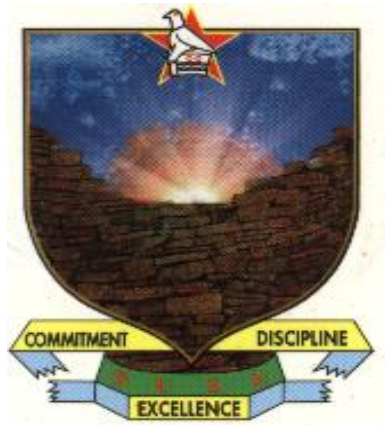


**BINDURA UNIVERSITY OF SCIENCE EDUCATION
FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCE
DEPARTMENT OF ANIMAL SCIENCE**



**COMPARATIVE ANALYSIS OF THE PREVALENCE OF *ESCHERICHIA COLI* FROM
POULTRY MEAT SOLD IN INFORMAL AND FORMAL BUTCHERIES IN EPWORTH.**

A RESEARCH PROJECT

BY

LINDA ZVANGUZVINO MURWISI

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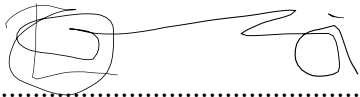
SUPERVISOR: Dr. DEBRA CHABWANDA

**A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS OF THE BACHELOR OF SCIENCE HONORS
DEGREE IN ANIMAL HEALTH AND PRODUCTION EXTENSION.**

JUNE 2026

DECLARATION

I, Linda Zvanguzvino Murwisi, declare that the project which is hereby submitted for the qualification of Bachelor of Science Honours Degree in Animal Health and Production Extension at Bindura University of Science Education is my own independent work and has not been handed in before for a qualification at/in another university/faculty/school. I further declare that all sources cited or quoted are indicated and acknowledged by means of a comprehensive list of references. I further cede copyright of the dissertation to Bindura University of Science Education.

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APPROVAL FORM

The undersigned certify that they have supervised, have read, and recommend to the university for acceptance and examination a research project entitled “*Comparative analysis of the prevalence of Escherichia coli from poultry meat sold in informal and formal butcheries in Epworth*” submitted by Linda Zvanguzvino Murwisi in partial fulfillment of the requirements for the award of the degree of Bachelor of Science Honours Degree in Animal Health and Production Extension.

Supervisor.....

A large, stylized handwritten signature in black ink, appearing to read 'Linda Zvanguzvino Murwisi', is written over the dotted line for the supervisor's signature.

Signature.....

Date.....

Co-Supervisor.....

Signature.....

Date.....

DEDICATION

To my dear friends and family. Love you all so dearly.

ACKNOWLEDGEMENTS

I couldn't have finished this dissertation on my own. To begin with, I would like to thank my supervisors, Dr Debra Chabwanda and Dr Claudious Gufe, whose doors were always open and whose compassion and knowledge enabled me to overcome the most trying circumstances. I appreciate your faith in both the project and me. My family has my sincere thanks. Your efforts, Mom and Dad, gave me this chance. You supported me after every setback and rejoiced over every small victory. This thesis is dedicated to you.

ABSTRACT

Contaminated poultry meat is a common source of dangerous bacteria, and food borne illnesses constitute a significant community health problem in low- and middle-income states. *Escherichia coli* is a trustworthy indicator of fecal pollution and inadequate hygiene throughout processing, retail, and slaughter. In Epworth, poultry meat is marketed through both registered and uncontrolled butcheries. However, comparative information on *E. coli* contamination between these two market channels is absent. The drive of this cross-sectional dissertation was to observe the *E. coli* infection prevalence, enumeration, and hygiene-related parameters in chicken meat served by official butcheries and informal vendors in Epworth. Twenty-one broiler meat samples were acquired from randomly selected informal sellers and 21 from formal butcheries (three visits each). Enrichment in pep tone water was used to recover *E. coli*, which was then cultured at 37°C on MacConkey, blood, and TBX agar. The identification was confirmed by colony morphology, Gram staining, and biochemical assays. Total *E. coli* counts were measured via direct plating (cfu/g). A systematic hygiene observation checklist (maximum score of 22) was utilized to evaluate handling methods. The data were analysed using R software, with chi-square tests for prevalence and Mann-Whitney U tests for numbers. The relationship between the cleanliness score and log-transformed counts was found using linear regression and Spearman's rank correlation. Vendor samples had a considerably greater prevalence of *E. coli* (86%, 18/21) compared to butchery samples (52%, 11/21) ($p=0.024$). Vendor meat had significantly higher median *E. coli* counts (2.5×10^5 cfu/g, IQR: 1.2×10^3 - 3.0×10^6) compared to butchery meat ($<1.0 \times 10^1$ cfu/g, IQR: $<1.0 \times 10^1$ - 2.0×10^3) ($p<0.001$). Several vendor samples surpassed Zimbabwe's acceptable limit ($<1 \times 10^6$ cfu/g). Butcheries had considerably higher hygiene scores (mean $\pm$ SD: 13.16 ± 2.07) compared to merchants (5.84 ± 1.03) ($p<0.001$, Cohen's $d=4.5$). A moderate negative correlation was found between hygiene score and log *E. coli* count (Spearman's $\rho = -0.259$, $p=0.045$). Linear regression revealed that a one-point increase in cleanliness score was linked with a 41% drop in *E. coli* count ($R^2=0.236$, $p<0.001$). Despite improved overall compliance, butcheries engaged in certain "bad practices" (e.g., soiled aprons, using the same apron for several activities) that require attention. Poultry meat supplied by informal vendors in Epworth has a considerably greater level of *E. coli* contamination than licensed butcheries, indicating inadequate fecal cleanliness and an increased public health risk.

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CHAPTER ONE

1.0 Introduction

1.1 Background of the study

The name "chicken" refers to the meat from *Gallus gallus domesticus* fowl (Underwood et al., 2014, Delany, 2004, Eda, 2021). In Zimbabwe, chicken is the most common meat in all markets and is consumed more compared to other meats and is accepted in all religions and cultures (Chisanga et al., 2017, Mseleku et al., 2023). However, meat can be contaminated by microorganisms such as bacteria and fungi. Bacterial contamination of meat is a global issue for food safety regulation (Ballout et al., 2023, Warmate and Onarinde, 2023, Ali and Alsayeqh, 2022). Germs can proliferate in infected meat to the point where they alter its flavour, smell, and appearance. Some of these germs can even cause illness (Ballout et al., 2023, Warmate and Onarinde, 2023, Ali and Alsayeqh, 2022). Microorganisms can spread by improper treatment of the carcass during slaughtering, processing, and sale (exogenic illness) or infect a living being (endemic illness) (Ballout et al., 2023, Warmate and Onarinde, 2023, Ali and Alsayeqh, 2022). Bacteria can contaminate chicken from the skin, intestines, and feet, as well as from unsterilized equipment used during slaughter, processing, and packing (Ballout et al., 2023, Warmate and Onarinde, 2023, Ali and Alsayeqh, 2022, Barbosa, 2025). Because poultry skin is wet, bacteria may proliferate rapidly. Stale chicken smells bad and has a slimy appearance (Ballout et al., 2023, Warmate and Onarinde, 2023, Ali and Alsayeqh, 2022, Barbosa, 2025). Immediately keeping the corpse at low temperatures (0–5 °C) reduces the rate of microbe multiplication on the skin surface, although psychrotrophic bacteria will endure and cause spoiling. Other elements that influence the pace of chicken spoiling include pH and the kind of packaging (Ballout et al., 2023, Warmate and Onarinde, 2023, Ali and Alsayeqh, 2022, Barbosa, 2025).

Clostridium perfringens, *Campylobacter jejuni*, *Salmonella* spp., and *Staphylococcus aureus* are food poisoning bacteria that are frequently linked to poultry deterioration (Ballout et al., 2023, Warmate and Onarinde, 2023, Ali and Alsayeqh, 2022, Barbosa, 2025, Bintsis, 2017, Veronese and Dodi, 2024, Ahmed et al., 2025a). Animals, particularly mammals, typically have *Escherichia coli* (*E. coli*), *Campylobacter jejuni*, and *Salmonella* spp. in their bowels (Bintsis, 2017, Veronese and Dodi, 2024, Ahmed et al., 2025a). When the gut contents come into contact

with further animal portions or the environment through excrement, they might then spread to other sections of the animal after slaughter.

The versatile bacterium *E. coli* often resides in the bowels of people as well as animals. Most pathogenic types are benign and vital to gut health, but others can cause dangerous food-borne diseases. *E. coli* is habitually widespread in the environment and is spread by unsanitary handling during sale, packing, and slaughter (Veronese and Dodi, 2024). The presence of *E. coli* in meat indicates that the meat was contaminated with faeces, and it is used as a marker bacterium for fecal contamination (Ballout et al., 2023, Warmate and Onarinde, 2023, Ali and Alsayeqh, 2022, Barbosa, 2025, Bintsis, 2017, Veronese and Dodi, 2024). Community well-being and food security are seriously threatened by the rising incidence of antibiotic-resistant *E. coli* in meat (Gweshe et al., 2020, Adzitey et al., 2020, Conceição et al., 2023, Farrukh et al., 2025, Musuka et al., 2025, Pulingam et al., 2022, Ronald et al., 2023, Ahmed et al., 2025b, Onohuean et al., 2025). Commensal such as *E. coli* can pass their resistome to pathogenic bacteria they are in the environment.

In many developing regions, including Epworth, a suburb of Harare, Zimbabwe, poultry meat is sold through both formal and informal channels. Formal butcherries are typically registered businesses that adhere to health regulations and hygiene standards, while informal butcherries often operate without strict oversight (Siluma et al., 2023a, Akuriba et al., 2025, Mphaga et al., 2024). This disparity raises critical questions about the potential risks and food safety concerns associated with meat consumption. Informal markets, while providing accessible and affordable food options, may compromise hygiene practices, leading to higher rates of contamination. Informal and formal meat markets represent two distinct environments where contamination and resistance may vary significantly. Evidence from previous studies highlights the frightening incidence of *E. coli* found in meat in informal markets. These results show not only the potential for Zoonotic transmission but also posture a serious risk to public well-being, as consumers can be infected with improperly handled contaminated poultry products (Danish et al., 2024).

E. coli incidence in chicken meat can be affected by a variety of variables, including handling procedures, storage conditions, and general hygiene in the selling environment (Risalvato et al.,

2025). Understanding the variations in *E. coli* prevalence between informal and formal butcheries is critical for assessing public health hazards and designing effective remedies. Given the interconnections of food production and public well-being, it is critical to develop a robust surveillance and regulatory framework aimed at monitoring contamination in poultry across these market segments (Risalvato et al., 2025, Kabeta et al., 2024). The need for stringent enforcement of hygienic practices during slaughtering and processing becomes imperative to mitigate the fecal contamination in poultry meat. This can be implemented effectively with the results of research such as ours. Finally, this study aims to educate local health officials, politicians, and poultry industry stakeholders on the important prerequisite for upgraded food safety procedures, particularly in informal settings where the risk of food-borne diseases is higher. By addressing these concerns, we can create safer food systems that benefit Epworth and the surrounding communities.

1.2 Problem Statement

Escherichia coli is a marker of fecal contamination of the meat during slaughter, packing, and sale, and its incidence and spread pose serious community health risks internationally, exclusively in low- and middle-income states (Gweshe et al., 2020, Adzitey et al., 2020, Conceição et al., 2023, Farrukh et al., 2025, Musuka et al., 2025, Pulingam et al., 2022, Ronald et al., 2023, Ahmed et al., 2025b, Onohuean et al., 2025). Although the supply of chicken meat in Zimbabwe is mostly dependent on the official and informal meat markets, little is acknowledged about the incidence of *E. coli* in these environments. Both institutional butcheries, which usually follow health laws, and informal butcheries, which sometimes lack strict cleanliness and regulatory control, sell poultry meat in Epworth, a peri-urban district of Harare. Concerns regarding possible variations in *E. coli* prevalence between these two market types are raised by this split. The absence of thorough information about the frequency of *E. coli* in poultry meat from innumerable foundations might compromise food safety regulations and result in insufficient public health responses. Therefore, a comparative analysis is essential to explore the frequency of *E. coli* in chicken meat traded by vendors versus formal butcheries in Epworth, aiming to identify potential risks associated with food-borne infections and inform policymakers and stakeholders in public health and food safety.

1.3 Justification of the study

Although meat is a significant source of nourishment for humans, it can also spread food-borne diseases. The purpose of this study is to provide information about the safety of meat, particularly chicken, and the degree of danger that meat poses to human health in various markets. Research on various types of raw meat has been conducted all over the world, and the majority of these studies have found that meat contains harmful bacteria. To determine the level of food safety in Zimbabwe, it is crucial to conduct such a study locally. When raw meat items are sold in stores, they may appear appetizing to the unaided eye, yet they may still be contaminated with harmful germs. When the product is offered by a reputable retailer, the infection worsens, and the buyer is typically unaware of it. In the past, pathogenic bacteria found in food, particularly meat, have been linked to some food-related illnesses (Gweshe et al., 2020, Adzitey et al., 2020, Conceição et al., 2023, Farrukh et al., 2025, Musuka et al., 2025, Pulingam et al., 2022, Ronald et al., 2023, Ahmed et al., 2025b, Onohuean et al., 2025). When these harmful bacteria are present in meat, there is an inherent risk to human health and the potential for food-borne poisoning. There are several legitimate official meat markets in Zimbabwe, and as a means of subsistence, numerous illicit informal markets have also recently surfaced. The impoverished guy in Zimbabwe will choose to purchase chicken from these unofficial meat markets since they often provide lower costs. Owners of these unofficial marketplaces, however, are more likely to put people's health at risk since they are typically ill-prepared to do all the tests and processes required for meat inspection and lack credibility when it comes to supplying society with healthful goods. Due to Zimbabwe's economic difficulties, certain legitimate official meat markets may occasionally encounter difficulties and be unable to adhere to the stringent value control protocols and assessments that are required throughout meat examinations. This results in the sale of contaminated meat, endangering customers' health. There may be instances where an establishment's laboratories is compromised since they are non monitoring board when a significant amount of meat spoils to prevent losses, which results in the delivery of contaminated meat.

The availability of healthy meat is crucial for both public health and market access to regional, national, and worldwide trade possibilities. The comparative analysis of *E. coli* in meat retailed in formal butcherries and vendors in Epworth is crucial for several reasons:

- i. Understanding the commonness of *E. coli* in commonly consumed chicken meat is essential for assessing the probable risks to public well-being in the community.
- ii. The distinction between informal and formal butcheries highlights varying levels of regulation, hygiene, and food safety practices. Informal markets often lack stringent oversight, which may contribute to higher rates of contamination of meat by *E. coli*. This study aims to elucidate these differences and their implications.
- iii. Data are scarce on the frequency of *E. coli* in chicken meat in Zimbabwe, particularly in peri-urban areas like Epworth. This study will fill a critical knowledge gap, providing baseline data that can inform future research and public health policies.
- iv. The findings will provide dear perceptions for legislators, food safety officials, and health authorities, enabling them to develop targeted interventions to alleviate the existence of food-borne pathogens in the nutrition supply chain.
- v. This research can serve as a foundation for public awareness campaigns around the hazards of food-borne disease causing organisms and the significance of safe food handling practices, ultimately promoting better health outcomes in the community.

In summary, this study is justified as it addresses a pressing public health issue, provides essential data for informed decision-making, and has the potential to advance food protection and community health in Epworth and beyond.

1.4 Purpose of the study

1.4.1 Main objective

- ❖ To compare the frequency of *E. coli* in poultry meat traded in informal and formal butcheries in Epworth.

1.4.2 Specific Objectives

- ❖ To determine the frequency of *E. coli* in poultry meat obtained from both informal and formal butcheries.
- ❖ To assess sanitariness and meat handling practices in both informal and formal butcheries.
- ❖ To enumerate the *E. coli* found in poultry meat obtained from informal and formal markets in Epworth.

- ❖ To assess the correlation between the prevalence of *E. coli* and hygiene and meat handling practices.

1.5 Research questions and Hypothesis

1.5.1 Research questions

1. How common is *E. coli* in meat traded in Epworth, Zimbabwe's official and unofficial markets?
2. Does the rate of *E. coli* in chicken pieces retailed in formal and informal markets in Epworth, Zimbabwe, differ significantly?
3. Do the observed hygienic and meat handling techniques in official and informal butcherries differ significantly?
4. Does the frequency of *E. coli* correlate with cleanliness and meat handling practices?

1.5.2 Hypothesis

1. H0: The frequency of *E. coli* in meat samples from both formal and informal butcherries does not significantly differ.

H1: The rate of *E. coli* in specimens of poultry meat from vendors and butcherries differs significantly.

2. H0: The observed cleanliness and meat handling procedures in both official and informal butcherries do not significantly differ from one another.

H1: The observed cleanliness and meat handling procedures in both official and informal butcherries varied significantly.

3. H0: The overall *E. coli* counts in broiler meat from Epworth's vendors and butcherries do not differ significantly.

H1: The overall *E. coli* counts in broiler meat from Epworth vendors and butcherries varied significantly.

4. H0: The frequency of *E. coli* is unrelated to cleanliness and meat handling procedures.

H1: The incidence of *E. coli* is correlated with cleanliness and meat handling procedures, either positively or negatively.

CHAPTER TWO

2.0 Literature Review

2.1 Food safety

Meat makes up the majority of many people's meals, and food is a fundamental source of sustenance for everyone's health. However, pathogenic bacteria present in different types of meat have previously been linked to a number of food-borne illnesses (Warmate and Onarinde, 2023). One of the World Health Organization's (WHO) 13 tactical ideas for 2023–2030 is nutrition security, which is a critical concern worldwide (Akuriba et al., 2025). Food safety is a detailed strategy that outlines how food should be handled, prepared, and stored to avoid possible health risks. The international standard for managing food safety is ISO 22000 (Mphaga et al., 2024). The Food Safety and Food Standard Act in Zimbabwe assigns Public Health Inspectors to local authorities, such as City and Town Councils and the Veterinary Services Departments, to periodically check food of animal origin, such as meat from various meat markets, to make sure it is safe to eat and to promote a healthy country. In Zimbabwe, every type of meat intended for human consumption must have a total bacterial count of less than 1×10^6 cfu/g (Mugadza et al., 2025).

2.2 Meat Physiology

One of the elements influencing meat's vulnerability to infections is flesh physiology (Ali and Alsayeqh, 2022, Martín-Miguelélez et al., 2025, Kang et al., 2026). Water, protein, fat, and water-soluble minerals make up meat in general. The most important component is water, albeit it changes as meat is prepared. The primary component of muscle tissue is protein, while the source animal's primary energy source is fat. Potassium, phosphorus, magnesium, calcium, zinc, and salt in trace amounts are the most important minerals found in meat. Fat dissolves vitamins (Ali and Alsayeqh, 2022, Martín-Miguelélez et al., 2025, Kang et al., 2026). Because of its nutritional importance, meat is a significant portion of the anthropological diet. Although intact meat pieces are often devoid of harmful bacteria on the inside, improper handling, unsterilized equipment, and unsanitary surroundings can contaminate the outside.

One of the most common forms of meat is chicken, which is the flesh from the *Gallus gallus domesticus* bird (Eda, 2021). Bacterial contamination of chicken meat mostly occurs during

slaughter. This is because the majority of commensal microbes that contaminate chickens originate in their bowels, and unsanitary slaughter will contaminate the remainder of the corpse (Kang et al., 2026). Due to improper management of the corpse, the usage of unsterilized equipment, or the usage of tainted water while packing and processing, contamination may also occur via the bird's skin. Among other nutrients, bird meat has a high water content (75%) (Eda, 2021). Because meat contains water and other vital nutrients, it creates an ecological niche where diseases may flourish (Gweshe et al., 2020). Meat should be refrigerated below 4.4 °C and well-cooked since the majority of dangerous bacteria begin to grow on the skin's surface between 4.4 °C and 60 °C. But psychrotrophic bacteria will endure and lead to spoiling (Barbosa, 2025). Figure 2.1 shows an example of fresh chicken slices.



Figure 2.1 Fresh chicken meat cuts (Gamil et al., 2019)

2.3 Common pathogenic bacteria in chicken

Numerous gastrointestinal ailments are caused by food poisoning, and in difficult situations, these illnesses can be deadly. Eating bacterial contaminated food is a common cause of food poisoning. The majority of pathogenic bacteria create toxins as part of their metabolic activities, which is what causes the diseases they cause. When the bacterial load reaches high levels, it is considered that most bacteria in food are pathogenic, since this would result in the creation of a high level of toxins. Though not entirely, microorganisms are harmful; some do cause food to degrade when they proliferate to excessive quantities (Gweshe et al., 2020, Adzitey et al., 2020,

Conceição et al., 2023, Farrukh et al., 2025, Musuka et al., 2025, Pulingam et al., 2022, Ronald et al., 2023, Ahmed et al., 2025b, Onohuean et al., 2025). *Pseudomonas* spp., *Salmonella typhi*, *Clostridium perfringens*, *Campylobacter jejuni*, and *Staphylococcus aureus* are infective microbes that are frequently linked to chicken food intoxication (Gweshe et al., 2020, Adzitey et al., 2020, Conceição et al., 2023, Farrukh et al., 2025, Musuka et al., 2025, Pulingam et al., 2022, Ronald et al., 2023, Ahmed et al., 2025b, Onohuean et al., 2025). Additionally, *E. coli*, *S. typhi*, *S. dysenteriae*, *Listeria monocytogenes*, *Campylobacter jejuni*, and *S. aureus* are pathogenic microbes that are frequently linked to severe food poisoning (Gweshe et al., 2020, Adzitey et al., 2020, Conceição et al., 2023, Farrukh et al., 2025, Musuka et al., 2025, Pulingam et al., 2022, Ronald et al., 2023, Ahmed et al., 2025b, Onohuean et al., 2025).

2.4 *E. coli*: A Risk to Public Health

E. coli is a varied collection of bacteria, most of which are harmless and originate in the bowels of persons and animals (Farrukh et al., 2025). However, some can be pathogenic, causing serious illness, making *E. coli* a major public health problem. Understanding the consequences of *E. coli* contagions is useful for developing effective preventive and treatment measures (Gweshe et al., 2020). *E. coli* may be categorized into many pathogenic groupings, each linked with a distinct type of disease:

- I. Traveler's diarrhoea is frequently triggered by Enterotoxigenic *E. coli* (ETEC) spread by unclean food and water.
- II. Enterohemorrhagic *E. coli* (EHEC) causes severe gastrointestinal disease and haemolytic uremic syndrome (HUS). It is frequently associated with under cooked meat and infected vegetables.
- III. Enteroinvasive *E. coli* (EIEC) causes diarrhoea similar to *Shigella* and mostly affects children in underdeveloped nations.
- IV. Enteropathogenic *E. coli* (EPEC): leads to chronic diarrhoea in babies and spreads mostly through contaminated food and drink.

E. coli infections can occur through:

- a) Infected food includes undercooked meats, unpasteurized milk, and infected fruits and vegetables.

- b) Drinking or swimming in polluted water sources.
- c) Person-to-person contact: Particularly in environments with inadequate hygiene, such as childcare facilities.

Some prevention strategies can be implemented to decrease the risks of *E. coli* in poultry meat, and some of them are as follows:

- I. Food Safety Practices: Ensuring safe cooking, handling, and storage of food, as well as encouraging excellent cleanliness in food preparation areas (Ahmed et al., 2025b).
- II. Water safety entails providing access to safe, clean drinking water and sufficient sanitary amenities (Mphaga et al., 2024).
- III. Public Awareness: Educating populations about the hazards connected with *E. coli*, as well as the significance of hygiene and proper food handling (Onohuean et al., 2025).

2.5 Food-related illnesses' economic effects

Food-borne disease outbreaks have unsettling health consequences and can even result in death. Because of this financial cost, the WHO introduced a program called "Estimating the global burden of food-borne diseases" in 2006 (Musuka et al., 2025). This was done to give statistics to decision-makers in various nations throughout the world so they could establish the proper priorities for food safety (Kabeta et al., 2024). Estimates of food-borne illnesses are crucial for businesses, regulatory bodies, and associated organizations to determine the overall burden of the illnesses and take future action, such as establishing public health objectives, managing risks, and giving enough funding to avoid infection (Kabeta et al., 2024). Economies are being strained by the high rates of illness and fatalities brought on by food-borne illnesses (Bintsis, 2017). In 2000, the USDA Economic Research Service calculated that food borne illness caused by *Campylobacter*, *Salmonella*, *Listeria*, and *E. coli* cost the US economy \$6.5 billion yearly in therapeutic expenses and lost production (Akhtar et al., 2012). Therefore, it is crucial to guarantee food safety to safeguard the health of customers, create healthy workers for a variety of businesses, and boost food exports, which will raise income in a number of nations (Akhtar et al., 2012).

CHAPTER THREE

3.0 Methodology

3.1 Study site

The Epworth markets were the focus of the investigation. The region has little sanitation and is often hyperactive. A map of the research site with the sample locations is shown below; the sampling locations are indicated by the key (Figure 3.1).

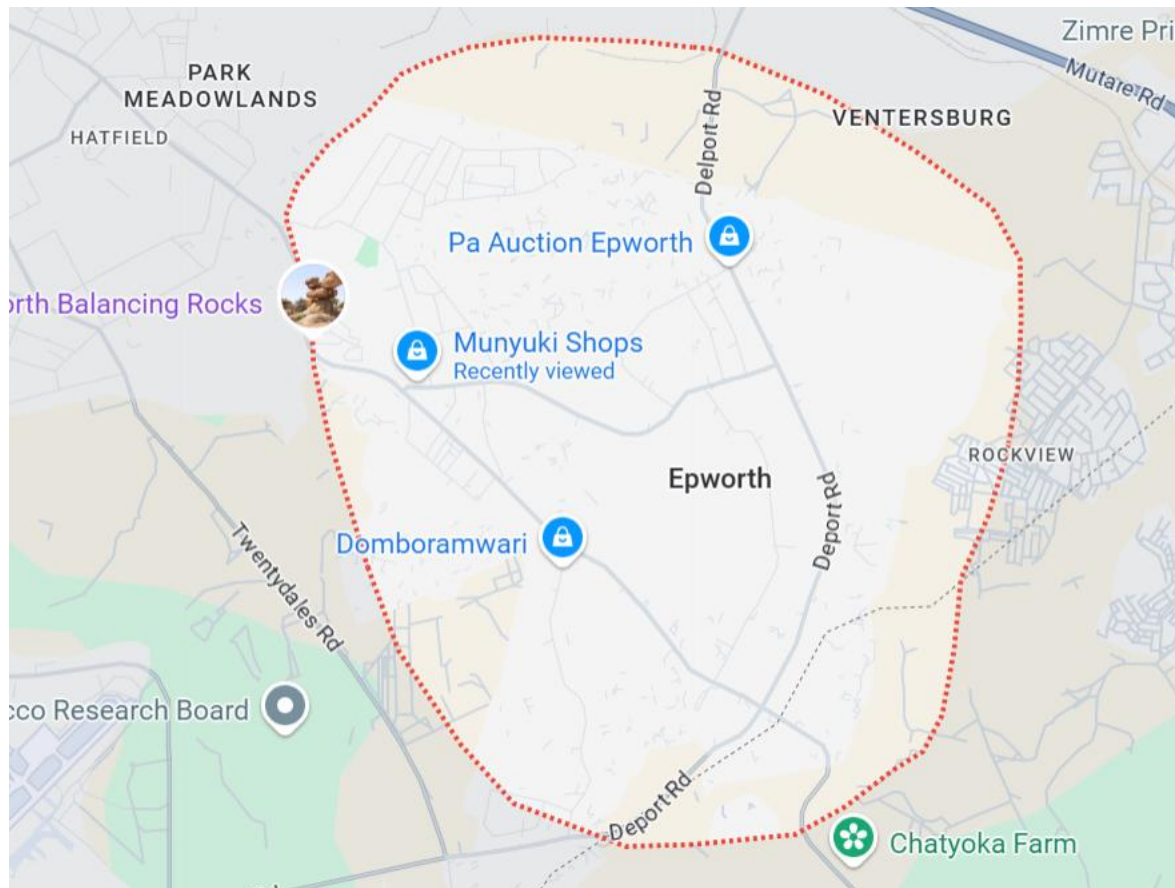


Figure 3.1 A map of Epworth

3.2 Sample collection

Using a number generator, seven butcheries and seven meat merchants in and around Epworth were chosen at random. 100g of chicken parts were bought from each chosen butchery and put into sterile plastic bags with labels. A dollar's worth of chicken was bought from each chosen meat seller and put into sterile plastic bags with labels. Three times, the sample was done. This produced forty-two samples in all. After being delivered to Harare Central Veterinary Laboratory for laboratory investigation, the samples were kept in a freezer at -20°C till tests were carried out.

3.3 Laboratory Analysis

All laboratory methods were performed based on the methods adopted from Markey *et al.* (Markey et al., 2013) and Quinn et al. (Quinn et al., 2011).

3.3.1 Sample Enrichment

The sample number was written on universal bottles containing ten milliliters of pep tone water. A sterile blade was used to cut one gram of each sample, which was then added to the peptone water. To enhance the likelihood of detecting the bacteria, the samples were homogenized using a sterilized homogenize at 15000 rpm until the suspension was homogenized. The samples were then incubated at 37°C for 24 hours.

3.3.2 *E. coli* Isolation and identification

The enriched samples were taken out of the incubator and cultured for 24 hours at 37°C and 44°C using the streak-plate technique on Blood Agar (BA) and MacConkey Agar (Mac). Thermotolerant *E. coli* was isolated at 44°C. BA distinguishes between haemopoietic and non-haemopoietic bacteria and promotes the development of a wide variety of bacteria. Mac distinguishes between lactose and non-lactose fermenters and favour gram-negative bacteria. The colonies' macroscopic appearance was recorded and contrasted with laboratory-available control pure cultures.

3.3.3 Gram Stain Test

Growing blood agar plates were chosen, and each plate's colonies were chosen for Gram staining. The sample number and colony type were written on glass slides. Each slide was infected with

sterile saline using a flamed wire loop, and colonies of interest were selected to create a suspension on the slide. The slides were put on a rack after being air-dried and heat-fixed by going through a flame. After 60 seconds of flooding with Crystal Violet dye, they were rinsed with water. After 60 seconds of flooding with Iodine solution to attach the dye to the bacterial cell walls, they were again rinsed with water. Each slide was treated with acetone for 15 seconds to decolourise the bacteria with thin cell walls before being cleaned with water. Following a 60-second deluge with the counter stain Carbon Fuchs in, the slides were cleaned with water and allowed to air dry. Each slide received a drop of immersion oil, which was then examined under a light microscope's high-power (X100) lens. The outcomes were noted.

3.3.4 Biochemical Tests

To confirm suspected bacteria, biochemical tests were conducted based on the Gram stain test findings and other macroscopic morphological features of isolated colonies. Specific biochemical assays were employed to confirm each putative bacterium. In all, the experiments listed below were carried out:

3.3.4.1 Citrate Test

The purpose of this test was to determine whether the bacteria could use citrate as their only carbon source. The sample number and colony type were labelled on Biotec vials containing Simmons' Citrate. A flaming straight wire was used to select individual colonies of interest, which were then pierced into the media's base. After that, they were streaked onto the medium slant and incubated for a whole day at 37°C. The results were noted after being seen and compared to the lab's positive and negative controls. A negative test stays green, but a positive test becomes blue.

3.3.4.2 Motility Test

The purpose of this test was to determine whether or not the bacteria are motile. The sample number and colony type were marked on Biotec vials containing Motility agar. A flame-straightened wire was used to select individual colonies of interest, which were then pierced into the media's center. For a whole day, they were incubated at 37°C. The results were noted after

being examined and compared to the laboratory's positive and negative controls. A negative test only shows pink on the stabbing line, whereas a positive test shows pink throughout the bottle.

3.3.4.3 Indole Test

The purpose of this test was to determine whether the bacteria could convert tryptophan in the medium to indole. The sample number and colony type were written on Bijoux bottles with Pep tone water. A flame-straightened wire was used to select the colonies of interest, and a suspension was created in the pep tone water. After a 24-hour incubation period at 37°C, two drops of Kovac's reagent were applied to each container. The results were noted after being examined and compared to the laboratory's positive and negative controls. On the media's surface, a positive test results in a red ring, whereas a negative test results in a brown ring.

3.4 *E. coli* enumeration

1 g of the meat was cut and placed into a 9 ml saline water and then homogenized to form a 10^{-1} dilution. From this dilution, serial dilutions were made up to 10^{-6} . 100 μ L from each dilution was then plated on MacConkey agar using the spread technique and were incubated at 37°C for 24 hours. The colonies were counted and colony forming units per gram were calculated.

3.5 Quality Control

For quality control from culturing to identification, *E. coli* ATCC 25922 and an un inoculated medium were used as positive and negative controls, respectively.

3.6 Data analysis

All the data was recorded in Excel. A test for normality Shapiro-Wilk test, was used to justify the use of parametric vs. non parametric tests. The prevalence rate of *E coli* was calculated using the positive number divided by the total number of samples tested and then multiplied by 100, and analysed using R software, testing to see if there is a significant difference in terms of *E.coli* prevalence among the two markets in Epworth. For the counts, Mann Witney U test was done because the data was not normal according to the Shapiro test. A linear regression test was performed to see if there is a correlation between hygiene and meat handling and the prevalence of *E. coli*.

CHAPTER FOUR

4.0 Results

4.1 *E. coli* isolation from chicken cuts

The *E. coli* bacteria was isolated from chicken slices and identified using colony morphology, Gram staining, and biochemical testing, as seen in Figure 4.1. Gram-negative (-ve) rods, Indole positive, Motility positive (+ve), and Citrate (-ve). *E. coli* exhibited distinct colony morphologies on the three agars utilized. On MacConkey agar, the colonies were brilliant pink, indicating that the bacteria could ferment lactose (lactose fermenters). Additionally, bacterium was seen as medium, glossy, spherical, grey, elevated colonies on blood agar, occasionally exhibiting β -hemolysis. The bacterium on TBX agar appeared as medium, round, and blue colonies.

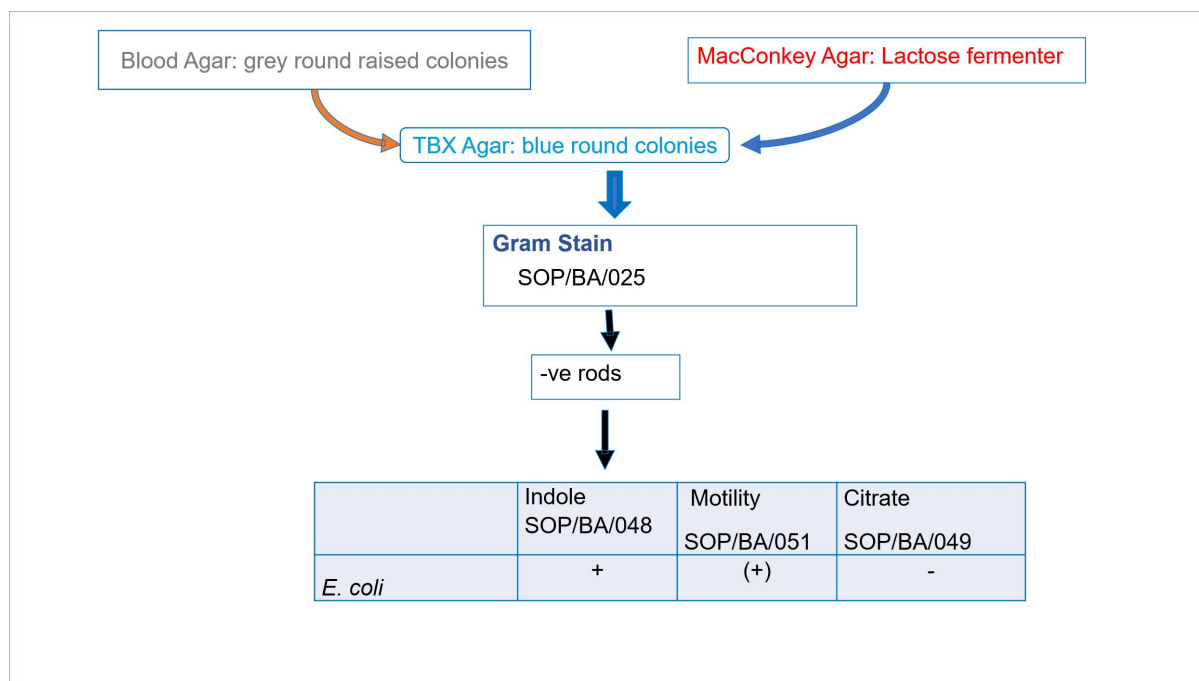


Figure 4.1: The flow chart illustrating *E. coli* identification.

4.2 Prevalence rates of *E. coli* in chicken cuts from Epworth

The incidence rate of *E. coli* was calculated for each type of outlet, such as butchery-chicken and vendor-chicken.. Chicken cuts collected from vendors were contaminated with *E. coli* more than those collected from the butcheries. As shown in Figure 4.2, chicken cuts from the vendors have a prevalence rate of 86%, and those collected from the butcheries had 52% prevalence rate.

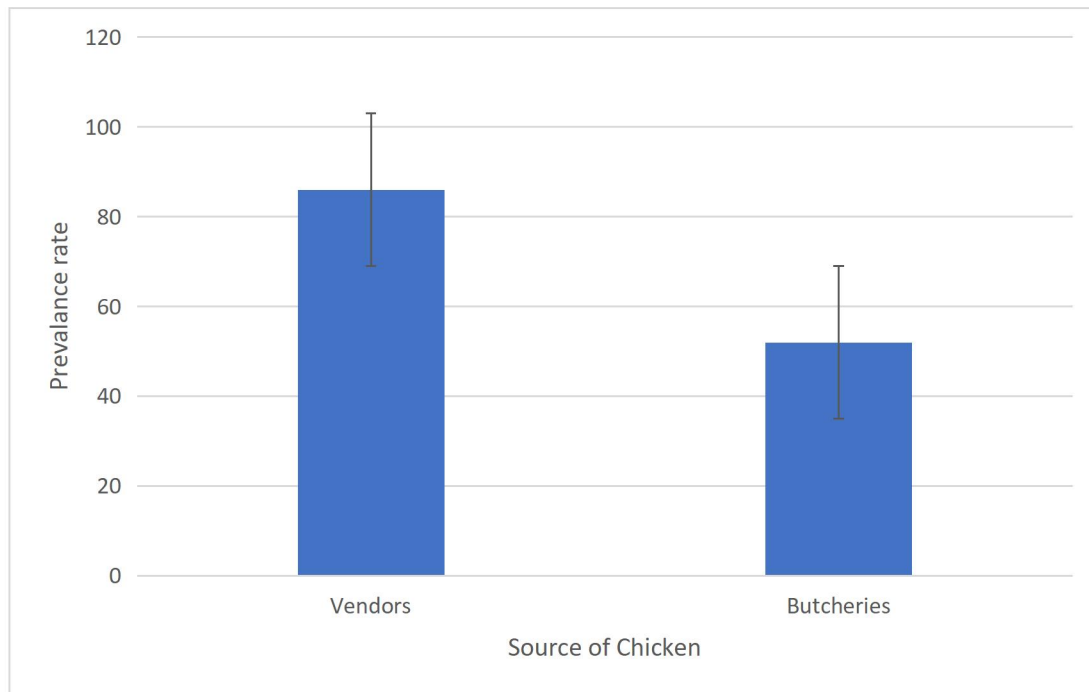


Figure 4.2 The prevalence of suspected bacteria on sample sources

4.3 Total *E. coli* count on chicken cuts from Epworth

As shown in Table 4.1, the total *E. coli* count (TEC) varied from $<1.0 \times 10^1$ cfu/g to the highest of 6.0×10^6 cfu/g, with the meat cuts from vendors containing more counts compared to the meat cuts from butcheries.

Table 4.1 Total *E. coli* count from chicken from the two sources

Sample ID	Result
vendor9	$<1.0 \times 10^1$

vendor8	2.0×10^3
vendor7	3.0×10^4
vendor6	6.0×10^6
vendor5	7.0×10^2
vendor4	9.0×10^5
vendor3	$<1.0 \times 10^1$
vendor21	3.0×10^4
vendor20	9.0×10^2
vendor2	6.0×10^6
vendor19	5.0×10^3
vendor18	9.0×10^4
vendor17	4.0×10^5
vendor16	5.0×10^3
vendor15	$<1.0 \times 10^1$
vendor14	7.0×10^4
vendor13	6.0×10^3
vendor12	4.0×10^6
vendor11	3.0×10^6
vendor10	2.0×10^5
vendor1	1.0×10^6
butcher9	$<1.0 \times 10^1$
butcher8	2.0×10^2
butcher7	$<1.0 \times 10^1$
butcher6	2.0×10^3
butcher5	$<1.0 \times 10^1$
butcher4	7.0×10^2
butcher3	$<1.0 \times 10^1$
butcher21	$<1.0 \times 10^1$
butcher20	$<1.0 \times 10^1$
butcher2	1.0×10^6
butcher19	$<1.0 \times 10^1$

butcher18	9.0×10^3
butcher17	8.0×10^2
butcher16	7.0×10^4
butcher15	$<1.0 \times 10^1$
butcher14	$<1.0 \times 10^1$
butcher13	7.0×10^3
butcher12	$<1.0 \times 10^1$
butcher11	1.0×10^3
butcher10	3.0×10^3
butcher1	6.0×10^4

4.4 Hygiene and meat handling practices observed for vendors and butcheries in Epworth

Chicken meat was more abundant among the vendors, and the meat was sold as single or packed meat. When comparing the individual practices between vendors and butcheries, the percentage of "Yes" answers for each practice was compared across vendors and butchers using chi-square tests. Table 4.2 is a summary of the findings observed among the vendors and butcheries in terms of hygiene and meat handling practices in Epworth. At the time of this investigation, there was no discernible variation in the hygienic practices of Epworth butchers and vendors. Additionally, there was no discernible difference between vendors and butcheries in terms of wearing watches or jewellery ($p=0.145$) or distinct equipment for ready-to-eat meats ($p=0.234$). However, there were significant differences in terms of hygiene and meat handling practices between vendors and butcheries ($p<0.05$), such as hand washing before work, use of gloves, and hairnets, usage of aprons/gowns/coats and many more. Some of the practices were classified as bad practices, such as wearing the same apron for different functions, such as carrying meat and cutting meat, dirt and stained aprons. Among these bad practices, butcheries have significantly higher rates when compared to the vendors, and this might indicate that butcheries handle meat more than the vendors (Table 4.2). When calculating the hygiene score, which had a maximum score of 22, butcheries had the highest mean score of 13.16 ± 2.07 , and the mean score of the vendors was 5.84 ± 1.03 . Therefore, when the hygiene score was evaluated using an independent samples t-test ($t(48) = 15.84$), the results showed a substantial distinction between the two groups ($p < 0.001$). This means that butcheries were more compliant towards meat hygiene and handling practices,

but they have some bad practices, which warrant awareness and training among butchery personnel.

Table 4.2 Hygienic and meat handling procedures of Epworth butcheries

Practice	Vendors (Yes/25)	Butchers (Yes/25)	p- value
Meat Handlers' Hygiene	25	25	p>0.05
Hand washing before work	15	22	0.024*
Use of gloves	0	14	<0.001*
Hair tied back & hair net	0	15	<0.001*
Wearing a coat, gown, or apron	6	18	<0.001*
Boots that are waterproof	0	11	<0.001*
Long-sleeved protective clothing	0	12	<0.001*
Wears watch/jewellery (1 = bad)	7	12	0.145
Same apron for different activities (1 = bad)	6	18	<0.001*
Separate staff for raw vs. ready-to-eat meats	13	25	<0.001*
Cleaning of job attire	0	14	<0.001*
Clothing with fresh filth (1 = terrible)	0	10	<0.001*
Ingrained dirt on clothes (1 = bad)	0	16	<0.001*
Infrastructure hygiene	0	20	<0.001*

Practice	Vendors (Yes/25)	Butchers (Yes/25)	p- value
Structure in good condition	0	19	<0.001*
The floor seems tidy	0	19	<0.001*
The hooks and counter are spotless	0	12	<0.001*
Non-harmful cutting tables	0	17	<0.001*
There are paper towels that can be thrown away	0	10	<0.001*
secure supply of water	0	14	<0.001*
Equipment specifically designed for raw meat	0	15	<0.001*
Equipment specific to packaged meats	0	3	0.234

4.5 Correlation between *E. coli* Counts and Meat Hygiene and Handling Practice

To determine if *E. coli* numbers and the hygienic procedures of vendors and butcheries were related, a Pearson (parametric) and Spearman rank (non-parametric) correlation analysis was carried out. It was discovered that there was a somewhat negative linear link between reduced *E. coli* levels and good cleanliness scores, with a Pearson correlation value of $r=-0.486$. This relationship was statistically significant across vendors and butcheries ($p < 0.001$). A modest negative monotonic association was shown by the Spearman's rank correlation coefficient, $p = -0.259$, which may imply that the association is not entirely linear and could have been impacted by anomalies or associated rankings. After seeing this, a straightforward linear

regression was carried out, and the results showed that the R^2 was 0.236 and the slope was -0.229. This indicates that $\log_{10}(\text{Count})$ falls by 0.229 units for every unit rise in Hygiene Score. Since $10^{-0.229} = 0.59$, this translates to a roughly 40% decrease in *E. coli* count for every 1-point rise in cleanliness score. *E. coli* contamination and hygiene habits are negatively correlated in a statistically meaningful way. Compared to vendors, butcheries have far lower *E. coli* counts and much higher cleanliness scores. About 24% of the variance in *E. coli* counts can be explained by hygiene standards, suggesting that other factors—such as temperature, storage, and supply chain also have a significant impact.

CHAPTER FIVE

5.0 Discussion

5.1 Introduction.

This study looked into the incidence and enumeration of *Escherichia coli* in chicken meat supplied by both informal vendors and formal butcheries in Epworth, Zimbabwe, as well as the relationship between hygienic practices and microbiological contamination. Informal chicken vendors exhibited considerably greater *E. coli* prevalence (86%) and counts (median 2.5×10^5 cfu/g) than institutional butcheries (52% prevalence; median $<10^1$ cfu/g). Hygiene scores were significantly lower among sellers, and there was a solid negative association amongst hygiene compliance and *E. coli* levels. This chapter interprets the findings in light of the existing literature, investigates potential reasons, examines public health consequences, recognizes study limitations, and suggests future research possibilities.

5.2 Identifying and confirming *Escherichia coli* isolates

Conventional microbial techniques, such as colony form, Gram staining, and biochemical assays, were used to identify all potential *E. coli* isolates. *E. coli* differs from non-lactose-fermenting enteric pathogens like *Salmonella* and *Shigella* on MacConkey agar because of its quick lactose fermentation, which results in vivid pink colonies (Markey et al., 2013, Quinn et al., 2011). Colonies on Blood agar were medium-sized, shiny, grey, and elevated, with occasional β -hemolysis, similar to *E. coli* strains containing haemolysin genes (Markey et al., 2013). On tryptone bile X-glucuronide (TBX) agar, *E. coli* emerged as blue colonies due to β -glucuronidase activity, which is an exceedingly precise marker for this species (Quinn et al., 2011). All isolates were Gram-negative bacilli, as confirmed by Gram stain. Biochemical assessments revealed the normal *E. coli* pattern: indole positive (tryptophan breakdown), citrate negative (Inability to utilize citrate as the only means of carbon), and motile (peritrichous flagella). These findings are consistent with Bergey's Manual of Systematic Bacteriology (Sneath et al., 1986) and established diagnostic algorithms. However, the lack of molecular proof (such as 16S rRNA sequencing or

PCR targeting the *uidA* or *phoA* genes) is a drawback. While phenotypic approaches are reliable for routine identification, they do not distinguish between commensal and pathogenic *E. coli* strains (STEC, ETEC, EPEC). If pathogenic serotypes were present, the public health risk could be substantially greater than previously reported (Gweshe et al., 2020). Future studies should use multiplex PCR to characterize virulence, biofilm formation, heavy metals, and AMR genes.

5.3 Frequency of *E. coli* in Meat: Informal versus formal markets

The fact that 86% of the meat from vendors was polluted with *E. coli* compared to 52% of butchery samples is noteworthy and statistically significant ($p = 0.024$). This prevalence rate among vendors is among the highest found in comparable studies. For example, Wardhana et al. (Wardhana et al., 2021) identified *E. coli* in 68% of poultry meat from resident marketplaces in Surabaya, Indonesia. Mathew et al. (Mathew et al., 2025) found a frequency of 54.5% in retail chicken meat in Kerala, India. In Ethiopia, research by Tegegne et al. (Tegegne et al., 2024) discovered *E. coli* in 63.3 % of raw chicken flesh samples from a slaughterhouse. The 86% frequency among Epworth sellers suggests a serious hygiene concern. This high rate of contamination can be due to the following factors:

5.3.1 Cause of Contamination

E. coli is unsurprisingly found in the guts of warm-blooded animals, including chickens. Its existence on meat suggests fecal contamination during slaughter, evisceration, or subsequent handling (Risalvato et al., 2025). Many sellers in Epworth apparently purchase live chickens, butcher them on-site or at home, and then sell the flesh. If evisceration is not done properly, digestive contents may leak onto the carcass. Using the same knives, cutting boards, and water for many birds without proper disinfection can lead to cross-contamination. Formal butcheries, on the other hand, are more likely to source from regulated abattoirs that require hygienic slaughter processes (for example, scalding, mechanical plucking, and washing with potable water). This structural difference most likely correlates with decreased contamination in butchery samples.

5.3.2 Environmental Hygiene and Sanitation.

Epworth study place is described as hyperactive and unsanitary. Several vendor stalls were seen near the commuter bus terminal's public restrooms. These toilets frequently lacked running water

for hand washing. Flies, dust, and runoff from these operations have the potential to infect exposed meat, either directly or indirectly. Research by Siluma et al. (Siluma et al., 2023b) in South Africa discovered that meat marketed in informal communities had higher coliform levels due to environmental contamination. The lack of adequate refrigeration, display cabinets, and protective covers in vendor settings exacerbates the situation.

5.3.3 Regulatory oversight

Formal butcheries are registered with the local council and subject to regular inspections by Environmental Health Officers (EHOs) under Zimbabwe's Food and Food Standards Act. Vendors, on the other hand, frequently operate without a licence and avoid inspection. Due to a lack of inspection, vendors are not held liable for hygiene violations. The findings of this study strongly support the need to expand regulatory surveillance into the informal sector, not to criminalize vendors, but to provide helpful supervision and training.

5.4 Enumeration of *E. coli*: Quantification risk analysis

Total *E. coli* levels ranged from less than 1.0×10^1 cfu/g to up to 6.0×10^6 cfu/g. Vendor samples had considerably higher median counts (2.5×10^5 cfu/g) compared to butchery samples ($<10^1$ cfu/g) ($p < 0.001$, Mann-Whitney U test). Several vendor samples surpassed Zimbabwe's allowed limit of 1×10^6 cfu/g for total bacterial count in beef (Mugadza et al., 2025), indicating significant contamination.

5.4.1 Public health thresholds

Although there is no precise *E. coli* count restriction for raw chicken in Zimbabwe, international recommendations indicate that any existence of *E. coli* in meat is unwanted (Koca et al., 2022, Matthee, 2007). Counts above 10^3 cfu/g in raw beef suggest poor hygiene, and above 10^5 cfu/g provide a severe danger if under cooked or cross-contaminated with other foods (Koca et al., 2022, Matthee, 2007). The investigation found that 14 out of 21 vendor samples (67%) had counts above 10^3 cfu/g, while 8 (38%) had counts above 10^5 cfu/g. Vendor chicken that is not fully cooked (core temperature $\geq 75^\circ\text{C}$) may pose a risk of foodborne illness.

5.4.2 Dose-Response Considerations.

Pathogenic *E. coli* (like O157:H7) can have an infectious dosage as low as 10–100 cells (Warmate and Onarinde, 2023). Even moderate numbers (10^2 - 10^3 cfu/g) can represent a concern if the strain is pathogenic. This study did not quantify pathogenic sub types, but the high total numbers indicate that the likelihood of harbouring pathogenic strains is considerable. According to a study conducted in Harare by Gweshe et al. (2020), 23% of *E. coli* isolates from milk tested positive for at least one virulence gene. Similar molecular characterization in chicken flesh is critically required.

5.5 Hygienic and meat handling practices

The cleanliness study found significant disparities between vendors and butcheries. Butcheries had considerably higher mean hygiene scores (13.16 ± 2.07) than merchants (5.84 ± 1.03) ($t(40) = 15.84$, $p < 0.001$). However, the highest possible score was 22, implying that even butcheries only achieved approximately 60% compliance. This suggests that there is plenty of space for improvement in both sectors.

5.5.1 Practices in which butcheries excelled

Butcheries had higher rates of hand washing (88% vs. 60%), gloves (56% vs. 0%), hair tied back or nets (60% vs. 0%), aprons/gowns (72% vs. 24%), waterproof boots (44% vs. 0%), clean infrastructure (80% vs. 0%), and separate staff for raw vs. ready-to-eat meats (100% vs. 52%). These methods are essential for food safety and explain why butchery samples showed lower *E. coli* concentrations. Butcheries can limit contamination risk by providing sterile water, disposable towels, and non-porous cutting surfaces, though this is not always possible.

5.5.2 Bad practices are more common in butcheries.

Butcheries, however, showed greater rates of several "bad practices": wearing the same apron for multiple operations (72% vs. 24%), recent dirt on clothes (40% vs. 0%), embedded dirt on clothes (64% vs. 0%), and wearing watches/jewellery (48% vs. 28%, but not significant). The amount of meat handled by butchers explains this paradox: they process more meat each day,

which causes dirt and stains to build up more quickly. For financial or practical reasons, they might also repurpose aprons without cleaning them. Vendors, on the other hand, usually deal with smaller quantities and might change or clean their clothing more frequently (even though they don't wear appropriate aprons at all). Enforcing more regular changes of protective gear—ideally, a clean apron for every shift or whenever clearly soiled—is the better course of action than criticizing butcheries.

5.5.3 Vendors: fundamental deficits

All vendors lacked clean infrastructure, waterproof boots, hair nets, and gloves. Water was occasionally obtained from unreliable sources (boreholes or municipal taps), and their work surfaces were frequently wooden planks, which are porous and challenging to disinfect. None of the sellers used disposable towels, and many people handled meat without first washing their hands. The vendors operate with little funding and in areas not intended for food handling, so they are not solely to blame for these gaps. Thus, basic infrastructure (such as stainless steel tables, running water, soap, and gloves) must be provided through micro grants or public-private partnerships.

5.6 Correlation of hygiene and *E. coli* contamination

A substantial negative connection was discovered between cleanliness score and log-transformed *E. coli* count (Spearman's $\rho = -0.259$; $p = 0.045$). Linear regression revealed that a one-point increase in hygiene score resulted in a 41% reduction in *E. coli* count ($R^2 = 0.236$; $p < 0.001$). This is a strong and practical association. It means that better hygiene measures can significantly reduce fecal contamination. The R^2 value of 0.236 indicates that hygiene behaviour account for only around 24% of the diversity in *E. Coli* counts. The remaining 76% is due to other factors, which include:

- Abuse of temperature: When chicken is kept at room temperature (20–30°C in Epworth), bacteria can proliferate quickly. Long-term display without refrigeration can result in large numbers even if the original contamination is minor.
- Time from slaughter to sale: Vendor chicken may be killed early in the morning and sold all day long, which promotes the growth of bacteria.

- Cross-contamination from other foods or surfaces: Vendors frequently have several items (grains, veggies) on the same table.
- Water quality: Re contamination might occur if washing water is tainted with *E. coli*.
- Animal health and conditions during slaughter: *E. coli* intestinal burdens may be higher in sick or stressed chickens.

Therefore, cold chain management, reduced holding times, and access to drinkable water must be added to the infrastructure and hygiene training that are crucial.

5.7 Comparison to National and International standards.

Zimbabwe's meat hygiene standards (Statutory Instrument 64 of 2010) require meat for human consumption to be free of harmful germs and indicator organisms such as *E. coli* in meat products. According to Mugadza et al. (Mugadza et al., 2025), raw meat should have a total viable count (TVC) of less than 1×10^6 cfu/g; no specific *E. coli* restriction exists. In this analysis, numerous vendor samples exceeded the TVC equivalent when considering only *E. coli* (e.g., 6.0×10^6 cfu/g). This suggests a major infringement of food safety norms. The Codex Alimentarius (Koca et al., 2022, Matthee, 2007) recommendations for meat hygiene advocate implementing HACCP-based systems and regular microbiological testing by authorized authorities. The results of this study indicate that Epworth present monitoring system is insufficient, especially concerning the unorganized sector. In addition to enforcing corrective measures, including an interim closure for persistent non-compliance, the City of Harare Health Department ought to take into account focused sampling of vendor chicken.

5.8 Public Health Consequences

Eating chicken contaminated with *E. coli* can lead to a number of disorders, from mild diarrhoea to more serious conditions such as hemorrhagic colitis and haemolytic uremic syndrome (HUS), especially in kids, older adults, and those with weakened immunity (Mphaga et al., 2024). An outbreak might have disastrous effects in a peri-urban location like Epworth, where access to healthcare is restricted. Furthermore, broad fecal contamination is indicated by the high frequency of *E. coli*, which may potentially be accompanied by other enteric pathogens, such as

Salmonella, *Campylobacter*, and *Listeria*. Since most local laboratories do not regularly test these, the actual prevalence of food borne illness is probably underestimated. From an economic standpoint, food borne illnesses put a strain on healthcare resources and lower productivity (days missed from work). Preventable outbreaks further deplete resources in Zimbabwe, where the economy is already precarious. Over time, it is more economical to invest in infrastructure and food safety training for vendors.

5.9 Limitations

This study acknowledged several limitations:

- ❖ Only 42 samples (21 per group) were examined; while statistically significant differences were discovered, a higher sample size might increase precision and allow for subgroup studies (e.g., season, vendor location, or chicken portion).
- ❖ The study was limited to Epworth; the findings may not be applicable to other peri-urban or rural parts of Zimbabwe, where behaviours and infrastructure vary.
- ❖ There is no molecular characterization for *E. coli* isolates that were not serotyped or tested for virulence genes (such as *stx1*, *stx2*, *eaeA*, and *bfp*). Thus, the proportion of potentially harmful strains is unknown.
- ❖ Given the widespread concern about antimicrobial resistance (AMR), it would have been beneficial to screen isolates against routinely used antibiotics. This is a priority for future research.
- ❖ The study measured contamination at a single time point (three replicates over a brief period). Seasonal differences (e.g., increased contamination during hot, wet months) were not investigated.
- ❖ The researcher was not blinded to the type of outlet (vendor or butchery), which could create observer bias. However, the checklist was objective and uniform.
- ❖ The study did not assess how customers handled or cooked the chicken. Thorough cooking can make even highly contaminated meat safe, but cross-contamination in household kitchens still poses a concern.
- ❖ Freezing samples at -20°C may impair the vitality of some *E. coli* cells, potentially resulting in an underestimate of counts. Ideally, samples should be processed immediately or stored for a maximum of 24 hours at 4°C.

CHAPTER SIX

6.0 Conclusion and Recommendation

6.1 Conclusion

The project demonstrates that compared to chicken from butcheries, chicken from Epworth vendors is more commonly and severely infected with *E. coli*. Additionally, although there are certain instances of non-compliance, butcheries often follow greater sanitary standards than vendors. *E. coli* infection and hygiene practice ratings are significantly correlated negatively, underscoring the significance of hygiene infrastructures and training in lowering microbiological hazards. The investigation also shed light on the security of meat vended in Epworth by vendors and butcheries. *E. coli* should not be identified in food since it is an indicator of fecal contamination. Contaminated chicken meat is being supplied to the public, demonstrating that food safety measures are not being adequately implemented in Epworth, and is thus deemed a major risk to human health. Additional research ought to investigate the impact of condition of storage and abuse of temperature on the growth of microbes. Also, the frequency of infections such as *E. coli* that are resistant to antibiotics and the long-term effects of organized hygiene prevention initiatives on contamination levels need further study.

6.2 Recommendations

In order to promote more secure meat handling practices in Epworth and comparable environments, cooperation among medical professionals, vendors, butcheries, and residents is crucial. Enhancing meat hygiene and handling practices is a feasible preventative measure which may substantially decrease the likelihood of food-borne diseases. The following actions are advised to increase the safety of chicken meat in Epworth:

- Provide vendors with comprehensive, targeted hygiene training to improve basic practices (including the use of gloves, hair nets, and hand washing) and modernize facilities to reduce microbial contamination.
- Maintain current standards while addressing specific problematic behaviour in butcheries (such as abusing aprons or collecting dirt) by bolstering cleaning protocols in order to further reduce risks.

- The two scenarios should carry out regular cleanliness inspections and microbiological surveillance to ensure continuous and long-lasting improvements.
- A thorough approach that tackles other risk factors (such as refrigeration and cleaning programs) is necessary in addition to appropriate sanitation training.
- Additional research, including more participants and additional variables (such as temperature and time from slaughter), is needed to develop a more comprehensive food hygiene programme.
- Increase availability of non-porous cutting surfaces, clean water, and disposable towels, particularly in vendor settings.
- Teach handlers and customers the value of safe handling procedures and meat cleanliness.

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Appendices

Appendix A Raw data

Table A1: Total E. coli counts from chicken cuts from Epworth

Sample ID	Result
vendor9	0
vendor8	2
vendor7	30
vendor6	6000
vendor5	0.7
vendor4	900
vendor3	0
vendor21	30
vendor20	0.9
vendor2	6000
vendor19	5
vendor18	90
vendor17	400
vendor16	5
vendor15	0
vendor14	70
vendor13	6
vendor12	4000
vendor11	3000
vendor10	200
vendor1	1000
butcher9	0
butcher8	0.2
butcher7	0
butcher6	2
butcher5	0

butcher4	0.7
butcher3	0
butcher21	0
butcher20	0
butcher2	1000
butcher19	0
butcher18	9
butcher17	0.8
butcher16	70
butcher15	0
butcher14	0
butcher13	7
butcher12	0
butcher11	1
butcher10	3
butcher1	60
vendor23	3
vendor24	40
vendor25	200
butchery22	0
butchery23	0
butchery24	0
butchery25	0
vendor22	70

Table A2 presence of *E. coli* in chicken cuts from Epworth

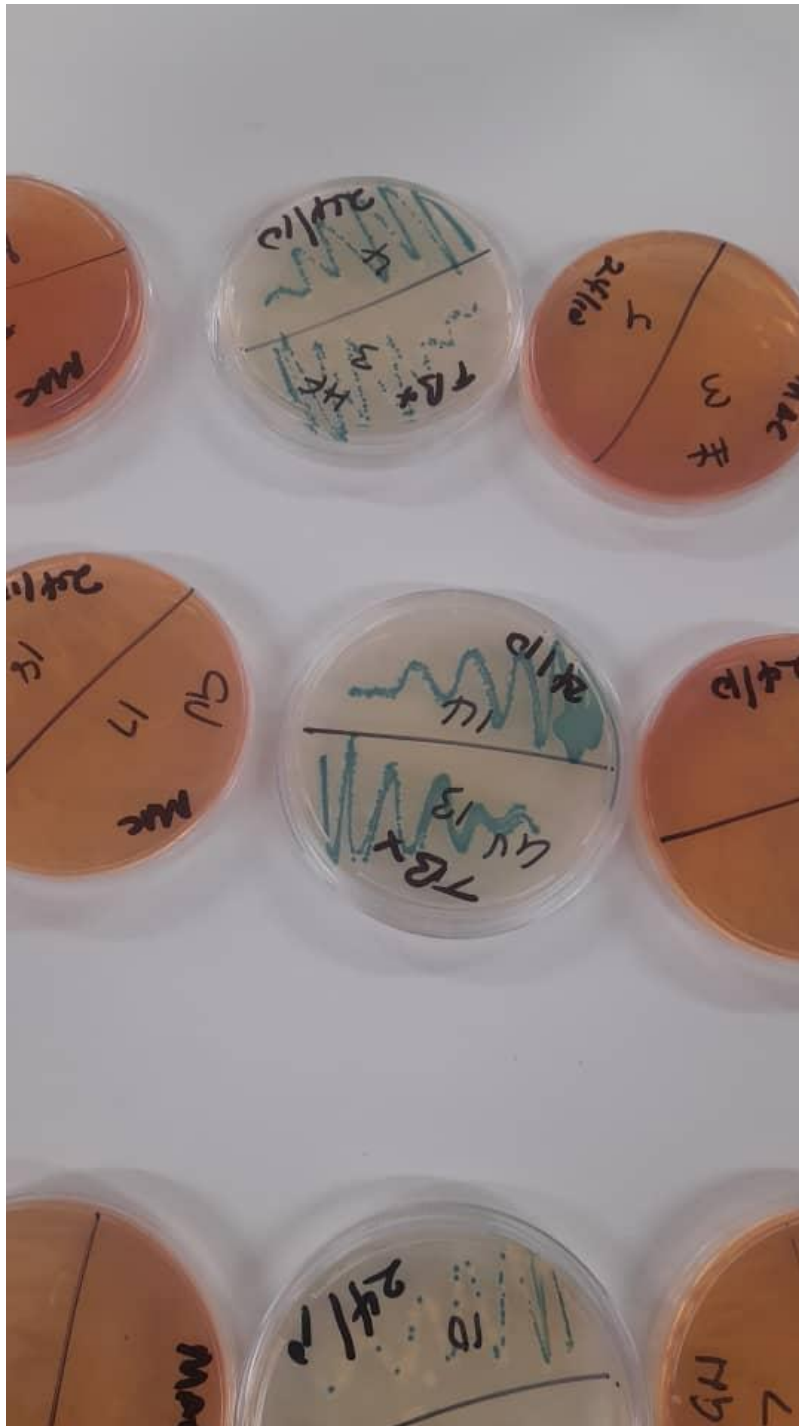
Sample ID	Result
vendor9	NG
vendor8	<i>E. coli</i>
vendor7	<i>E. coli</i>
vendor6	<i>E. coli</i>
vendor5	<i>E. coli</i>

vendor4	E. coli
vendor3	NG
vendor21	E. coli
vendor20	E. coli
vendor2	E. coli
vendor19	E. coli
vendor18	E. coli
vendor17	E. coli
vendor16	E. coli
vendor15	NG
vendor14	E. coli
vendor13	E. coli
vendor12	E. coli
vendor11	E. coli
vendor10	E. coli
vendor1	E. coli
butcher9	NG
butcher8	E. coli
butcher7	NG
butcher6	E. coli
butcher5	NG
butcher4	E. coli
butcher3	NG
butcher21	NG
butcher20	NG
butcher2	E. coli
butcher19	NG
butcher18	E. coli
butcher17	E. coli
butcher16	E. coli
butcher15	NG
butcher14	NG
butcher13	E. coli
butcher12	NG
butcher11	E. coli
butcher10	E. coli
butcher1	E. coli

Appendix B Hygiene checklist

Table B1. Survey checklist to evaluate meat safety practices and hygiene in various butcheries and Vendors.

Age approximate		
Gender		
Checklist	Yes	No
Hygiene of Meat handlers		
Meat handlers wash hands before commencing work/prior to handling meat		
Use of gloves when meat is handled		
Hair is tied back, and hair net/cap is used		
Use of Apron/gown/coat		
Use of waterproof boots for footwear		
Protective clothes are long-sleeved and completely cover personal clothes		
Staff wears watch/jewellery while meat is handled		
Same Apron is used for different activities in the shop/butchery		
Persons handling meat also handle money		
Staff preparing and handling raw meat is separate from staff preparing and handling ready to eat meats		
Cleanliness of working clothes		
Recent dirt on working clothes		
Ingrained dirt on working clothes		
Infrastructure and maintenance of hygiene in Supermarket/butchery		
Structure of shop/butchery including walls, floors, ceilings, and fixtures are in good condition and will not yield cross contamination		
Butchery/shop floor appears clean		
Counter and hooks of butchery/shop are clean		
Cutting tables contain non-harmful materials (rust, mold)		
Disposable paper towels are available		
There is a safe water supply to the butchery/shop		
Clean equipment such as weighing scales, mincers and slicers are separately used for raw meat and ready to eat meats		
Chopping boards, knives, tongs, and other utensils are separated for raw meat and ready to eat meats		
Waste is confined, managed, and properly disposed		
Cleaning cloths and detergents are stored in sight		
Pest control devices are available		
Display of meat		
Meat of different species are physically separated and are in same window display		
Meat appears red in color and has no unpleasant odor		
Meat appears dark brown/discolored and has a strong odor		



Appendix C Appearance of *E. coli* on TBX agar

Figure C1 Appearance of *E. coli* of TBX agar

