community Pharmacy Professionals on Poultry Antibiotic Dispensing, Use and Bacterial Antimicrobial Resistance in Zambia: Implications on Antibiotic Stewardship and WHO AWaRe Classification of Antibiotics. *Antibiotics (Basel)*, *11*(9). https://doi.org/10.3390/antibiotics11091210

Mugadza, D. T., Feresu, K. W., Jombo, T. Z., Mugombi, J. W., Nyarugwe, S. P., Chimuti, S., Nyanhete, V., Manditsera, F. A., & Macheka, L. (2025). Food safety governance in Zimbabwe: Challenges, regulatory gaps and strategies for global compliance. *Food Control*, *174*, 111254. https://doi.org/https://doi.org/10.1016/j.foodcont.2025.111254

Mugoti, A., & Munengwa, A. (2024). QUANTIFICATION OF VETERINARY CRITICALLY IMPORTANT ANTIBIOTIC (VCIA) USE IN ZIMBABWE: TOWARDS COMBATING ANTIMICROBIAL RESISTANCE IN DEVELOPING COUNTRIES. *Journal of Agricultural Research*.

Muriuki, F., Ogara, W., Njeruh, F., & Mitema, E. (2001). Tetracycline residue levels in cattle meat from Nairobi salughter house in Kenya. *Journal of Veterinary Science*, *2*(2), 97-101.

Musuka, G., Machakwa, J., Mano, O., Iradukunda, P. G., Gashema, P., Moyo, E., Nsengimana, A., Manhokwe, S., Dhliwayo, T., & Dzinamarira, T. (2025). Antimicrobial Resistance and Its Impact on Food Safety Determinants Along the Beef Value Chain in Sub-Saharan Africa-A Scoping Review. *Trop Med Infect Dis*, *10*(3). https://doi.org/10.3390/tropicalmed10030082

Mwanja, M., Jacobs, C., Mbewe, A. R., & Munyinda, N. S. (2017). Assessment of pesticide residue levels among locally produced fruits and vegetables in Monze district, Zambia. *International Journal of Food Contamination*, *4*(1), 11.

Naheed, S., & Rukhsana. (2024). Transitioning to sustainable food systems in a changing climate and gender equality: a brief review. *Agriculture & Food Security*, *13*(1), 41. https://doi.org/10.1186/s40066-024-00492-2

Nakuwa, M. S., Mongi, R., & Ngoma, S. (2023). Food handling practices, the prevalence of aflatoxin dietary exposure and its associated factors among children aged 6–23 months in Bukombe District, Tanzania. *NFS Journal*, *31*, 162-170. https://doi.org/https://doi.org/10.1016/j.nfs.2023.05.004

Ndemera, M., De Boevre, M., & De Saeger, S. (2020). Mycotoxin management in a developing country context: A critical review of strategies aimed at decreasing dietary exposure to mycotoxins in Zimbabwe. *Critical reviews in food science and nutrition*, *60*(4), 529-540.

Ndemera, M., Landschoot, S., De Boevre, M., Nyanga, L., & De Saeger, S. (2018). Effect of agronomic practices and weather conditions on mycotoxins in maize: A case study of subsistence farming households in Zimbabwe. *World Mycotoxin Journal*, *11*(3), 421-436.

Nigussie, Z., Tsunekawa, A., Haregeweyn, N., Adgo, E., Nohmi, M., Tsubo, M., Aklog, D., Meshesha, D. T., & Abele, S. (2017). Factors influencing small-scale farmers' adoption of sustainable land management technologies in north-western Ethiopia. *Land use policy*, *67*, 57-64.

Njoga, E. O., Ogugua, A. J., Nwankwo, I. O., Awoyomi, O. J., Okoli, C. E., Buba, D. M., Oyeleye, F. A., Ajibo, F. E., Azor, N., & Ogunniran, T. M. (2021). Antimicrobial drug usage pattern in poultry farms in Nigeria: Implications for food safety, public health and poultry disease management. *Veterinaria Italiana*, *57*(1), 5-12.

Ocho, F. L., Abdissa, F. M., Yadessa, G. B., & Bekele, A. E. (2016). Smallholder farmers' knowledge, perception and practice in pesticide use in South Western Ethiopia. *Journal of Agriculture and Environment for International Development (JAEID)*, *110*(2), 307-323.

Omuse, E. R., Machekano, H., Sokame, B. M., Mutyambai, D. M., Dubois, T., Subramanian, S., & Chidawanyika, F. (2025). One Health interventions and challenges under rural African smallholder farmer settings: A scoping review. *One Health*, *20*, 100959. https://doi.org/https://doi.org/10.1016/j.onehlt.2024.100959

Orivri, H., & Ogwezzy-Ndisika, A. (2023). Application of health belief model in understanding wash behaviour practices among mothers of U-5 children in Lagos urban slums. *Journal of Humanities and Social Sciences Studies*, *5*(1), 91-104.

Orwa, J. D., Matofari, J. W., Muliro, P. S., & Lamuka, P. (2017). Assessment of sulphonamides and tetracyclines antibiotic residue contaminants in rural and peri urban dairy value chains in Kenya. *International Journal of Food Contamination*, *4*(1), 5.

Owen, N., Fisher, E., Glanz, K., Rimer, B., & Viswanath, K. (2008). Ecological models of health behavior. *Health behavior and health education: theory, research and practice San Francisco: Jossey-Bass*.

Parker, D., Manstead, A. S., & Stradling, S. G. (1995). Extending the theory of planned behaviour: The role of personal norm. *British journal of social psychology*, *34*(2), 127-138.

Phan, U. T. X., Tran, C. T. T., & Nguyen, N. M. T. (2024). Socioeconomic constraints on low-income individuals' perceptions toward food safety. *Journal of Sensory Studies*, *39*(3), e12918.

Pinkerton, R., Oriá, R. B., Lima, A. A., Rogawski, E. T., Oriá, M. O., Patrick, P. D., Moore, S. R., Wiseman, B. L., Niehaus, M. D., & Guerrant, R. L. (2016). Early childhood diarrhea predicts cognitive delays in later childhood independently of malnutrition. *The American journal of tropical medicine and hygiene*, *95*(5), 1004.

Popoola, O. O., Adepitan, D. S., Adeyemi, A. S., Oladeru, O. F., & Yusuff, S. I. (2024). A national survey of the antibiotic use, self-medication practices and knowledge of antibiotic resistance among graduates of tertiary institutions in Nigeria. *Scientific African*, *23*, e01978.

Robinson, T. P., Bu, D. P., Carrique-Mas, J., Fèvre, E. M., Gilbert, M., Grace, D., Hay, S. I., Jiwakanon, J., Kakkar, M., Kariuki, S., Laxminarayan, R., Lubroth, J., Magnusson, U., Thi Ngoc, P., Van Boeckel, T. P., & Woolhouse, M. E. J. (2016). Antibiotic resistance is the quintessential One Health issue. *Transactions of The Royal Society of Tropical Medicine and Hygiene*, *110*(7), 377-380. https://doi.org/10.1093/trstmh/trw048

Roesel, K., & Grace, D. (2014). *Food safety and informal markets: Animal products in sub-Saharan Africa*. Routledge.

Sadiq, M. B., Syed-Hussain, S. S., Ramanoon, S. Z., Saharee, A., Ahmad, N., Zin, N. M., Khalid, S., Naseeha, D., Syahirah, A., & Mansor, R. (2018). Knowledge, attitude and perception regarding antimicrobial resistance and usage among ruminant farmers in Selangor, Malaysia. *Preventive veterinary medicine*, *156*, 76-83.

Saez-Sanz, N., Sanchez-Lara, E., Gonzalez-Perez, R., Caracuel, A., & Peralta-Ramirez, I. (2025). The Psychological Resilience of Older Adults Is Key to Their Independence in Instrumental Activities of Daily Living and Social Participation. *Brain Sci*, *15*(4). https://doi.org/10.3390/brainsci15040383

Swiswa, S., Pinto, C. J., & Chandler, C. I. (2022). Antimicrobial Use/Consumption Surveillance in Zimbabwe: Desk Review Report.

Tohonon, A. C., Ouétchéhou, R., Hounsou, M., Zannou, O., & Dabadé, D. S. (2025). Food hygiene in Sub-Saharan Africa: A focus on catering services. *Food Control*, *168*, 110938. https://doi.org/https://doi.org/10.1016/j.foodcont.2024.110938

Uddin, T. M., Chakraborty, A. J., Khusro, A., Zidan, B. M. R. M., Mitra, S., Emran, T. B., Dhama, K., Ripon, M. K. H., Gajdács, M., Sahibzada, M. U. K., Hossain, M. J., & Koirala, N. (2021). Antibiotic resistance in microbes: History, mechanisms, therapeutic strategies and future prospects. *Journal of Infection and Public Health*, *14*(12), 1750-1766. https://doi.org/https://doi.org/10.1016/j.jiph.2021.10.020

Ugboko, H. U., Nwinyi, O. C., Oranusi, S. U., & Oyewale, J. O. (2020). Childhood diarrhoeal diseases in developing countries. *Heliyon*, *6*(4).

Unnevehr, L. J. (2022). Addressing food safety challenges in rapidly developing food systems. *Agricultural Economics*, *53*(4), 529-539.

Unusan, N. (2007). Consumer food safety knowledge and practices in the home in Turkey. *Food Control*, *18*(1), 45-51. https://doi.org/https://doi.org/10.1016/j.foodcont.2005.08.006

Varma, J. K., Oppong-Otoo, J., Ondoa, P., Perovic, O., Park, B. J., Laxminarayan, R., Peeling, R. W., Schultsz, C., Li, H., & Ihekweazu, C. (2018). Africa Centres for Disease Control and Prevention's framework for antimicrobial resistance control in Africa. *African Journal of Laboratory Medicine*, *7*(2), 1-4.

Wang, M., Huang, L., Pan, C., & Bai, L. (2021). Adopt proper food-handling intention: An application of the health belief model. *Food Control*, *127*, 108169.

Wang, W., Mensah, I. A., Atingabili, S., Omari-Sasu, A. Y., Nouwati, E., Kunkuaboor, C. Y., & Qiao, M. (2025). The nexus between food security, health outcomes and climate change: a multisectoral approach to sustainable development in Africa. *BMC Public Health*, *25*(1), 2319.

WHO. (2022). Antimicrobial resistance surveillance in Europe 2022–2020 data. In *Antimicrobial resistance surveillance in Europe 2022–2020 data*.

WHO. (2024). *Water, sanitation and hygiene and infection prevention and control measures for infectious diarrhoea in health-care settings: operational guide*. World Health Organization.

Woyessa, M., Agga, G. E., Gumi, B., Ayana, D., & Mamo, G. (2020). Antibiotic use in poultry production in selected districts of East Showa Zone, Central Ethiopia: from antibiotic stewardship perspective. *American-Eurasian Journal of Scientific Research*, *15*(3), 101-111.

Wüthrich-Grossenbacher, U., Midzi, N., Mutsaka-Makuvaza, M. J., & Mutsinze, A. (2023). Religious and traditional beliefs and practices as predictors of mental and physical health outcomes and the role of religious affiliation in health outcomes and risk taking. *BMC Public Health*, *23*(1), 2170. https://doi.org/10.1186/s12889-023-17030-7

Zimba, M., & Zimudzi, C. (2016). Pesticide management practices among rural market gardening farmers near Harare, Zimbabwe. *South African Journal of Science*, *112*(9-10), 1-5.

Zinyemba, C., Archer, E., & Rother, H.-A. (2021). Climate Change, Pesticides and Health: Considering the Risks and Opportunities of Adaptation for Zimbabwean Smallholder Cotton Growers. *International journal of environmental research and public health*, *18*(1), 121. https://www.mdpi.com/1660-4601/18/1/121

In the heart of Zimbabwe's rural landscapes, the silent but powerful forces of food safety, public health, and community resilience converge. This book has journeyed through the challenges and triumphs of households striving to safeguard their families against invisible risks and to nourish the next generation. As rural Zimbabwe stands at a crossroads, balancing tradition and innovation, informal markets and regulatory reforms, the voices and experiences captured here illuminate the urgent need for inclusive, evidence-based action. The findings and recommendations presented serve not only as a call to policymakers and practitioners, but as an invitation to every reader: to support safe food, resilient livelihoods, and a healthier future for all. The path forward demands both conviction and collaboration; between government, communities, and individuals; to ensure that no family is left vulnerable, and that the promise of safe, nutritious food becomes a reality across Zimbabwe.

This Technical Report can also be found on the Food and Nutrition Council of Zimbabwe website (scan QR code).

ISBN 978-1-77928-654-3

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