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EVALUATION OF WORKERS' KNOWLEDGE, ATTITUDES, AND HYGIENE PRACTICES REGARDING FOOD SAFETY AND THE MICROBIAL LOAD ON MEAT AND ITS CONTACT SURFACES IN ABATTOIRS AND BUTCHER SHOPS IN SELECTED TOWNS OF THE EAST SHOA ZONE, OROMIA, ETHIOPIA



MSc THESIS

**ADDIS ABABA UNIVERSITY
COLLEGE OF VETERINARY MEDICINE AND AGRICULTURE
DEPARTMENT OF VETERINARY MICROBIOLOGY, IMMUNOLOGY, AND
PUBLIC HEALTH**

BY

TEFERI ATLAW ABAY

JUNE 2024

BISHOFTU, ETHIOPIA

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MSc THESIS

**A Thesis Submitted to the College of Veterinary Medicine and Agriculture of Addis Ababa
University in partial fulfilment of the requirements for the degree of Master of Veterinary
Science in Veterinary Public Health**

BY

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LIST OF ABBREVIATIONS

CDC	Centre for Disease Control
FAO	Food Agriculture Organization
FNP	Good and nutrition policy
GMP	Good Manufacturing Practices
HACCP	Hazard Analysis Critical Control Point
ILIRI	International Livestock Research Institute
ISO	International Organization for Standardization
KAP	Knowledge Attitude Practice
NCC	National Codex Committee
OIE	Organization for International Des Epizootics
SD	Standard Deviations
SSOP	Sanitation Standard Operating Procedure
WHO	World Health Organization

ABSTRACT

A primary global goal shared by both the public and private sectors is to ensure the food safety of the meat supply chain to protect public health. Processing meat products in an unsanitary way and selling contaminated meat may harm public health. This study is aimed at the evaluation of workers' knowledge, attitudes, and hygiene practices regarding food safety and the microbial load on meat and its contact surfaces in abattoirs and butcher shops in selected towns of the East Shoa Zone, Oromia, Ethiopia. A cross-sectional survey and sampling were conducted from November 2023 to March 2024. A total of 110 meat handlers from which 52 from slaughterhouses and 58 from butcher shops by using systematic simple random sampling methods were selected. Data was gathered via structured interviews, and 48 swab samples were randomly selected for bacterial detection. These samples aimed to demonstrate the hygienic conditions at both a slaughterhouse and a butcher shop. The statistical analysis of the data was done by STATA software version 14 for statistical analysis, with descriptive statistics and Pearson's chi-square test for evaluating socio-demographic factors' association with food safety knowledge, attitude, and practices of food handlers in slaughterhouses and butcher shops. Of the 52 slaughterhouse worker meat handlers, 75.0% had good score-level knowledge. The score level of knowledge of slaughterhouse workers was also significantly associated with socio-demographic factors of age group (χ^2 , 13.982; P value = 0.003), level of education (χ^2 , 12.515; P value = 0.002), and experiences (χ^2 , 7.704; P value = 0.021). The good attitude score levels of the slaughterhouse respondents were also assessed and found to be 61.5%. The study found the highest aerobic plate count (APC) in butcher shops hand and meat swabs from slaughterhouses in Modjo town, with *E. coli* and *S. aureus* colonies on cutting boards. The findings emphasize the importance of knowledge and attitude in influencing food safety practices, emphasizing the need for strict protocols and training.

Keywords: *Attitude, food safety, knowledge, meat, hygienic practice, East Shoa zone*

1. INTRODUCTION

A primary global goal shared by both the public and private sectors is to ensure the food safety of the meat supply chain to protect public health. Processing meat products in an unsanitary way and selling contaminated meat may harm public health (Grace (2015)). Approximately 600 million humans globally become diseased each year as a result of eating contaminated food, a number equal to 27 million lost years of healthy life (WHO, 2015). Consuming contaminated meat is a major contributing factor to foodborne disease, as is one of the leading causes of sickness in humans (Jacob *et al.*, 2010).

Meat serves as a favourable medium for the growth of infections and spoiling organisms, resulting in a frequent source of foodborne diseases (Scharff, *et al.*, 2009). Meat must be handled carefully both during and after harvest to prevent contamination due to the significant potential for it to foster the growth of germs (Abdul-Mutalib *et al.*, 2012). Food-borne diseases are mostly caused by contaminated and cross-contaminated raw meat, especially in developing countries (Adesokan, and Raji, 2014).

In Ethiopia, as in many other developing countries, most food-borne diseases are caused by microbes that are regularly shed in the feces of diseased animals and contaminate bodies during the slaughter process due to improper handling and cross-contamination (Atnafie *et al.*, 2017; Eguale *et al.*, 2018). For example, research studies on children in Ethiopia with diarrhoea show a high prevalence of pathogenic Salmonella (3.1%) (Zeleele *et al.*, 2019) and 1.3%) (Tosisa *et al.*, 2020) and *E. coli* (28.8%) (Zeleele *et al.*, 2019). Studies conducted on humans, poultry, and pigs have shown that the prevalence of Salmonella is 7.2%, 4.7%, and 4.4%, respectively (Eguale *et al.*, 2015; Eguale *et al.*, 2018). Ethiopia also reported cases of microbiological contamination in animal-derived foods throughout the supply chain. A recent meta-analysis of studies on *E. coli* prevalence in milk and meat revealed an overall random pooled prevalence of 15% (Assefa, and Bihon, 2018). However, another investigation revealed the presence of Salmonella, *E. coli*, Listeria, and Campylobacter in beef meat distributed in shops (Edget, 2014). Understanding the extent of meat handlers' knowledge, attitudes, and practices (KAP) on food safety is crucial to

developing interventions suitable for implementation. Slaughterhouses and meat shops have responsibilities to ensure food safety. Studies conducted in Ethiopia have shown that the behaviour of meat handlers poses a substantial risk of food contamination, potentially compromising the quality of food for human consumption. For example, a study in Eastern Ethiopia revealed inadequate awareness among meat handlers regarding foodborne pathogens, the importance of temperature and time control to inhibit bacterial growth, cross-contamination risks, and the distinction between sanitation and cleaning practices (Tegege, and Phyto, 2017).

In a separate study in the northern part of Ethiopia, it was found that the slaughterhouse lacked a sterilizer, cooling facility, or hot water. Additionally, 15.4% of the personnel did not possess a health certificate. Moreover, during meat handling, 11.3% of butchers did not utilize safety clothing (Haileselassie *et al.*, 2013). “Downstream” food safety procedures, such as inspections of food establishments and product recalls, are not well-established in Ethiopia. To ensure customers have access to safe foods, more attention should be given to “upstream” factors, like the personal hygiene of meat handlers in slaughterhouses and retail establishments. The public is at risk of meat-borne diseases because of inadequately trained workers handling meat in unsanitary conditions. This risk could be mitigated by offering proper training and maintaining quality control measures (Gutema *et al.*, 2021). Only one study has comprehensively reviewed the food safety knowledge, attitudes, and practices (KAP) of meat handlers in slaughterhouses and retail meat shops, despite numerous studies focusing on food handlers in Ethiopian food outlets (Admasu *et al.*, 2018; Tesfaye, and Tegene, 2020). Previous research has primarily centered on food safety regulations ((Haileselassie *et al.*, 2013; Yenealem *et al.*, 2020; Gutema *et al.*, 2021).

Recently, abrupt progress has been seen in the privatization, market, and consumption of livestock products in slaughterhouses and butcher shops related to changes in income and lifestyle, causing changing demands of society for hygienic, affordable, and quality meat and meat products (Sameh *et al.*, 2020). The expansion of the modern retail sector in urban areas changes consumers’ shopping habits and behaviours, improves their awareness and preference for buying healthy, convenient, processed, and packed meat and meat products, and drives demand for safe, high-quality, and affordable meat and meat products that meet international standards. However, various factors could affect the quality, safety, wholesomeness, and suitability of meat and meat products,

which might be dangerous to human health and cause a decline in consumer confidence and high medical expenses due to the infection of foodborne pathogens after the consumption of contaminated meat (Hamza *et al.*, 2023).

Owners' managers and regulatory bodies of slaughterhouses and butcher shops are responsible for maintaining cleanliness, safe food production practices, hygienic operations, and compliance with regulations (Miyamoto *et al.*, 2022). They must adopt various cleaning and sanitization procedures to remove microorganisms, debris, and contamination of meat (Sameh *et al.*, 2020). Bacterial counts of meat are used as an acceptable indicator of its hygienic quality. Lack of implementation of good hygienic practices contribute to the high bacterial load in meat. Thus, by assessing the bacterial counts, the threat posed to human health can be ascertained (Birhanu *et al.*, 2017). There are only a few research reports presented in the study area concerning food safety KAP and microbial load on meat even those are only reported in Bishoftu Town.

1.1 General objective

The overall objective of the study was to generate updated information on knowledge, attitude, and hygiene practices of workers in slaughterhouses and butcher shops regarding food safety and to assess the microbial load on meat and its contact surfaces as indicators of food safety.

1.2 Specific objectives

- ✚ To evaluate the food safety knowledge, attitude, and practice of workers in slaughterhouses and butcher shops of study areas.
- ✚ To assess the microbial load on the meat and its contact surface of slaughterhouses and butcher shops of study areas.

2. LITERATURE REVIEW

2.1 Meat Production and Marketing in Ethiopia

Meat is the flesh or other edible parts of animals, usually from domesticated cattle, pigs, and sheep, consumed as food. It comprises muscles, fat, tendons, and ligaments, offering a full protein source with crucial amino acids for the human body (Collins and Huey, 2014). Progressing the security of nourishment of creature roots includes direction on great hones in creature nourishing, creature cultivation, butchering, and dealing with and preparing creature items. Yearly per capita meat utilization in Ethiopia is less than 8.5 kg per individual per year, which is the second lowest in all of Africa. This has a genuine effect on the whole animal's esteem chain from breeding to meat generation (FAO, 2019).

Ethiopia has a diverse range of animal resources and a strategic location, enabling it to promote animals and animal products to a broader global audience than other African countries. The nation exports meat and live animals to the Middle East and a few African nations. Chilled/frozen beef burgers, goat meat, sheep, chilled veal, chilled camel meat, and red offal are predominantly exported to the United Arab Emirates (UAE), Saudi Arabia, Angola, Egypt, Bahrain, Turkey, and Kuwait. All the exported meat is distributed through official channels, complying with the regulations of the importing countries. Live animals are exported to Somalia, Kenya, Sudan, Djibouti, Egypt, UAE, Saudi Arabia, and Yemen (Alemayehu, 2011).

2.2 Food Safety

Food safety is defined as the conditions and measures necessary to guarantee the safety, quality, and appropriateness of food throughout its preparation and consumption. It remains a key issue in public health for numerous nations, crucial for avoiding foodborne diseases and promoting human health (WHO, 2015). Food safety and hygiene are a significant global health concern, especially in developing countries due to the rise of food-borne diseases (FBDs) and related fatalities. This issue remains critical in both developed and developing nations for individuals, food firms, and food oversight authorities (Abd *et al.*, 2018).

Factors contributing to the potential threat posed by food involve the establishment of a food safety system, comprising various elements. Initially, legal frameworks should specify minimum hygiene standards; food producers need to implement safety protocols; and regulatory bodies must oversee and audit food industry entities to ensure compliance with prevailing laws. Instances of foodborne illnesses, jeopardizing public health worldwide, stem from food contamination throughout the entire supply chain. As outlined by Aslı *et al.* (2016), significant practical efforts are still required to address the factors challenging food safety, despite their apparent straightforwardness in theory.

Workers who engage in unhygienic practices in slaughterhouses create an environment where zoonosis may spread among them and contaminate the meat that will be sold (FAO, 2008). Strict adherence to good slaughterhouse hygiene practices in meat production is crucial in preventing microbial carcass contamination (Zweifel *et al.*, 2005). Food handlers must maintain excellent hygiene practices to reduce cross-contamination and protect consumers from foodborne diseases (Abdul-Mutalib *et al.*, 2012).

Ensuring food handlers possess the needed awareness, knowledge, and skills in food handling is vital. Training and education play essential roles in their responsibilities (Martins *et al.*, 2012). In comparison to general food hygiene training, specific training for meat handlers emerges as a highly effective strategy for addressing and reducing food safety risks (Jianu and Golet, 2014). Comprehensive food safety training provided by organizations, along with sufficient resources, can enhance food handling and workplace safety protocols.

2.3 Prevalence of meat-born microbial pathogenic in Ethiopia

Outbreaks of foodborne diseases remain a major global health challenge. Improper handling of raw meat leading to cross-contamination is a significant issue in developing countries (Adesokan, 2014). Foodborne illnesses occur when food is contaminated by microbiological agents, naturally occurring toxins, and chemicals (Seleshe *et al.*, 2014).

Enterotoxigenic E. coli, *Campylobacter jejuni*, and other bacterial entero-pathogens were the most common cause of acute diarrhea (Sanders *et al.*, 2019). Non-typhoidal *Salmonella enterica* was

responsible for the highest number of deaths among diarrheal disease agents. *Salmonella typhi*, hepatitis A virus, and aflatoxin were also significant causes of foodborne deaths (WHO, 2015). Poor facilities and improper animal handling in slaughterhouses exacerbate beef's microbial contamination, potentially leading to the transmission of foodborne diseases to humans (Cook *et al.*, 2017).

Consumption of contaminated beef and beef products is a significant route of *Salmonella* and *E. coli O157* transmission to humans (Pires *et al.*, 2019). This has been associated with numerous foodborne outbreaks (Plumb *et al.*, 2023), particularly important in Ethiopia where the consumption of raw or under-cooked beef, such as raw meat (“kurt”) or beef tartare (“kitfo”) made from raw minced beef, is prevalent (Seleshe *et al.*, 2014). Hence, the consumption of raw beef products poses a risk of *Salmonella* and *E. coli O157* infections in Ethiopia. During the slaughtering process, beef carcasses may get contaminated with *Salmonella* and/or *E. coli O157* due to direct exposure to feces and animal hide (Gutema *et al.*, 2021). Research by Ayenew *et al.* (2021) revealed that swab samples from cattle carcasses slaughtered at the Bahir Dar municipal slaughterhouse were found to carry virulent *E. coli O157:H7*. The occurrences of *S. aureus*, *E. coli O157:H7*, and *Salmonella* outbreaks in various Ethiopian regions are outlined in Table 1.

Table 1: Meat-origin food-borne bacterial pathogens prevalent in Ethiopia.

Pathogenic Bacteria	Sample	Prevalence (%)	Region	Reference
<i>S. aureus</i>	Meat	9.4	Addis Ababa	(Adugna <i>et al.</i> , 2018)
	Camel Carcass	12.1	Jijiga	(Tegegne <i>et al.</i> , 2019)
	Meat (beef)	22.5	Bishoftu	(Bersisa <i>et al.</i> , 2019)
	camelmeat	35.3	S. Oromia	(Hassen <i>et al.</i> , 2021)
<i>E.coli O157:H7</i>	Camel meat	4.3	Jijiga	(Tegegne and Phyto, 2017)
	Meat	4.4	Jimma	(Sebsibe and Asfaw, 2020)
	Carcass	7.1	Bishoftu	(Gutema <i>et al.</i> , 2021)
	Meat	7.2	Ambo	(Tadese <i>et al.</i> 2021)
	carcass swab	8.9	Bahir Dar	(Ayenew <i>et al.</i> , 2021)
<i>Salmonella</i>	Carcass	12.5	Wolaita	(Wabeto <i>et al.</i> , 2017)
	carcass swab	11.3	Jimma	(Takele <i>et al.</i> , 2018)
	Meat	14.3	C/Ethiopia	(Bersisa <i>et al.</i> , 2019)
	Meat	5.6	Ambo	(Gebremedhin <i>et al.</i> , 2021)
	Carcass	6.67	East Shewa	(Alemu <i>et al.</i> , 2022)

The safety and quality of meat are indeed crucial concerns in marketing and have garnered significant attention within the medical community and the broader population. Proper sanitary slaughtering and dressing procedures are essential to minimize the contamination of fresh raw meats. Understanding the levels of microorganisms in food items is fundamental to ensuring food safety and quality. Additionally, the presence of high levels of *Coliforms* and *E. coli* in food samples is commonly used as an indicator of poor food quality, fecal pollution, and inadequate sanitation during food processing (Bhandari *et al.*, 2013, Kim *et al.*, 2016). The importance of estimating the total number of microorganisms in food samples, such as meat, cannot be overstated (Lee *et al.*, 2010, Tafesse *et al.*, 2014). Various techniques and methods have been developed to enumerate the total number of microbes, including the total Enterobacteriaceae count (TEC), *coliform count*, and *E. coli* count in any given food sample. One such method is the total viable

plate count (VPC) or aerobic plate count (APC), which serves as a valuable indicator of overall bacterial populations in food samples (Bhandari *et al.*, 2013, Tafesse *et al.*, 2014).

2.4. Food Safety Interventions

Food safety interventions are of vital importance to ensure public health, as they affect the amount and types of foodborne microbes that can cause diseases in public health. Approximately 76 million cases of foodborne illnesses occur each year in the United States. It is important to practice good food safety measures to reduce the risk of contracting a foodborne illness. These microbes are often present in meat and poultry products. Although many microbes are destroyed during cooking, some are not. If the consumer is not aware of the presence of the microbe because the food does not appear to be spoiled, this can lead to high-risk behaviours such as consuming undercooked meat, furthering the spread of the microbe. It is critical to maintain a clean and pathogen-free environment at all stages of meat production, from live animal production to reaching the consumer's plate (White *et al.*, 2022). This concept involves the farm-to-table process and is most accurately explained through the Hazard Analysis and Critical Control Points (HACCP) framework. HACCP is a methodical approach to recognizing, assessing, and managing food safety risks. A food safety hazard is any biological, chemical, or physical property that may cause a food to be unsafe for human consumption. The HACCP approach has been to implement these food safety interventions in the form of microbiological testing of carcasses and environments, genetic-based microbial identification, whole genome sequencing to determine sources and dissemination of pathogens and engaging in epidemiological and observational studies. Through these studies, the industry intends to prevent foodborne illnesses and protect public health by better understanding the pathogens and how they contaminate meat and poultry products (Da and Hibdon, 2022). This research is more complex than it seems and is often taken for granted by the public. Food safety interventions are not easily carried out and require an understanding of the pathogen in its totality, including how it functions and survives how it contaminates products, the extent of the contamination, and the implications of the contaminated product on public health. High-quality interventions will provide the best insurance to prevent foodborne illness and safer products for the consumer (Sher *et al.*, 2021).

2.5 Importance of Food Safety

Food production now faces significant challenges related to food safety. The consequences of contaminated food and food safety have come to the attention of the general population. The need for better food safety procedures has become more pressing in light of recent outbreaks of foodborne illnesses (Tierney, 2022). This is especially true in the meat and food industries, as customers' concerns about the safety of the food they eat have grown. When it comes to meat, customers are worried about both the safety of the meat during processing and the safety of the finished product. This worry is warranted because, in comparison to other foods, meat and poultry products have been linked to a disproportionately high number of reported cases of foodborne illnesses (Canning *et al.*, 2023). As a result, there is now more regulation and oversight of food safety in the meat sector. The goals of food safety interventions are to protect food during processing and to avert foodborne illnesses. This is achieved by implementing science-based control strategies that prioritize avoiding viruses and contamination in food. Due to their large reduction in the number of foodborne illnesses linked to meat and other foods, these measures are now considered crucial to food safety (Havelaar *et al.*, 2022).

Types of Food Safety Interventions

Although it is widely recognized that individual food behaviours do impact the safety of food, the majority of food safety research has been conducted in consumer and/or institutional food handling and preparation environments (Liguori *et al.*, 2022). There is a great need for more research at the individual and food worker level that seeks to identify specific behaviours, develop interventions to change those behaviors, and then measure the impact on food safety (Insfran-Rivarola *et al.*, 2020; Alemayehu *et al.*, 2021). The same study documented failures in safe food handling practices during the preparation of hamburgers, including cross-contamination between the raw meat and ready-to-eat food and the washing, rinsing, and sanitizing of cooking utensils (Zhang *et al.*, 2022). These food-handling behaviours directly led to laboratory-confirmed cases of foodborne diseases due to E. coli O157 and Hepatitis A in the workers and consumers of the hamburgers (Adzitey *et al.*, 2021). By simply changing these individual food-handling practices, the incidence of foodborne diseases could have been greatly reduced (Anihouvi *et al.*, 2020).

Individual practices such as safe food handling behaviour, the use of a food thermometer and safe cooking temperatures, and food recall behaviour, which are influenced by attitudes, can greatly impact the safety of the food being prepared (Yang *et al.*, 2021). A recent study documented the occurrence of undercooked hamburgers cooked in food service establishments (Teffo & Tabit, 2020). Forty-eight percent of the food workers reported that they never used a thermometer to check the doneness of hamburgers. For those who did, only 11% knew the safe minimal internal cooking temperature for ground beef. This lack of knowledge and practice of safe cooking temperature guidelines is a contributing factor to foodborne illness (Da *et al.*, 2023). Interventions that influence food safety all have a distinct goal (Ehuwa *et al.*, 2021). The implementation of food safety procedures is done to ensure that the food being prepared is safe to eat (Garcia *et al.*, 2020). Among the various types of food safety interventions, work at the individual, work environment, and institutional level has been widely recognized as being of great importance (Shahbaz *et al.*, 2020)

Implementation of Food Safety Interventions

The implementation of food safety interventions should be conducted with a scientific approach to ensure that every step taken is beneficial to the production of safe, raw products. It has to be accepted by the regulatory authorities, the industry, and the consumers. For these interventions to be widely accepted, they must be economically feasible for both industry and regulatory authorities (Soon *et al.*, 2020). It is often difficult to convince company management to invest in a concept that does not have a guaranteed economic return. For interventions to be sustained, they must also be simple, logical, and flexible. Changes in legislation and consumer trends can result in modifications to food safety interventions, and the intervention should be able to accommodate this. The objectives of interventions must be met each time they are implemented; therefore, it is necessary to have monitoring procedures to verify their success. Interventions in food safety cover a wide range of methods. They can include anything from complete system changes to the simple application of a specific antimicrobial (Tesson *et al.*, 2020). Generally, the most effective interventions are those that are targeted at a specific hazard and those that can be integrated into a process. If it is possible, physical methods are preferred than chemical methods as they are

generally less harmful to the product. An example of this would be using high-pressure processing as an alternative to heat pasteurization. The development of food safety interventions is an ongoing process. The effectiveness of interventions is heavily dependent on how well they are understood by the industry and how they are implemented. The continued engagement of food safety professionals is essential so that assistance is provided to the industry and new, effective methods can be developed (Nardi *et al.*, 2020).

2.6. Knowledge and Attitude on Food Safety

Reasons for risk perception differences may not only be because of the food itself or the process through which it is manufactured. It is often connected to the severity of the illness or the vulnerability of the individual. The identified high-risk groups of foodborne disease are the elderly, pregnant women, young children, or people with a weakened immune system. Young, fit, and healthy consumers are usually considered less concerned about food safety compared to others. Those who are high-risk themselves and those who have experienced any disease by food poisoning usually have a high concern for food safety as recognized by Gallo *et al* (2020). A foodborne disease for a high-risk group may lead to a chronic disease, miscarriage, a severe disease in the baby, the death of a child, and serious damage to an adult's health, as stated in Lennard (2020). Severe incidents can act as a driving force for behaviour changes. Cases in which a high-risk individual suffered from foodborne infection have led to legal actions against a food manufacturer. This draws a strong conclusion that food is relatively a hazardous asset to a certain crowd and there should be the existence of safer food and stringent with more control in the food industry (Mshelia *et al.*, 2022).

While the majority of individuals with foodborne diseases will recover quickly and effectively without any medical intervention (Daniel *et al.*, 2020), for some people the consequences of foodborne disease can be very serious and, in the most serious of cases, fatal (Lennard, 2020). The importance of safe food to people and societies should not be underestimated. Food is a vital commodity that everyone needs to consume to live. With such a common commodity, it is only natural for people to gain food from whatever source without giving a second thought to food safety (Imathiu, 2020). In recent years, food safety has become a matter of great significance to

consumers, policymakers, and enforcement agencies (Nardi *et al.*, 2020). The food supply is dynamic and ever-changing, and the increase in the consumption of fresh and convenient food products combined with lifestyle changes have brought consumers a variety of new and potential food safety risks. In addition, foodborne disease outbreaks continue to occur in many countries around the world and are reported frequently in the media, which has had an effect on consumer attitudes and the food industry (Gallo *et al.*, 2020). The number of foodborne disease outbreaks that occur is unknown, as many of these infections will not be reported, either because the individual did not realize that they had a foodborne disease, or because the individual simply did not report the illness (El-Zein *et al.*, 2018). However, it has been estimated that there are approximately 7 million people across the UK who suffer from a mild to severe form of food poisoning each year, with 5000 of these cases being serious enough to require hospital treatment. Of these cases, it is reported that 100 people die from foodborne diseases each year (Aljamali *et al.*, 2021).

In Ethiopia, it was agreed that a baseline survey of slaughterhouses, butchers, and consumers should be conducted to understand the existing practices and problems and set a point of comparison for later impact assessments of the interventions (Zelalem *et al.*, 2024). This is the report on the baseline survey data collected from the slaughterhouses, butchers, and consumers of Bishoftu, Dukem, and Modjo towns in central Ethiopia, and its focus is on the food safety knowledge, attitudes, and reported behaviours of the people involved in slaughtering animals and handling and consuming meat (Zelalem *et al.*, 2023; Mazhangara *et al.*, 2024). An informal survey of consumers and stakeholders conducted by the International Livestock Research Institute (ILRI) in central Ethiopia found that there is a perception of declining standards of animal slaughter and meat hygiene and a demand for improvements in meat cleanliness, butcher facilities, and meat inspection (Gadisa, 2022). This research was to provide a thorough understanding of the above situations and involve consumers, butchers, and relevant stakeholders to identify and implement feasible individual and community-based interventions (Mekuriaw and Harris-Coble; Muleta *et al.*, 2022). An understanding of local food safety problems and effective interventions is also a requirement for stakeholders hoping to ensure the safety of the global food supply (Teferi, 2020). In Ethiopia, the importance of safe food is recognized in legislation (Proclamation No. 661/2009), which requires food establishments to practice food safety and hygiene and food handlers to obtain

training and certification of their food handling competencies. Nevertheless, enforcement of this legislation is undoubtedly limited, and food safety remains a concern, especially concerning the traditional practices of slaughtering animals and preparing meat and milk products (Ayelign and De Saeger, 2020; Parikh *et al.*, 2022).

None of the above-mentioned studies specifically considered attitudes, which is a more complex psychological construct than knowledge. Moreover, evidence from evaluations of numerous health promotion interventions that involve attitude change, suggests that these interventions are often less successful (Wang *et al.*, 2021). Nonetheless, it is a general contention that when people demonstrate more safety attitudes, the adoption of safe food handling practices tends to be more positive (Sayuti, and Materal, 2020). Thus, it is important to take knowledge-attitude-practice links into account and seek to identify these relationships in different sociocultural settings that inform the design of food safety interventions to yield the best results (Da, and Spier, 2021).

It is generally agreed that knowledge and attitudes are key factors in the practice of safe food handling, and food safety interventions increasingly incorporate behavioural change models as a result (Ncube *et al.*, 2020). Knowledge can be gained and measured, and if defined in terms of familiarity with and understanding of facts, it can be relatively readily conveyed to consumers and food handlers (Soon *et al.*, 2020). Indeed, many food safety educational campaigns have sought to improve knowledge as a first step to changing behaviour (Alemayehu *et al.*, 2021).

The importance of food in providing nutritional benefits for the improvement of good health is not in doubt (Alimi *et al.*, 2022). Nonetheless, unsafe food and the improper procedures to handle and process it cause many health hazards and lead to foodborne diseases and deaths (Rakha *et al.*, 2022). Although governments and international bodies take various measures to protect food, the role of consumers and food handlers is still more important than it is at present, as their behaviour and practices have a significant impact on the production and consumption of safe food (Christiana *et al.*, 2022).

2.7. Awareness of Food Safety Practices

The pathogen division of Health Canada, the Bureau of Microbial Hazards, conducted a risk assessment of pathogenic bacteria in beef run on alternative Lookout times to the recommended endpoint. According to the risk results, populations of both young children and elderly people are frequently exposed to the risks of consuming undercooked beef (Brusa *et al.*, 2020). Addis Ababa and urban areas are consuming more beef than before may be attributed to increasing urbanization and, notably, the rapid growth of fast-food restaurants in reformed urban areas of Ethiopia (Tesson *et al.*, 2020; Deneke *et al.*, 2022).

Many bacteria that cause disease are fecal-borne, meaning that contamination of the surface of meat with feces during slaughter and subsequent cross-contamination in meat handling and preparation may lead to foodborne illness (Zdolec and Kiš, 2021). Meat safety has relevance to public health; in most instances, undercooked meat is not safe for human consumption (Gutema *et al.*, 2021). Consumption of raw or undercooked contaminated meat can lead to bacterial infection and food poisoning (Singha *et al.*, 2023).

Previous studies have shown that slaughterhouses and butchers in Addis Ababa have unsatisfactory levels of food safety, with important levels of visible fecal and blood contamination in the slaughterhouses and on the meat (Gebremedhin *et al.*, 2021). A study conducted in Addis Ababa found that meat from butchers contained important levels of bacterial contamination, with 17.5% of minced meat samples testing positive for *Salmonella* species (Zelalem *et al.*, 2024). This has serious implications; the important level of bacterial contamination in food is associated with several episodes of large outbreaks of food poisoning in Addis Ababa and, in some instances, has led to life-threatening illness (Admasu *et al.*, 2023).

Food safety is an essential part of the food production chain (Girmay *et al.*, 2021). The need for proper food safety practices is particularly important in developing countries, where a lack of knowledge, awareness, an implicit attitude, and proper infrastructure for ensuring food safety may lead to higher levels of foodborne diseases (Mutua *et al.*, 2022). Ethiopia is no exception, with

reports of high levels of food and waterborne diseases, many resulting from bacterial contamination in meat (Dinede *et al.*, 2020).

2.8. Attitude to Food Safety Regulations

It was noted in the result carried out in Addis Ababa, Ethiopia, that slaughterhouse and butcher shop staff showed inadequate formal training or technical failings, and many survey respondents frequently appear to be proxy teachers without adequate practical experience. Consequently, process-specific or derived knowledge, such as the concern for compliance with global quality or center food safety standards, is less familiar to the local industry of livestock and production (Gebeyehu and Tsegaye, 2022). At least for workers and, to some extent, for farmers, this leaves the residents slack to submit to failings and produce low-quality goods of inadequate standards. Additionally, over-regulation and achievement risk may become barriers to global industry compliance with minimum benefit levels and climate-economy policies as observed. Large and small establishments alike would be profusely wounded by regulations that fail to acknowledge the financial price ratio of technology (Gutema *et al.*, 2021). Failure to realize the maximum profit targets for establishments' safety and quality regulation that sets the requirements as levels unsustainable for economic interpretation would yield cost hardship due to incompliance complexities (Zelalem *et al.*, 2024).

However, food safety regulations in developing countries, particularly in Ethiopia, will be unproductive and suffer great foodborne disease incidences and heavy economic losses, as well as food security issues in general, when compliance and giving importance to the basic principles of good processing and slaughtering standard operating procedures (SOPs) between slaughterhouse and butchery retailers are not adequate (Teferi, 2020). The focus was on output-based rather than process-based inspection, where emphasis was on microbial testing of products rather than plant and process controls, for determining when product defects are most likely to result. Even in the United States and the United Kingdom, industries located in both developed and developing countries are faced with unforgiving pressure under the new regulations. These rules, aimed at both the nation's local industry and the domestic use and imprisonment of the local players, need to be acquainted with the agenda of leading-edge global development and mechanisms (Asfaw *et*

al., 2022). The importance and regulatory regimes for international trade mean that historically, the territories within the developed world are still obliged to grapple with international quality designs. The challenge with these is to reflect the highest ethical and environmental considerations into capacity, regulation, and privilege (Gazu *et al.*, 2023).

2.9. Training and Education on Food Safety

Time and motion data revealed that out of 36 minutes of work for butchers, 23.2%, 23.0%, 30.0%, 20.2%, and 23.4% of the time were spent on idle time, waiting, butchering/hiding, cleaning, and other works, respectively. The prevalence of chronic fatigue was 43.8% in trained butchers and 31.6% in non-trained butchers (Miazga *et al.*, 2023). Wilson Citadel was the only slaughterhouse with three trained and one untrained worker. Education status at all levels, background in food safety training and education, and working experience among butchers and health professionals were not significantly different among the three towns (Maicas-Pérez *et al.*, 2023). Food safety management requires regular educational training for food handlers (Insfran-Rivarola *et al.*, 2020). Safe food handling practices serve as a public health intervention to reduce the burden of food contamination (Addo-Tham *et al.*, 2020; Young *et al.*, 2020).

2.10. Hygienic Practices in Slaughterhouses and Butcher Shops

This study aimed to evaluate the hygienic practices in slaughterhouses and butcher shops in the three selected towns of Bishoftu, Dukem, and Modjo. Hygienic handling of meat in time is necessary to get a minimum level of hygiene in slaughterhouses and butcher shops, therefore helping to prohibit the production and supply of unsafe, wholesome meat (Nagel-Alne *et al.*, 2022). Animal slaughter control and safe, clean meat handling before and after reaching the butcher shop are crucial for consumer protection and overall food safety (Waldman *et al.*, 2020). Consumers have the right to safe food, and governments have the responsibility to mandate and uphold high hygiene standards in food establishments (Edwards-Callaway and Calvo-Lorenzo 2020).

2.10.1. Personal Hygiene of Workers

Workers in slaughterhouses and butcher shops benefit from good hygiene practices by enhancing skills, competitiveness, and job creation (Gebeyehu and Tsegaye, 2022). Official support, financing for expansion and modernization, consulting projects, maintaining the establishment's image, and market presence are crucial (Agu *et al.*, 2021). Meat being perishable, its processing, handling, storage, and logistics require meticulous control to prevent any potential damage. Therefore, special care is essential in meat production to avoid any adverse outcomes (Zelalem *et al.*, 2021). Workers in slaughterhouses and butcher shops come into direct contact with animals and various animal parts like meat, bones, feathers, and internal organs. It is crucial for employees at these facilities to maintain high standards of personal hygiene, receive adequate training, and use personal protective equipment correctly (Gebeyehu and Tsegaye, 2022). Failure to adhere to hygiene regulations by workers in slaughterhouses and butcher shops not only risks their well-being but also impacts the quality of sanitary practices within the establishments (Gutema *et al.*, 2021). These repercussions significantly influence the supply of animal products, potentially leading to negative outcomes for both businesses and public health (Yimana and Hassen, 2024).

2.10.2. Cleaning and Sanitization Procedures

Industrial meat production is indisputably the main source of most animal protein consumed in both developed and developing countries. It is also an undeniable fact that meat production has grown faster than the growth of the wages of the workers involved in the productive process, both socially and technically undermining the development of better methods for the systematic control of health and food safety (Kleyn and Ciacciariello, 2021). Therefore, it was necessary to regulate the sector, thus creating control mechanisms that would guarantee the population a traceable, safe, and reliable product before consumption (Henchion *et al.*, 2021). Sanitary inspection is understood as an institutional system responsible for making meat and its derivatives safe and clean, avoiding the transmission of diseases, whether infectious, contagious, to man, animals, or non-contagious (Espinosa *et al.*, 2020).

For centuries, people have explored the consumption of meat, whether domesticated or wild animals. The discovery of fire and the use of cutting tools have favoured even more animal consumption. The consumption of meat is a worldwide habit and has also been the protagonist of stories and religions (Magouras *et al.*, 2020). Today, we can find many religions that prohibit the free consumption of certain types of meat. Anatomically and physiologically, human beings can consume meat from any animal species; however, cultural habits interfere with the choice of meat. Some tribes mainly fill their diet with blood, milk, and meat, and over the years, anthropologists have seen that they are agile and very healthy (Hayek, 2022). Their animals are wild and rarely sick. With the domestication of animals, this situation changed because animals began to have diseases typical of domestic animals. The relationship between risk and public health was evident, reinforcing the need for inspection services and sanitization (Milbank and Vira, 2022)

2.10.3. Pest Control Measures

As intra-domicile disinfestation is not allowed, the implication of public health risks through flies can be pondered. The ineffectiveness of public health measures for disease prevention questioned the existence of better environmental management strategies for fly control and better methods to manage slaughterhouse effluents (Dupont *et al.*, 2017). Recent research has shown that flies can facilitate dissemination to food and water bodies from the excreta of patients. Thus, flies are known to be one of the transport agents of antibiotic resistance genes, disseminating resistant bacteria from point sources to non-susceptible hosts, both among terrestrial and aquatic ecosystems. Precluding this vital fly of domestic animals, where a larger share of antibiotics is administered, would thus reduce the probability of the occurrence of possible health disasters for the human race. The transmission of antibiotic resistance from animal to human is also a substantial concern. All these two resistances come from the excreta of animals in slaughterhouses and the treated, which enter an environment along the antibiotic resistance genes (Bersisa *et al.*, 2019). Slaughterhouses and butcher shops are the places where household animal carcasses are dressed, dissected, and prepared for marketing. Slaughterhouse refers to places in premises where livestock is slaughtered and prepared for the market, while butcher defines only the houses where animals or birds are slaughtered, and meat is prepared for sale. It is a common practice that after each slaughter or

dissection, house flies infest the animal flesh and suck blood from the carcass (Pearl Agu *et al.*, 2021).

2.10.4. Equipment and Utensil Hygiene

Irrespective of source, food of animal origin should be safe, nutritious, and wholesome. However, contamination of these foods can occur at any point during the entire production process, from farm to plate. Subsequently, the preparation and handling of such foods initiates recontamination, which breaches the standards for food safety and hygiene (Prache *et al.*, 2022). Equipment, tools, and utensils repeatedly used in the process of food preparation, especially for ready-to-eat and other highly nutritious foods, are common surfaces for the attachment and build-up of microorganisms (Odeyemi *et al.*, 2020). As a result, it is necessary to sanitize and disinfect equipment to maintain cleanliness and prevent recontamination. It is particularly important to pay attention to the primary meat sector (including slaughterhouses and butcher shops), where the food safety approach is often deficient due to factors such as poor management, inappropriate sanitation practices, and inadequate facilities (Abebe *et al.*, 2020).

Poor hygiene in equipment and utensils might result in infection and food poisoning to the community. Beyond the health danger, it might also give rise to other risks, harms, and unethical issues affecting the institution. Handling of meat and meat products are potential sources of pathogens in slaughterhouses and butcher shops (Shaltout, 2024). The necessary processes and tools that will ensure that these sources of contamination are either not present or are not a risk to human health should be strictly followed (Alves *et al.*, 2021). The use of contaminated equipment and utensils, coupled with the practice of unhygienic behaviour, could result in a high prevalence of contamination. Equipment and utensil hygiene ensures food safety, quality, and standards with no potential harm to human health (Galindo *et al.*, 2021).

Safe food is the major requirement of food quality. To keep the food safe, it has to be in perfect standard throughout the food chain and processing. Meat provides food that is good for energy and protein in body consumption (Yimana and Hassen, 2024). But in contemporary times, meat has been associated with foodborne diseases because of contact with different harmful bacteria, which

can be caused by equipment and utensils (Kebede and Getu, 2023). Equipment and utensils used for butchering and related activities are very important for the spread of microorganisms. Studies show that slaughterhouses and butcher shops can contribute to population health problems and diseases (Nyokabi *et al.*, 2023).

2.11 Microbial Load on Meat and Its Contact Surfaces

The fecal material that is not completely removed from the skin of animals and that comes out of the gut of cattle while they are hanging in the slaughterhouse can contaminate the skin of animals from victims of animal diseases. Many pathogenic bacterial species can contaminate meat in the slaughterhouse. Of these, *Salmonella* spp., *Campylobacter* spp., and *L. monocytogenes* are the major bacterial species that contaminate meat, resulting in disease (Asfaw *et al.*, 2023). Different studies from different countries have shown that the microbial load on the surface of meat in slaughterhouses, meat facilities, and butcheries is high and puts our health at risk. There is little evidence of the microbial load on the surface of meat and its environment in Ethiopia, with most of the detailed work conducted in different states of America and Africa (Nurye and Demlie, 2021). The research described in this article aimed to provide sheep, goat, and cattle producers with an understanding of the hygiene and sanitation that slaughterhouses and butcher shops are practicing in the city slaughterhouse and butcher shops, and finally, it also offers solutions to the public's complaints during the purchase and handling of meat at retail shops (Kebede and Getu, 2023).

A meat producer that purchases live animals, slaughters them and distributes the meat to retail locations processes meat in a slaughterhouse. Contamination begins when the meat is transferred to the retail outlet (Asfaw *et al.*, 2023). Meat and its touch surfaces are much polluted, from the slaughterhouse to the retail store. There are no disease-free animals, and feces are not entirely cleaned from corpses, resulting in high levels of contamination of meat and touch surfaces at the slaughterhouse. The ready-to-eat meat and its touch surfaces at retail stores are believed to be contaminated by a variety of sources, including cutting machinery, salespeople, and air (Kebede and Getu, 2023). Surfaces in butcher shops are important pathways for the possible cross-contamination of ready-to-eat meat. Despite this, meat is a complete source of protein that contributes to the growth and health of the body. The research aimed to investigate the microbial

load on the surface of the meat and its surroundings in a slaughterhouse and provide shops in a city in Ethiopia (Sebsibe and Asfaw, 2020).

2.11.1. Sources of Microbial Contamination

Microbial contamination of food animals begins on farms where animals are being reared under unhygienic conditions (Uzoigwe *et al.*, 2021). The possibility of contamination in meat may be related to the level of animal gastrointestinal shedding, dirtiness, and infectious agents in the farm environment (Kyayesimira *et al.*, 2020). A study revealed that 70% of beef contamination was attributed to the fecal load in the slaughterhouse and suggested that handling practices should be improved to reduce it (Gutema *et al.*, 2021).

Rapid urbanization has exposed the consumption of meat to a variety of microbial species due to poor hygienic conditions throughout the food continuum and poor or no infrastructure (Teshome *et al.*, 2020). The huge disparity between the demand and supply of meat has increased the price and the risk of exceeding the capacity of low-income urban consumers (Nurye and Demlie, 2021). During slaughtering and meat-cutting practices or handling, the meat becomes infected or contaminated by animal faeces and skin (Atlabachew and Mamo, 2021).

Microbial contamination of food of animal origin is a major food safety concern that leads to human illness. Urbanization and population growth have multiplied the number of slaughterhouses and butcher shops in Ethiopia to meet the increasing demand for safe animal-sourced protein (Asfaw *et al.*, 2022). In Ethiopia, documented evidence shows that animals' unprocessed food products are responsible for the transfer of microbial infectious agents (Abebe *et al.*, 2020). However, these sources of contamination are often neglected in the implementation of food safety and quality management systems along the food continuum (Gemedo *et al.*, 2021)

2.11.2. Testing Methods for Microbial Load

The importance of estimating the total number of microorganisms in food samples, such as meat, cannot be overstated (Lee *et al.*, 2010, Tafesse *et al.*, 2014). Various techniques and methods have

been developed to enumerate the total number of microbes, including the total Enterobacteriaceae count (TEC), coliform count, and E. coli counts in any given food sample. One such method is the total viable plate count (VPC) or aerobic plate count (APC), which serves as a valuable indicator of overall bacterial populations in food samples (Bhandari *et al.*, 2013, Tafesse *et al.*, 2014).

2.11.3. Factors Affecting Microbial Growth

Rapid microbial growth in meat is usually indicated by a high initial microbial load, temperature, and inappropriate packaging. In anticipation of these negative effects, manufacturers take various measures, such as packaging with a modified atmosphere resulting in the replacement of air with another gas or group of gases that are more suitable for meat preservation, a reduction of moisture migration from the product, etc. (Rolfe and Daryaei, 2020). A reduction in storage temperature is one of the most important methods, especially when fresh meat needs to remain refrigerated for a long time. Inhibition of pathogenic and spoilage microorganisms in meat can be achieved by various chemicals, physical agents, and biological approaches (Tapia *et al.*, 2020). These techniques are complementary and have a cumulative effect on the extension of the shelf life of meat and meat products. In this way, spoilage microorganisms affecting the sensory quality of the product can be inhibited, as well as pathogenic microorganisms. Meat is an essential contribution to the food sector (Barbosa-Cánovas *et al.*, 2020).

However, it is one of the most perishable foodstuffs and can transmit disease. This is mainly due to the high water and protein content of meat. Factors affecting microbial growth in meat are divided into intrinsic factors such as pH, water activity, oxidation-reduction potential, etc., and extrinsic factors such as temperature, humidity, packaging, air, and gas quality (Rolfe and Daryaei, 2020).

2.12. Food Safety Regulations and Compliance

In Ethiopia, there is a strong focus on aligning food safety regulations with global trade norms established by organizations such as Codex, World Trade Organization (WTO) offers, and agreements on technical trade barriers. To modernize and raise the standards for food safety and

quality, some institutional and legislative changes have been made since the 1970s. The problem has remained largely unsolved in practice due to the failure in the enforcement of standards due to a lack of financial and technical capability of the food regulatory authority and legal system, despite various governments taking steps to improve food enforcement and try to harmonize food safety regulations with the developments in international food hygiene measures (Nyokabi *et al.*, 2023). Institutional changes drive decision-making. The food industry is being grouped into something negative rather than something that people need, and this is being done by renaming and restructuring regulatory bodies, as well as by establishing alternative organizations without improving regulatory capability (Traore, 2021).

Despite the challenges affecting the implementation, execution, and control of national rules and regulations concerning food companies, capacity building has not been successful. Therefore, the government should view enforcement issues to safeguard the public against foodborne illnesses by enforcing laws and regulations (Jiren *et al.*, 2021).

The regulation requires resources, enforcers, and adherence to clear standards. Regulatory agencies must possess the skill and competence to effectively regulate (Mengistu and Mahesh, 2020). Food safety and security principles, such as transparency, scientific understanding, necessity, international goals, consistency, and market and consumer responsibilities, are crucial for market failure prevention, shaping standards, codex, policy, legal systems, and enforcement (Wabelo, 2020; Semete-Makokotlela *et al.* 2022)

3. MATERIALS AND METHODS

3.1 Study Area

The research was conducted at slaughterhouses and butcher shops in selected towns of the East Shoa Zone, Oromia, Ethiopia (Dukem, Bishoftu, and Modjo town) from November 2022 to May 2024. These study areas were in central Ethiopia, in the East Shoa zone of Oromia regional estate at 34.1 km, 60.5 km, and 75.5 km respectively from Southeast of Addis Ababa, Ethiopia (Fig. 1). Presently, Dukem town is merged with Bishoftu city; thus, Dukem now stands as the largest sub-city of Bishoftu. The selection of these three towns was purposeful, driven by their rapid population growth and urbanization, leading to a high demand for animal-derived food.

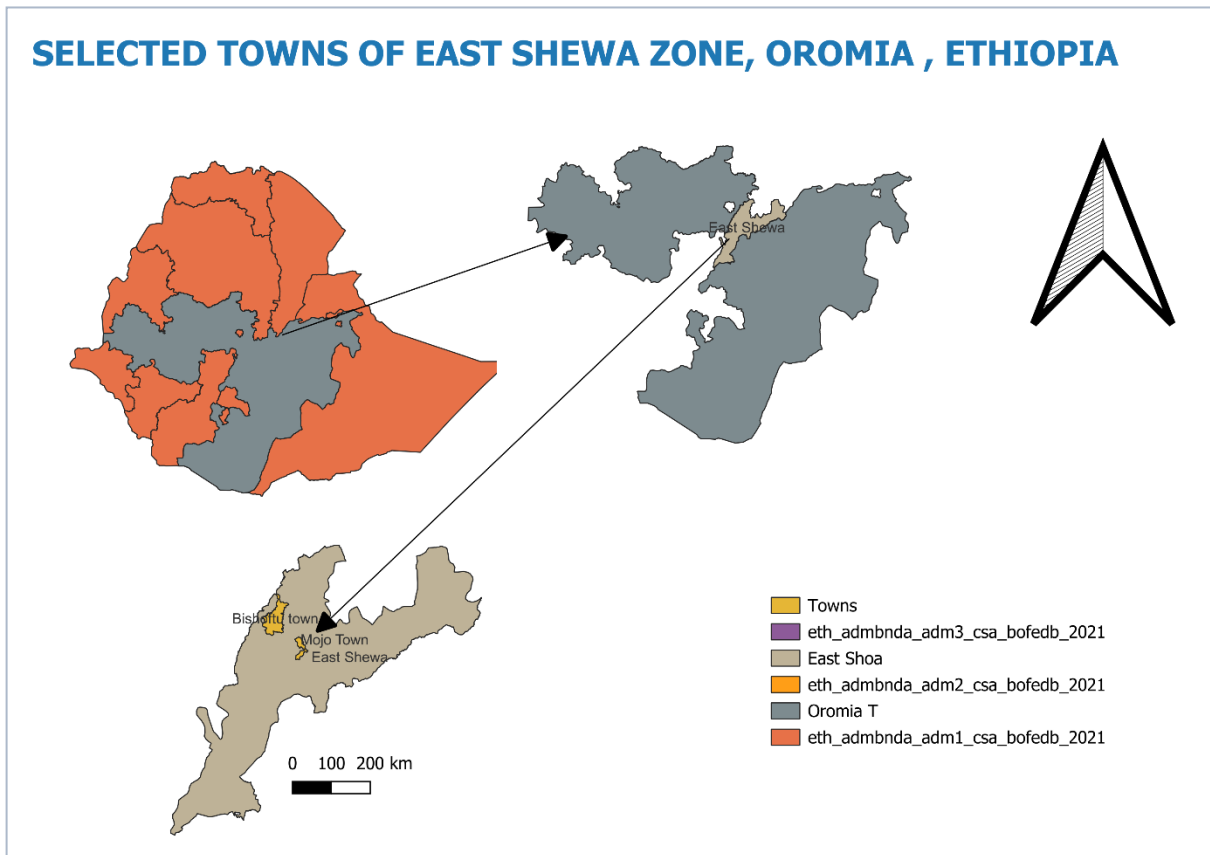


Figure 1: Map of Ethiopia and Oromia region depicting the location of the study area

3.2. Study population.

The target study population was slaughterhouse and butcher shop workers in Bishoftu, Modjo, and Dukem towns of the Oromia region of Ethiopia that was selected systematic simple random sampling method from the list of employees. Slaughterhouse and butcher shop workers, including meat inspectors (veterinarians and animal health workers), meat sellers, meat transporters and managers, were the sources of information for this study.

3.3. Study Design

A cross-sectional survey and swab sampling for bacteriological identification were conducted with meat handlers at Bishoftu, Modjo, and Dukem Town from 58 butcher shops and 3 slaughterhouses, where they were involved in the handling of meat in butcher shops and slaughterhouses sample has taken from meat and its contact surface from November 2022 to March 2024.

3.4. Inclusion and Exclusion Criteria

A systematic simple random (lottery method) selection method of 110 workers in meat handling and quality positions in slaughterhouses and butcher shops who have direct contact with meat and meat handling surfaces with one year of experience was the study population. Those meat handlers who were not well communicated with due to any disability, < 18 years old, illness, or were seriously ill or involuntary to participate in the interviews were excluded from the study.

3.5. Sample Size Determination and Sampling Procedures

A total of 110 participants were selected for the study using systematic simple random sampling based on their employee identification cards. Employees working at slaughterhouses and butcher shops were assessed. This sample size was calculated based on the central limit theorem ($n = 0.25/SE^2$). Where SE is the standard error, which is 0.05 with a 95% CI, according to Arsham (2005), the workers participating in the survey were systematically and randomly for the first one selected according to their wishes. No one was forced to participate in the investigation. The

distribution of the participants was presented as 52 (47.27%) working in the slaughterhouse and 58 (52.73%) in the butcher shop. The hygiene knowledge, attitude, and practice levels of handlers were determined by face-to-face interviews and through direct observation of handler hygiene status and practices. The study was supplemented by bacteriological analysis using sterile swabs taken from meat and its contact surfaces to count colonies with the intention of microbial load. The slaughterhouses and butcher shops located in Bishoftu, Modjo, and Dukem Towns were taken as a sampling frame.

A. Slaughterhouse workers: In the study area, there were a total of 78 employees across 6 slaughterhouses. Out of these, only 52 workers had direct contact with meat samples from Bishoftu, Modjo, and Dukem Town. Bishoftu accounted for 48.08% of the participants, while Modjo and Dukem Town had 25% and 26.92%, respectively.

B. Butcher shop workers: The study area encompassed 260 legally registered butcher shops: 145 in Bishoftu, 70 in Modjo, and 45 in Dukem Town. A total of 58 workers from the towns of Bishoftu (24), Modjo (15), and Dukem (19) were selected for interviews using a systematic process that considered factors like education, gender, employment status, and location. Interviews were conducted until information saturation was reached.

3.6. Data Collection Tools and Methods

3.6.1. Questionnaire Survey

In this study, a semi-structured, pretested questionnaire was used to collect data on meat handlers' knowledge, attitudes, and hygienic practices toward food safety interventions. The questionnaire was based on a research article that had been published previously and was modified for use in this study (Tegegne and Phyto, 2017; Admasu and Kelbessa, 2018; Al-Shabib *et al.*, 2016; Akabanda *et al.*, 2017). A cross-sectional survey using a systematic random sampling technique was conducted with a total of 52 meat handlers from slaughterhouse workers and 58 from retail meat shops in Bishoftu, Modjo, and Dukem Towns. An interview schedule was developed in English for data collection. To obtain data on the identified variables, the interview schedule

included both easy and straightforward questions. Before the final data collection, 5% of the interview schedule was pre-tested. Based on pre-test results, the necessary corrections, additions, changes, and re-arrangements were made to the interview schedule.

The survey was divided into four separate sections. The first part of the survey asked about socio-demographic information, including respondents' location, age, sex, years of experience in meat handling, level of education, position, training after employment, and time of training. Scores of 0, 1, 2, 3, and 4 were assigned to the respective questions asked for all questions in each section. The second part of the questionnaire addressed the knowledge of food safety by asking both slaughterhouse workers 15 questions and butcher shop workers 16 questions. The third section focused on the attitude of meat handlers towards food safety. Both slaughterhouse workers and butcher shop workers were asked 12 and 10 attitudinal questions concerning attitudes toward food safety, respectively. Questions covered topics such as food handling, cross-contamination, hand washing, storage, etc. The fourth part of the questionnaire examined the hygienic practices of meat handlers regarding food safety. In the slaughterhouse, butcher workers were selected with a systematic random sampling method followed by face-to-face interviews. The questions cover essential food safety and hygiene practices, the use of protective wear, proper handling of equipment, etc. In this study, most of the questions asked were closed-ended, meaning participants could only respond with "Yes" or "No" or "I don't know" or "never" or "rarely" or "sometimes" or "often"(Annex. 8.1-8.3).

The interviews were conducted in a private area within the participants' workplace to ensure comfort and minimize disturbances. The questionnaire was read out loud by an interviewer, who then recorded the responses on a paper form. The interviews were conducted face-to-face during working hours without prior notice. On average, each interview took around 30 to 60 minutes to complete. All knowledge-related questions, attitudes, and practices were summarized into a single variable, which had two categories (good and poor knowledge, attitudes, and practices) (Abdullahi *et al.*, 2016; Hamed and Mohammed, 2020; Azanaw *et al.*, 2021).

cutoff points of respondent's Score levels at the slaughterhouse

In the knowledge section of the questionnaire at slaughterhouses, workers were asked 15 questions to gauge their understanding of food safety measures. Each question had three answer choices: "Yes," "No," and "I don't know." Scoring awarded one point for correct answers and zero points for incorrect or "I don't know" responses. Total points were calculated as a percentage of the maximum points available. Respondents' final scores were classified as poor knowledge ($\leq 50\%$) or good knowledge ($> 50\%$) (Agüeria *et al.*, 2018).

For assessing food safety attitudes in the slaughterhouses, 12 statements were given, and respondents were asked the same questions about their attitude of the slaughterhouses: Yes, No, and I don't know. The scoring criterion for the answers was 1 point for each correct answer and 0 points for each incorrect answer and/or I don't know. Finally, the total points per respondent, per section, were calculated as a percentage score based on the total points possible. The final percentage scores of respondents were categorized as poor attitudes ($\leq 60\%$ score) and good attitudes ($> 60\%$ score) with slight modification (Agüeria *et al.*, 2018).

To evaluate the hygiene practices of respondents in the slaughterhouses, 24 questions were given with a 4-point rating scale: never, rarely, sometimes, and often. Ratings varied from 0 points (never) to 3 points (often). Yet, for actions indicating incorrect practices, points were reversed, ranging from 3 (never) to 0 (often). Respondents' total scores were then calculated as a percentage of the maximum possible points. These scores were classified as either poor practices ($\leq 50\%$) or good practices ($> 50\%$) (Agüeria *et al.*, 20018).

Cutoff points of respondent's Score levels at the butcher shop

For knowledge questions, a score of 1 was given for each correct answer. The sum of scores (ranging between 0 and 16) was then calculated, giving an overall score on food safety knowledge. Meat handlers who had an overall score of ≤ 12 were considered to have "poor knowledge," and those who scored ≥ 12 (i.e., $\geq 70\%$ of questions answered correctly) were considered to have "good knowledge" of food safety interventions (Akabanda *et al.*, 2017; Abunna *et al.*, 2023).

Similarly, for attitudes questions, a score of 1 was given to each answer that was consistent with “good attitudes,” and an overall score out of 10 was calculated. Consistent with other studies (Abunna *et al.*, 2023), meat handlers with a score of ≥ 7 (i.e., $\geq 70\%$ of questions answered in the positive) were supposed to have “good attitudes,” and respondents with scores < 7 were believed to have “poor attitudes” (Akabanda *et al.*, 2017; Abunna *et al.*, 2023).

For hygienic practice questions, a score of 1 was given to each correct answer (“good hygienic practice”) and 0 for incorrect answers (“poor hygienic practice”), and an overall score out of 21 was calculated. Consistent with other studies (Abunna *et al.*, 20023), meat handlers with a score of ≥ 15 (i.e., $\geq 70\%$ of questions answered in the good hygienic practice) were thought to have “good hygienic practice,” and respondents with scores < 15 were believed to have “poor hygienic practice.” This cut-off point was used to generate a binary dataset (i.e., good = 1, poor = 0) for each indicator (Akabanda *et al.*, 2017; Abunna *et al.*, 2023).

3.6.2. Meat swab

A total of 48 samples were collected from 4 slaughterhouses 25 samples and 3 butcher shops 23. Samples were taken aseptically from the meat, knife, hands, weighing balance, cutting board, and hook. Regarding sampling points according to Ethiopian Standard (ES) ISO 17604:2006 for beef, there are four sites (brisket, flank, and flank groin, round lateral). These sites are selected based on the prevalence of contamination. The swab method is applicable for the collection of samples from different pieces of equipment used in meat production, like knives, manipulators hands, weighing balances, cutting boards, and d hooks. In the swab method, a sterile cotton swab is rubbed vertically and horizontally against the limited surface area of the material to be sampled. Approximately 25 cm² will be covered by a moistened swab (the swab should be pre-moistened using a sterile rinse medium). The swab is placed in a sterile, cap-capped tube containing 10 ml of buffered solution (peptone water); then, the rod is broken under aseptic conditions. Each swab is numbered appropriately, indicating the site and date of collection. The samples were kept in the icebox and transported directly to the microbiology laboratory of the Ethiopian Agricultural Authority's

animal product and input quality testing centers for microbiological analysis, following biosafety and biosecurity instructions (Daba *et al.*, 2021).

3.6.3 Microbiological analyses

Samples were analysed immediately upon arrival at the laboratory (Annex 8.4). Aerobic plate count (general bacteria), coliform count (related to hygiene and indicator for pathogens), *Escherichia coli* (Gram-negative pathogen), and *Staphylococcus aureus* (Gram-positive pathogen) were determined using slaughterhouse laboratory guidelines for meat hygiene and safety analysis and interpret the outcomes (Daba *et al.*, 2021).

Aerobic plate count

Measure 10 ml of material into a sterile homogenizing bag containing 90 ml of buffered peptone water and thoroughly homogenize it. Prepare a 1:10 sample solution (serial dilution: 10^{-1} - 10^{-6}). One milliliter of each dilution (sample) is poured into sterile petri plates and mixed with APC agar. Incubate at $30\pm 1^{\circ}\text{C}$ for 72 ± 3 hours. Choose plates for the total plate count with colony numbers ranging from 10 to 300 CFU. For each dilution degree, the average number of two plates will be used.

Escherichia coli and *Staphylococcus aureus* on TEMPO count.

Transfer the sample and principal diluents to the TEMPO bag. Add 3 ml of secondary diluent (distilled water) to a vial of culture medium. Transfer 1 mL of the sample to another vial of culture medium. Place the card and culture medium vial on the TEMPO rack, then insert it into the TEMPO filler to initiate the process. Incubate the filtered cards at 37°C for 24 hours. After incubation, place the cards into the TEMPO reader, examine their condition, and interpret the outcomes (ES ISO 4833-1-2022).

$$N = \frac{\sum c}{[(1 \times n_1) + (0.1 \times n_2) \times (d)]}$$

Where N = Number of colonies per ml or g of product

Σc = Sum of all colonies on all plates counted

n1 = Number of plates in the first dilution counted

n2 = Number of plates in the second dilution counted

d = Dilution from which the first counts were obtained

3.7. Study Variables

There are two types of variables in this study: independent and dependent variables. The independent variables were socio-demographic factors like location, sex, age group, experiences, educational level, position, training time after employment, and time of training. Whereas the dependent variables were food safety knowledge, attitudes, and hygienic practices in both slaughterhouses and butcher shop workers. The other variables found were microbial loads on meat and its contact surfaces. The independent variables were the sites of samples taken, like meat, hands, knives, hooks, weighing balances, and cutting boards, and the dependent variables were samples taken from both slaughterhouses and butcher shops.

3.8. Quality Control

The questionnaire was peer-reviewed by food safety experts. The items were revised, reordered, and modified to improve clarity. The new questionnaire was then pretested on 5% of respondents in a slaughterhouse and butcher shop located outside the research area. The internal consistency of the KAP questionnaire in the pilot research was acceptable and reliable (Cronbach's alpha: 0.87). The questionnaire was created in English. The consent of the respondents was obtained before the administration of the questionnaire. All questionnaires were followed by a face-to-face

interview. To administer the questionnaire, the questions were read aloud, with respondents given (30 to 60 minutes) to respond.

3.9. Data Management and Analysis

The data collected during the study, which involved questionnaire survey data and other laboratory investigations, was cleared, coded, and stored in a Microsoft Excel spreadsheet in 2013. The statistical analysis of the data will be performed by using STATA (Statistical Package for the Social Sciences) software version 14. Descriptive statistics such as frequency (%) for categorical, mean, and standard deviation (SD) for numerical data were used, to sum up the data. The significance level was set at a 0.05 alpha value ($\alpha \leq 0.05$) and a 95% confidence level.

3.10. Ethical Clearance

The Animal Research Ethics Review Committee of the Addis Ababa University College of Veterinary Medicine and Agriculture in Bishoftu, Ethiopia, provided ethical approval under the reference number **VM/ERC/03/15/022, 25/01/2023(Annex 8.5)**.

4. RESULTS

4.1. Sociodemographic characteristics of abattoir and butcher shop workers

4.1.1 Sociodemographic profile of respondents from slaughterhouses

The largest proportion (42.3%) of respondents fell within the 30-39 age group. Most meat handlers were male (80.8%), and just over half (51.9%) of slaughterhouse workers had attained a university-level education.

From those respondents, 82.7% reported receiving food safety training less than three times since starting their job. All individuals were employed in slaughterhouses, with 69.2% of them having less than five years of experience (Table 2).

Table 2: Frequency distribution of Socio-demographic characteristics of meat handlers working in slaughterhouses in the study area (N=52)

Variables	Category	Frequency, n (%)
Location	Bishoftu slaughterhouse	25 (48.1)
	Modjo slaughterhouse	12 (23.1)
	Dukem slaughterhouse	15 (28.8)
Sex	Male	42 (80.8)
	Female	10 (19.2)
Age	18-20 years	10 (19.2)
	21-29 years	16 (30.80)
	30-39 years	22 (42.3)
	40-50 years	4 (7.7)
Level of education	Elementary school	19 (36.5)
	High school	6 (11.5)
	University Degree	27 (51.9)
Position	Veterinarian	5 (9.6)
	Meat inspector	2 (3.8)
	Manager	1 (1.9)
	Assistant veterinarian	2 (3.8)
	Another unqualified worker	42 (80.8)
Experience meat handling	≤ 5 years	36 (69.2)
	6-10 years	12 (23.1)
	≥ 11 years	4 (7.7)
Training	≤ 3 times	43 (82.7)
	≥ 4 times	9 (17.3)
Time of training	The last 3 months	43 (82.7)
	The last 6 months	7 (13.5)
	1 years and more	2 (3.8)

Food safety knowledge of slaughterhouse workers

The study result shows that 75% of respondents demonstrated a strong understanding of food safety interventions. They recognized the risks posed by improper meat handling and the importance of good hand hygiene, as well as proper cleaning, sanitization, and disinfection in reducing contamination risks. However, awareness of specific foodborne pathogens, like bacteria

and viruses, was lacking, with only around half of the participants knowing that meat contaminated with unhygienic material could lead to foodborne diseases (Table 3).

Table 3: *Food safety knowledge of slaughterhouse workers*

Variables	Category	Frequency n (%)
Noncompliance means failure to act according to the rules and regulations set Compliance with slaughterhouse laws helps minimize the spread of diseases to the public.	Yes	36 (69.2)
	No	14 (26.9)
	I don't know	2 (3.8)
Compliance with slaughterhouse laws helps minimize the spread of diseases to the public.	Yes	47 (90.4)
	No	5 (9.6)
	I don't know	0 (0.0)
Noncompliance does not result in the transmission of disease from animal to human beings.	Yes	6 (11.5)
	No	41 (78.8)
	I don't know	5 (9.6)
If meat processing is done properly and hygienically, it can spread pathogens to the public.	Yes	16 (30.8)
	No	13 (25.0)
	I don't know	23 (44.2)
Good personal hygiene by slaughterhouse workers can result in contamination of the processed carcass.	Yes	10 (19.2)
	No	39 (75.0)
	I don't know	3 (5.8)
All equipment used during meat processing should be properly washed and sterilized after each usage.	Yes	48 (92.30)
	No	4 (7.7)
	I don't know	0 (0.0)
Disposal of solid waste, blood, and effluents into the nearby river does not cause water pollution.	Yes	11 (21.1)
	No	34 (65.4)
	I don't know	7 (13.5)
Providing practical knowledge on meat hygiene standards for producers, transporters, retailers, and consumers is a key food safety intervention.	Yes	44 (84.6)
	No	3 (5.8)
	I don't know	5 (9.6)

	Yes	42 (80.8)
	No	3 (5.8)
Do you know the correct application of cleaning and disinfecting procedures of equipment to reduce the risk of contamination of disease transmission to people?	I don't know	5 (13.4)
Do you know washing hands before handling meat reduces the risk of meat contamination?	Yes	45 (86.5)
	No	7 (13.5)
	I don't know	0 (0.0)
Did you know that washing hands before handling meat reduces the risk of meat contamination?	Yes	43 (82.7)
	No	7 (13.5)
	I don't know	2 (3.8)
Do you understand that using caps, masks, protective gloves, and proper covering can lower the risk of meat contamination?	Yes	42 (80.8)
	No	1 (1.9)
	I don't know	9 (17.3)
Is it important to know the temperature of the chiller/cooler to reduce the risk of meat/carcass contamination?	Yes	48 (92.3)
	No	1 (1.9)
	I don't know	3 (5.8)
Do you know that production service workers with cuts and abrasions on their hands should not touch/handle meat/carcasses?	Yes	42 (80.8)
	No	5 (9.6)
	I don't know	5 (9.6)
Food handlers not practicing good hygiene could cause food contamination.	Yes	21 (40.4)
	No	4 (7.7)
	I don't know	27 (51.9)
Are you familiar with the current food safety laws?	Yes	20 (38.5)
	No	6 (11.5)
	I don't know	26 (50.0)
Score Level of food safety knowledge	Poor	13 (25.0)
	Good	39 (75.0)

Food safety attitude of slaughterhouse workers

Most respondents (61.5%) displayed a negative attitude towards such interventions. Overall, meat handlers did not recognize their responsibility to minimize contamination through practices like regular hand washing, maintaining clean surfaces, and checking meat freshness (Table 4). Attitudes towards cleaning practices did not consistently align with proper food hygiene, as most (92.3%) believed that using the same towel for cleaning multiple areas was acceptable.

Table 4: Food safety attitude of slaughterhouse workers.

Variables	Category	Frequency n (%)
Do you think all those slaughterhouses are required to register and operate under regulations established by the Ministry of Agriculture and the Ministry of Trade?	Yes	30 (57.7)
	No	10 (19.2)
	I don't know	12 (23.1)
If so, have all facilities been established to meet these standards?	Yes	25 (48.1)
	No	15 (28.8)
	I don't know	12 (23.1)
Does Ethiopian food law provide a legal basis for regulating meat and meat products intended for domestic consumption?	Yes	13 (25.0)
	No	21 (40.4)
	I don't know	18 (34.6)
Do you think all meat inspectors and veterinarians have sufficient practical knowledge and skills in their respective municipalities?	Yes	17 (32.7)
	No	27 (51.9)
	I don't know	8 (15.4)
How would you rate the stage of your knowledge on meat inspection activities?	Yes	19 (36.5)
	No	26 (50.0)
	I don't know	7 (13.5)
Do you think the food handlers are responsible for preventing food-borne diseases?	Yes	45 (86.5)
	No	0 (0.0)
	I don't know	7 (13.5)
Do you think that food safety needs a prerequisite program?	Yes	41 (78.8)

	No	11 (21.2)
	I don't know	0 (0.0)
All personnel working in the slaughterhouse must wear protective clothes during operation.	Yes	43 (82.7)
	No	7 (13.5)
	I don't know	2 (3.8)
Compliance with the slaughterhouse laws during meat processing and waste disposal can only be achieved if all proper measures are taken and followed.	Yes	36 (69.2)
	No	10 (19.2)
	I don't know	6 (11.6)
Only clean and safe water should be used to wash all carcasses in the slaughterhouse.	Yes	48 (92.3)
	No	1 (1.9)
	I don't know	3 (5.8)
Training and learning about meat hygiene is important to me:	Yes	42 (80.8)
	No	1 9(1.9)
	I don't know	9 (17.3)
Washing and disinfecting hands prevents meat contamination:	Yes	48 (92.3)
	No	1 (1.9)
	I don't know	3 95.8)
Score Level of food safety attitudes	Poor	20 (38.5)
	Good	32 (61.5)

Food safety hygienic practice of slaughterhouse workers

Table 5 presents the practices of meat handlers concerning food safety interventions. 50.0% of meat handlers demonstrate good hygiene practices in these activities. None of the respondents possess sufficient food hygiene knowledge to perform their duties accurately. Over half (53.8%) of the abattoir workers expressed their disapproval of unfit carcasses. None of the respondents claim to have ever conducted an ante-mortem examination. Regarding slaughterhouse operations, half of the respondents (50.0%) state that all solids, blood, and effluents from the slaughterhouse are disposed of in compliance with regulations. Additionally, (73.1%) of respondents acknowledge the HACCP system to ensure food safety interventions, with 69.2% understanding the meaning of HACCP. Most respondents (94.2%) working in slaughterhouses do not engage in GHP

implementation at their level. Similarly, 94.2% of the slaughterhouse employees lack understanding and participation in SSOP implementation related to hygiene practices Table 5.

Table 5: Food safety hygienic practice of slaughterhouse workers

Variables	Category	Frequency (%)
Do you only receive animals that appear healthy from farms or markets?	Never	7 (13.5)
	Rarely	3 (5.8)
	Sometimes	10 (19.2)
	Often	32 (61.5)
Does food hygiene knowledge allow you to do your job correctly?	Never	0 (0.0)
	Rarely	4 (7.7)
	Sometimes	17 (32.7)
	Often	31 (59.6)
Do veterinarians or meat inspectors regularly perform their duties?	Never	0 (0.0)
	Rarely	17 (32.7)
	Sometimes	10 (19.2)
	Often	25 (48.1)
Do you wear protective clothing daily before starting work in the slaughterhouse?	Never	0 (0.0)
	Rarely	8 (15.4)
	Sometimes	12 (23.1)
	Often	32 (61.5)
Is an ante mortem examination conducted before the slaughter of each animal?	Never	0 (0.0)
	Rarely	7 (13.5)
	Sometimes	8 (15.4)
	Often	37 (71.2)
Are carcasses condemned either totally or partially if found unfit for human consumption?	Never	3 (5.8)
	Rarely	14 (26.9)
	Sometimes	7 (13.5)
	Often	28 (53.8)
Is potable water used for washing carcasses after processing?	Never	0 (0.0)
	Rarely	13 (25.0)
	Sometimes	4 (7.7)
	Often	35 (67.3)
Are all solid, blood, and any form of effluent from the slaughterhouse properly disposed of as required by the regulation/law?	Never	9 (17.3)
	Rarely	11 (21.3)
	Sometimes	6 (11.5)
	Often	26 (50.0)

Is the slaughterhouse environment clean and hygienically maintained regularly?	Never	1 (1.9)
	Rarely	17 (32.7)
	Sometimes	6 (11.5)
	Often	28 (53.8)
Poor hygiene practices among food handlers can lead to food contamination.	Never	5 (9.6)
	Rarely	8 (15.4)
	Sometimes	5 (9.6)
	Often	34 (65.4)
Do you understand the meaning of HACCP?	Yes	36 (69.2)
Are the objectives of the HACCP plan important to you?	No	16 (30.8)
Is the HACCP system used to ensure food safety?	Yes	33 (63.5)
Does the HACCP system focus on the quality of the final product rather than preparation procedures?	No	19 (36.5)
Do you typically adhere to the HACCP plan to maintain food safety?	Yes	38 (73.1)
	No	14 (26.9)
Does your knowledge of food hygiene enable you to perform your job effectively?		
Are you involved in the implementation of GHP at your level?	Yes	21 (40.4)
	No	31 (59.6)
Do you monitor the implementation of GHP?		
Are you familiar with the principle of GMP?	Yes	36 (69.2)
Are you engaged in implementing GMP at your level?	No	16 (30.8)
Do you oversee the implementation of GMP?	Yes	22 (42.3)
Do you understand the principle of SSOPs?	No	30 (57.7)
Are you working on implementing SSOPs at your level?	Yes	3 (5.8)
	No	49 (94.2)
Do you understand the meaning of HACCP?	Yes	3 (5.8)
Are the objectives of the HACCP plan important to you?	No	49 (94.2)
Is the HACCP system used to ensure food safety?	Yes	4 (7.7)
Does the HACCP system focus on the quality of the final product rather than preparation procedures?	No	48 (92.3)
Do you typically adhere to the HACCP plan to maintain food safety?	Yes	3 (5.8)
	No	49 (94.2)
Does your knowledge of food hygiene enable you to perform your job effectively?		
Are you involved in the implementation of GHP at your level?	Yes	3 (5.8)
	No	49 (94.2)
Do you monitor the implementation of GHP?		
Are you familiar with the principle of GMP?	Yes	16 (30.8)
Are you engaged in implementing GMP at your level?	No	36 (69.2)

Do you oversee the implementation of GMP?	Yes	3 (5.8)
Do you understand the principle of SSOPs?	No	49 (94.2)
Are you working on implementing SSOPs at your level?	Yes	3 (5.8)
	No	49 (94.2)
Score Level of food safety hygienic practices	Poor	26 (50.0)
	Good	26 (50.0)

Association of sociodemographic with knowledge, attitude and practice of the meat handler

There is an association between respondents' socio-demographic characteristics and their knowledge, attitudes, and practices concerning food safety in slaughterhouses. Analysis showed a significant correlation between sound knowledge and age group (0.003), education level (0.002), and work experience (0.021) (Table 7).

Conversely, attitudes on food safety measures were notably associated with age groups (0.014). Additionally, hygienic practices in food safety measures were associated with gender (0.005) and receiving training post-employment initiation (0.010). Nevertheless, other factors showed no significant association with socio-demographic understanding (knowledge), viewpoints (attitudes) and behaviours (practices).

Table 6: Association of sociodemographic with KAP of the meat handler (N=52).

Sociodemographic factors	Categories	Knowledge		χ^2	P value	Attitude		χ^2	P value	Practice		χ^2	P value
		Poor	Good			Poor	Good			Poor	Good		
Location	Bishoftu	6	19			12	13			10	15		
	Modjo	4	8	0.66	0.72	5	7	3.17	0.21	6	6	2.67	0.26
	Dukem	3	12			3	12			10	5		
Sex	Male	10	32	0.17	0.69	17	25	0.38	0.54	17	25	7.94	0.00*
	Female	3	7			3	7			9	1		
Age (years)	18-20	7	3			8	2			3	7		
	21-29	3	13	13.92	0.00*	3	13	10.52	0.01*	12	4	6.37	0.10
	30-39	3	19			7	15			9	13		
	40-50	0	4			2	2			2	2		
Level of education	Elementary school	10	9			11	8			11	8		
	High school	0	6	12.52	0.00*	2	4	4.89	0.09	3	3	0.81	0.67
	University degree	3	24			7	20			12	15		
Position	Veterinary	1	4			0	5			3	2		
	Meat inspector	0	2			0	2			1	1		
	Manager	0	1	2.02	0.73	0	1	5.93	0.21	1	0	3.20	0.51
	Assistant veterinary	0	2			1	1			0	2		
	Other	12	30			19	23			21	21		
	≤ 5	13	23			15	21			21	15		

Experience (in years)	6-10	0	12	7.70	0.02*	5	7	2.71	0.26	4	8	3.33	0.19	
	≥ 11	0	4			0	4			1	3			
Training after getting job	< 3 times	13	30	3.63	0.06	15	28			25	18			
	> 4 times	0	9			5	4	1.34	0.25	1	8	6.58	0.01*	
Time of previous training	Last month	3	13	30		18	25			23	20			
	Last month	6	0	7	3.63	0.16	2	5	1.75	0.42	1	6	5.78	0.06
	1 year and more	0	2			0	2			2	0			

*Significant association (P value < 0.05); χ^2 = Pearson's-chi square

Association between Food safety knowledge, attitude, and hygienic practice in the Slaughterhouses

Table 7 below summarizes the association between food safety knowledge, attitudes, and hygienic practices among the slaughterhouse worker respondents. The associations between knowledge and practices were significantly associated (χ^2 , 8.308; P value = 0.004). Attitudes toward practices were also significantly associated (χ^2 , 15.93; P value = 0.0001).

Table 7: Association between Food safety knowledge, attitude, and hygienic practice in Slaughterhouses (N=52)

Factors	Food Safety hygienic practice		χ^2	P value	
	Poor	Good			
Food safety knowledge	Poor	2	11	8.31	0.004*
	Good	24	15		
Food safety Attitudes	Poor	3	17	15.93	0.0001*
	Good	23	9		

*Significant association (P value < 0.05); χ^2 = Pearson's-chi-square

4.1.2. Socio-demographic characteristics of meat handlers working in Butcher shops.

The socio-demographic characteristics of butcher worker respondents are presented in Table 8 below. Most respondents were from Bishoftu (41.4%) and Dukem Towns (32.8%). Nearly all respondents were male (93.1%). Among the age groups, 69.0% were aged 21–29. None of the respondents held a university degree. However, over half (58.6%) had 6–10 years of experience. All respondents had not received training after beginning their job (100%)

Table 8: Frequency distribution of Socio-demographic characteristics of meat handlers in Butcher shops (n= 58).

Variables	Category	Frequency, n (%)
Location	Bishoftu Butcher shops	24 (41.4)
	Modjo Butcher shops	15 (25.9)
	Dukem Butcher shops	19 (32.8)
Sex	Male	54 (93.1)
	Female	4 (6.9)
Age	18-20 years	5 (8.6)
	21-29 years	40 (69.0)
	30-39 years	13 (22.4)
	40-50 years	0 (0.0)
Level of education	Elementary school	47 (81.0)
	High school	11 (19.0)
	University Degree	0(0.0)
Position	Butcher	26 (44.8)
	Manager	18 (31.1)
	Assistant butcher	14 (24.1)
	Cashier	0 (0.0)
Experience	≤ 5 years	13 (22.4)
	6-10 years	34 (58.6)
	≥ 11 years	11 (19.0)
Training	≤ 3 times	58 (100)
	≥ 4 times	0 (0.0)
Time of training	The last 3 months	53 (91.4)
	The last 6 months	2 (3.4)
	1 years and more	3 (5.2)

Food safety knowledge of butcher shop workers

In the butcher shops, the frequency distribution of the respondent knowledge and its cumulative level are summarized in Table 9. Among the respondents (89.8%), none of them received any training on the hygienic handling of meat. However, 96.6 percent of the respondents washed their hands before handling meat. Almost all said yes by washing their hands after using the toilet.

On the other hand, 69.0% had managed or processed meat while they were ill. All respondents used potable water. Among the respondents, 94.8 percent did not remove their rings and watch during their work in butchery.

In addition, all of them used a refrigerator for storage of the meat that remained from a daily sale. The overall food safety knowledge level was only 89.7%; the rest (10.3%) had a poor food safety knowledge level.

Table 9: *Food safety knowledge of butcher shop workers* (N=58)

Variables	Category	Frequency (%)
Have you ever received any training on the hygienic handling of meat?	Yes	6 (10.3)
	No	52 (89.7)
Do you have a refrigerator vehicle for the means of transporting meat from the slaughterhouse to the retail shop?	Yes	30 (51.7)
	No	28 (48.3)
Do you wash your hands before handling meat?	Yes	56 (96.6)
	No	2 (3.4)
Do you know about the shelf life of red meat?	Yes	28 (48.3)
	No	30 (51.7)
Do you wash your hands after handling meat?	Yes	57 (98.3)
	No	1 (1.7)
Do you wash your hands after handling waste/garbage?	Yes	56 (96.6)

	No	2 (3.4)
Do you know hand washing is necessary after using the toilet?	Yes	58 (100.0)
	No	0 (0.0)
Do you know to remove your rings and watch before handling meat?	Yes	3 (5.2)
	No	55 (94.8)
Do you know the person who becomes ill can't touch meat?	Yes	40 (69.0)
	No	18 (31.0)
Do you know meat handlers with cuts, wounds, or injuries on their hands are prohibited from handling meat?	Yes	40 (69.0)
	No	18 (31.0)
Do you know the importance of routine control of flies in your butcher shop?	Yes	31 (53.4)
	No	27 (46.6)
Is the water used in your butchery's potable?	Yes	58 (100.0)
	No	0 (0.0)
Does the meat stay in your butchery for over one day?	Yes	34 (58.6)
	No	24 (41.4)
Do you use a refrigerator for storage of the meat that remains from a daily sale?	Yes	58 (100.0)
	No	0 (0.0)
Do you collect money while handling or selling meat?	Yes	40 (69.0)
	No	18 (31.0)
Do you have a separate cashier for collecting money?	Yes	40 (69.0)
	No	18 (31.0)
Score Level of food safety knowledge	Poor	6 (10.3)
	Good	52 (89.7)

Food safety Attitude of butcher shop workers

In attitude assessment, respondents considered medical examinations every six months and unhygienic procedures as 100% health risks. 50.0% believed that wearing watches, earrings,

and rings could increase the risk of red meat contamination. 91.4% felt that using protective clothing when handling meat was crucial to prevent contamination and diseases.

Most of the participants, 98.3%, believed that consistent training and awareness programs could improve meat safety and hygiene practices. Similarly, 98.3% expressed a sense of responsibility for guaranteeing the safety of the meat they provide.

Additionally, 96.6% agreed on the importance of hand washing with soap and wearing, protective wear during meat handling. As a result, the overall good attitude towards food safety interventions was 81.0% these result details are shown below in Table 9.

Table 10: Food safety Attitude of butcher shop workers(N=58).

Variables	Category	Frequency, n (%)
Do you believe being medically examined every six months is important for a red meat handler's health?	Yes	58(100.0)
	No	0 (0.0)
Do you think improper/unhygienic meat storage is dangerous to health?	Yes	58 (100.0)
	No	0 (0.0)
Do you think wearing watches, earrings, and rings will increase the risk of red meat contamination?	Yes	29 (50.0)
	No	29 (50.0)
Do you think wearing protective clothing for safe meat handling to avoid contamination and diseases is a prerequisite of meat handlers' job responsibilities?	Yes	53 (91.4)
	No	5 (8.6)
Do you think that your responsibility as a food handler is to ensure that the meat sold is safe?	Yes	57 (98.3)
	No	1 (1.7)
Do you think washing hands with soap can reduce meat contamination or food poisoning?	Yes	57 (98.3)
	No	1 (1.7)
Did you expect regular training and awareness programs to improve meat safety and hygiene practices?	Yes	57 (98.3)
	No	1 (1.7)
	Yes	55 (94.8)

Are you willing to change your food-handling behaviours when you know that they are incorrect?	No	3 (5.3)
Do you believe that your butchery needs some improvement for better handling?	Yes	51 (87.9)
	No	7 (12.1)
Do you agree to wash your hands with soap and wear an apron, gloves, cap, shoes, and masks during meat handling?	Yes	56 (96.6)
	No	2 (3.4)
	Poor	11 (19.0)
Score Level of Food Safety Attitudes	Good	47 (81.0)

Food safety and hygienic practice of butcher shop Workers

The respondents' frequency distribution of Food safety hygienic practices in butcher shops was summarized in Table 10 below. They always used (94.8%) sanitizer when washing service utensils (knives, hooks, cutting tools).

However, some of them did not remove (15.5%) personal items such as rings, necklaces, and watches during the meat handling period. Besides, (58.6%) of them did not wash raw meat before cutting or preparing it.

On the other hand, more than half (53.4%) of the proper cleaning and handling of instruments reduce the risk of food contamination. Moreover, 100.0% of them used a hair cover on the head while they were in meat cutting time.

Table 11: Food safety hygienic practices of butcher shop workers (N=58).

Variables	Category	Frequency (%)
Do you always use sanitizer when washing service utensils (knives, hooks, cutting tools, etc.)?	Yes	55 (94.8)
	No	3 (5.2)
Do you remove personal items such as rings, necklaces, and watches during the meat handling period?	Yes	49 (84.5)
	No	9 (15.5)
Do you wash raw meat before cutting or preparing it?	Yes	24 (41.4)
	No	34 (58.6)
Do proper cleaning and handling of instruments reduce the risk of food contamination?	Yes	27 (46.6)
	No	31 (53.4)
Do you wash and disinfect working surfaces and tools for handling meat?	Yes	57 (98.3)
	No	1 (1.7)
Do you use a hair cover on the head while you are in meat cutting time?	Yes	58 (100.0)
	No	0 (0.0)
Do you use a hair cover on the head while you are in meat cutting time?	Yes	55 (94.8)
	No	3 (5.2)
Do you wash hands and equipment after handling waste/garbage?	Yes	54 (93.1)
	No	4 (6.9)
Do you use different storage and display cabinets for offal and meat?	Yes	57 (98.3)
	No	1 (1.7)
Do you use the same equipment while handling meat and the green offal?	Yes	26 (44.8)
	No	32 (55.2)
Do you practice training given to improve your butcher shop?	Yes	33 (56.9)
	No	25 (43.1)
Is there any cover on the display case?	Yes	44 (75.9)
	No	14 (24.1)
Is there any cover on the display case?	Yes	1 (1.7)
	No	57 (98.3)

Is the Butcher shop floor made of wooden?	Yes	35 (60.3)
	No	23 (39.7)
Is the Butcher shop floor made of concrete?	Yes	58 (100.0)
	No	0 (0.0)
Is the Butcher shop floor made of other specific material?	Yes	36 (62.1)
	No	22 (37.9)
Is the wall painted white color?	Yes	58 (100.0)
	No	0 (0.0)
If yes, is there a sign of dirt on the wall?	Yes	36 (62.1)
	No	22 (37.9)
Rate the ventilation status of the display case and butchery.	Yes	58 (100.0)
	No	0 (0.0)
Is there a use of bulbs in the display case?	Yes	9 (15.5)
	No	49 (84.5)
The presence of a meat cooling facility at the display cabinet	Yes	5 (8.6)
	No	53 (91.4)
Score Level of Food Safety Practices	Poor	10 (17.2)
	Good	48 (82.8)

Association of socio-demographic factors with food safety knowledge, attitude, and hygienic practices in butcher shops

The association of socio-demographic factors with food safety knowledge, attitudes, and hygienic practices in butcher shops is summarized in Table 12 below. Among the socio-demographic associations, level of education is significantly associated (χ^2 , 4.194; P value = 0.041) with food safety knowledge. Whereas the association between socio-demographics and attitudes was significantly associated with location (χ^2 , 8.820; P value = 0.012), sex (χ^2 , 8.777; P value = 0.003), age group (χ^2 , 16.807; P value = 0.001), and experience (χ^2 , 20.415; P value = 0.001). On the other hand, hygienic practices were significantly associated with sex, age group, and experience.

Table 12: Association of socio-demographic factors with food safety KAP in butcher shops (n=58)

Sociodemographic factors	Categories	Knowledge		χ^2	P value	Attitude		χ^2	P value	Practice		χ^2	P value
		Poor	Good			Poor	Good			Poor	Good		
Location	Bishoftu	4	20	3.31	0.19	5	19	8.82	0.01*	6	18	5.91	0.05
	Modjo	2	13			6	9			4	11		
	Dukem	0	19			0	19			0	19		
Sex	Male	5	49	0.99	0.32	8	46	8.78	0.003*	7	47	10.05	0.002*
	Female	1	3			3	1			3	1		
Age (years)	18-20	0	5	3.20	0.20	2	3	16.87	0.001*	2	3	8.56	0.01*
	21-29	3	37			2	38			3	37		
	30-39	3	10			7	6			5	8		
Level of school education	Elementary	3	44	4.19	0.04*	8	39	0.610	0.44	6	41	3.479	0.06
	High school	3	8			3	8			4	7		
	Butcher	2	24			5	21			5	21		
Position	Manager	4	14	4.55	0.10	2	16	1.56	0.46	3	15	0.16	0.92
	Assistant butcher	0	14			4	10			2	12		
Experience (in ears)	≤ 5	2	11	1.81	0.40	7	6	20.45	0.001*	6	7	10.700	0.005*
	6-10	2	32			0	34			2	32		
	≥ 11	2	9			4	7			2	9		

Training after getting a job	< 3 times	6	52	-	-	11	47	-	-	10	48	-	-	
	> 4 times	0	0			0	0			0	0			
	Last month	3	6	47		11	42			10	43			
Time of previous training	Last month	6	0	2	0.63	0.73	0	2	1.28	0.53	0	2	1.14	0.57
	1 year and more	0	3			0	3			0	3			

*Significant association (P value < 0.05); χ^2 = Pearson's-chi square

Association between Food safety knowledge, attitude, and hygienic practice in Butcher shops

The association between Food safety knowledge, attitude, and hygienic practice in Butcher shops is described in table 13 below. Food safety Attitudes were significantly associated (χ^2 , 13.239; P value = 0.001) with Food Safety hygienic practice. However, Food safety knowledge was not associated with hygienic practices.

Table 13: Association between Food safety KAP in Butcher shops ($n=58$).

Factors		Food Safety hygienic practice		χ^2	P value
		Poor	Good		
Food safety knowledge	Poor	1	5	0.002	0.969
	Good	9	43		
Food safety Attitudes	Poor	6	5	13.239	0.0001*
	Good	4	43		

*Significant association (P value < 0.05); χ^2 = Pearson's-chi square

4.2 Microbial load on meat and its contact surface of slaughterhouses and butcher shops

The current investigation found the highest bacterial count for aerobic plate count (APC) on hand swabs collected from employees at butcher shops in Modjo town reached up to 7×10^7 colony forming units (CFU)/cm². Furthermore, in the same town, the cutting boards showed a maximum *E. coli* count of 4.9×10^4 CFU/cm² and a peak *S. aureus* colony count of 1.7×10^4 CFU/cm². The investigation also found *E. coli* contamination on cutting boards and weighing balances across three towns, hooks in Bishoftu, and knives in both Modjo and Bishoftu. Bacteria counts in butcher shops located throughout Modjo, Bishoftu, and Dukem exceeded established safety thresholds for both APC and *E. coli* in a vast majority of samples collected. The results of Tukey's Honest Significant Difference test (p-value of 0.039) indicated that there was a statistically significant difference between the mean bacterial count on hands and meats. The mean of aerobic plate counts on hands was higher than in meat samples (Table 14). Similarly,

Log 10 of APC count on hands at Butcher shops in Modjo town indicated a higher value (7.8) Table 14.

Table 14: *S. aureus*, APC, and *E. coli* count in various samples at Butcher shops in Bishoftu, Modjo, and Dukem towns.

Sample type	Towns	APC	<i>E. coli</i>	<i>S. aureus</i>
Cutting Board	Modjo	2.9X10 ⁷	4.9X10 ⁴	1.7X10 ⁴
	Bishoftu	1.7X10 ⁷	8.5X10 ³	7.8X10 ²
	Dukem	6.0X10 ⁵	2.6X10 ³	4.4X10 ^{1*}
Hands	Modjo	7.0X10 ^{7a}	6.8X10 ³	3.5X10 ²
	Bishoftu	2.5X10 ^{7a}	3.7X10 ²	3.5X10 ²
	Dukem	7.4X10 ^{5a}	2.0X10 ³	8.6X10 ^{1*}
Hook	Modjo	2.8X10 ⁶	0*	4.3X10 ²
	Bishoftu	5.5X10 ⁵	3.6X10 ²	1.1X10 ^{2*}
	Dukem	2.4X10 ⁵	0*	5.9X10 ^{1*}
Knife	Modjo	7.5X10 ⁶	7.8X10 ³	3.3X10 ^{1*}
	Bishoftu	7.7X10 ⁵	2.6X10 ⁴	8.7X10 ²
	Dukem	0*	0*	0*
Meat	Modjo	2.7X10 ^{6a}	2.1X10 ³	2.6X10 ²
	Bishoftu	1.8X10 ^{6a}	1.0X10 ³	5.2X10 ^{1*}
	Dukem	1.0X10 ^{6a}	2.8X10 ²	1.0X10 ^{1*}
Weighing Balance	Modjo	1.2X10 ⁶	9.0X10 ²	4.9X10 ²
	Bishoftu	3.1X10 ⁶	8.2X10 ²	2.2X10 ²
	Dukem	6.5X10 ⁶	2.7X10 ³	4.5X10 ^{1*}

APC: Aerobic Plate count; ^a Meat vs Hands: *F* test: 0.0280 and Tukey HD test indicates *P*-value 0.039. *Indicates Tolerable bacterial count on the surface of samples

Aerobic Plate Count-ES ISO 4833-1(2022) 10⁶CFU/g,

E-coli Count – ES ISO 16649-2 (2022) 10²CFU/g

Coagulase Positive *Staphylococcus aureus* ES ISO 6888-1(2022) 10²CFU/g

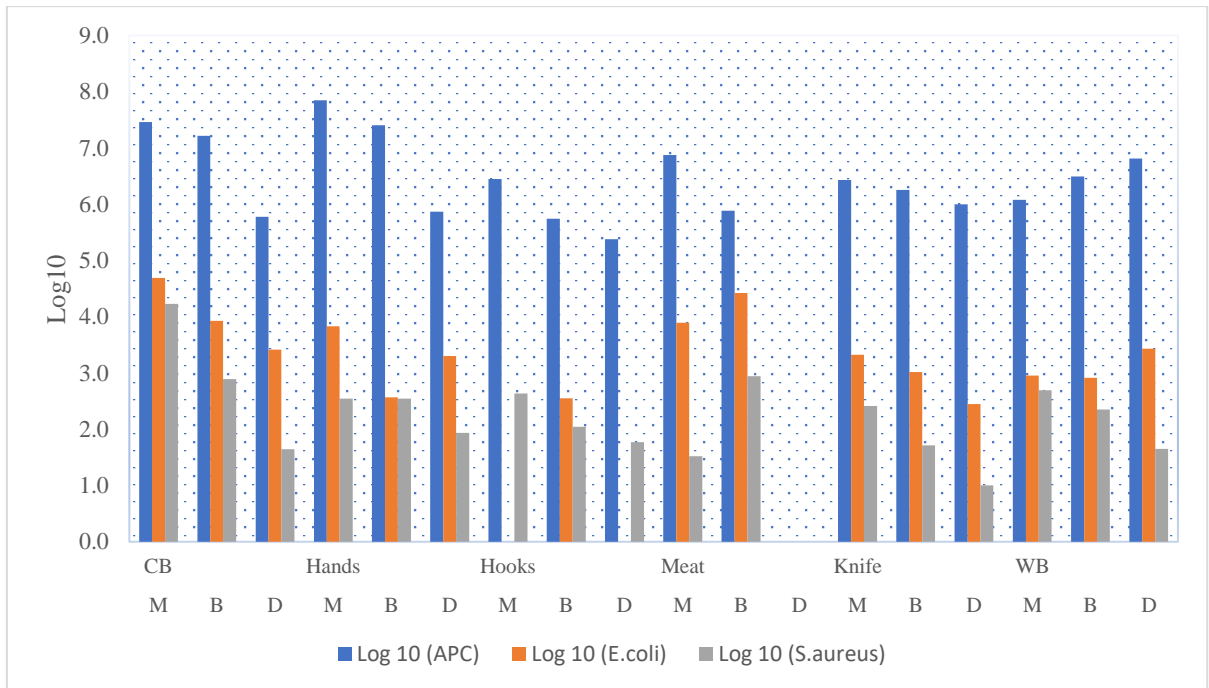


Figure 2: *S. aureus*, *APC*, and *E. coli* count in $\text{Log}_{10} \text{CFU}/\text{cm}^2$ in various samples at Butcher shops in Bishoftu, Modjo, and Dukem towns.

WB: Weighing Balance; CB: Cutting Board; M: Modjo B: Bishoftu D: Dukem

According to the current investigation, the maximum APC of bacteria on flesh swabs taken from meat at a slaughterhouse in Modjo town was found to be up to $5.2 \times 10^7 \text{CFU}/\text{cm}^2$. Moreover, the knife swab from the same town revealed a maximum *S. aureus* colony count of $1.7 \times 10^2 \text{CFU}/\text{cm}^2$ and a maximum *E. coli* value of $2.5 \times 10^4 \text{CFU}/\text{cm}^2$. Additionally, a comparable level of *E. coli* was found in Bishoftu town on a knife swab. The count of APC and *E. coli* in slaughterhouses in Modjo, Bishoftu, and Dukem indicated almost all were categorized as unsatisfactory. Similarly, Log 10 of APC count in meat in slaughterhouses in Modjo town indicated a higher value (7.7) Table 15 and Figure 3.

Table 15: *S. aureus*, APC, and *E. coli* count in various samples at Slaughterhouses in Bishoftu, Modjo, and Dukem towns.

Sample type	Towns	APC	<i>E. coli</i>	<i>S. aureus</i>
Knife	Modjo	5.1X10 ⁶	2.5X10 ⁴	1.0X10 ^{1*}
	Bishoftu	3.3X10 ⁶	2.5X10 ⁴	2.1X10 ¹
	Dukem	6.5X10 ⁵	1.4X10 ²	2.1X10 ¹
Meat	Modjo	5.2X10 ⁷	2.7X10 ³	2.1X10 ¹
	Bishoftu	8.7X10 ⁶	1.1X10 ³	1.0X10 ^{1*}
	Dukem	3.3X10 ⁷	5.8X10 ^{1*}	1.0X10 ^{1*}
Gauge	Modjo	6.0X10 ⁶	3.3X10 ¹	1.0X10 ^{1*}
	Bishoftu	2.6X10 ⁶	1.3X10 ³	1.0X10 ^{1*}
	Dukem	7.0X10 ⁵	1.4X10 ²	1.0X10 ^{1*}
Hands	Modjo	1.5X10 ⁵	9.3X10 ²	1.7X10 ²
	Bishoftu	1.4X10 ⁶	3.7X10 ²	1.1X10 ²
	Dukem	1.0X10 ⁶	8.6X10 ¹	1.0X10 ^{1*}

APC: Aerobic Count; *Indicates Tolerable bacterial count on the surface of samples.

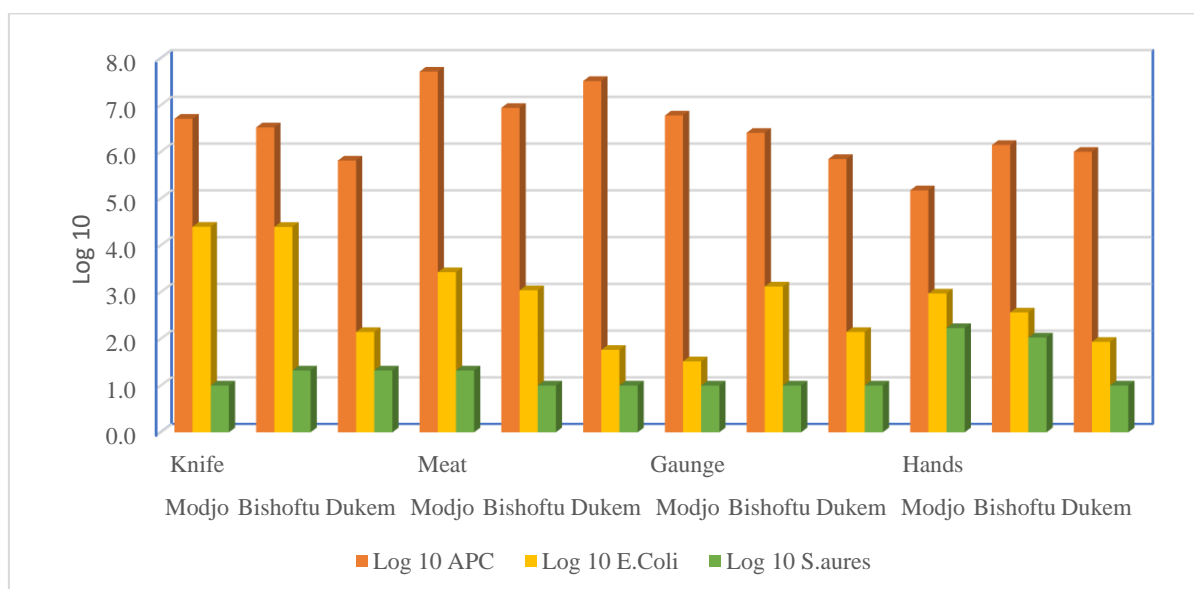


Figure 3: *S. aureus*, APC, and *E. coli* count in Log₁₀ CFU/cm² in various samples at Slaughterhouses in Bishoftu, Modjo, and Dukem towns.

5. DISCUSSION

This study investigated the food safety knowledge, attitudes, hygienic practices, and microbial loads on meat and its contact surfaces of meat handlers working in slaughterhouses and retail meat shops in Bishoftu, Modjo, and Dukem Towns, central Ethiopia.

The result of this study showed that the majority (75.0%) of the slaughterhouse workers were knowledgeable about meat safety questions. The result of score level knowledge is shown above the acceptable level for this study. This indicates that the participants were informed or trained about the proper food safety standards, which encourages them to have good food safety awareness, filling gaps. The present finding is higher than previous reports in Jigjiga Town, Eastern Ethiopia 30.8% (Tegegne & Phyto, 2017), in Addis Ababa, Hawassa, and Dire Dawa slaughterhouses 36.7% (Zelalem *et al.*, 2021), in Bishoftu town 72.4% (Abunna *et al.*, 2023), and in Babich and Gedo Towns West Showa, Ethiopia 56.67% (Urgesa & Sorsa, 2023). This implies that the slaughterhouse workers in the study area received more education on meat safety than those in the other areas mentioned.

The score level of knowledge of slaughterhouse workers was also significantly associated with socio-demographic factors of age group (χ^2 , 13.982; P value = 0.003), level of education (χ^2 , 12.515; P value = 0.002), and experiences (χ^2 , 7.704; P value = 0.021). The reason for the age group effect might be due to the exposure to different experiences as age increases, especially in medium-age groups, to updated information by using social media or school-based food safety awareness creation programs. On the opposite side of this finding, a study conducted in Gondar (Iwu *et al.*, 2017) showed that the age of the slaughterhouse workers was not associated with their knowledge, but the result was supported by other research findings conducted in Gondar (Jember *et al.*, 2019). Respondents associated with primary school and informal education were more likely to have poor knowledge compared to those with a higher university level of education (P = 0.002). This is in line with Lee *et al.*'s (2017) study, which highlighted the varying impacts of education level on food safety knowledge.

The knowledge score level showed a significant association (χ^2 , 8.308; P value = 0.004) with the score level of hygienic practice among slaughterhouse workers. These suggest that the level of food safety knowledge among slaughterhouse workers may impact their practices regarding meat safety. This is corroborated by Al-Kandari *et al.* (2019), who showed a significant connection between these two variables.

The other results of this study were slaughterhouse worker attitudes. The good attitude score levels of the slaughterhouse respondents were also assessed and found to be 61.5%. This result shows the initial boundary of acceptable level for this study. This finding is higher than previous reports in Addis Ababa, Hawassa, and Dire Dawa slaughterhouses (45.7%) (Zelalem *e al.*, 2021). However, the current report was lower than the one reported by Jiggiga (64%) (Tegegne and Phyto, 2017), and in Babich and Gedo Towns West Shoa of, Ethiopia 68.15% (Urgesa and Sorsa, 2023).

The knowledge score level displayed a comparable pattern; the attitude score level also demonstrated associations with sociodemographic factors and was particularly associated with specific age groups (χ^2 , 10.552; P value = 0.014). The attitude of meat handlers has a key role that may influence food safety practices that help to decrease the chance of foodborne disease outbreaks. Olumakaiye and Bakare (2013) mentioned that food handlers at their older age have a better hygienic practice score than their younger colleagues.

The attitude score level showed a significant association (χ^2 , 15.925; P value = 0.0001) with the score level of hygienic practice among slaughterhouse workers. These results indicate that the food safety attitude score of slaughterhouse workers may influence their implementation of meat safety interventions. Al-Kandari *et al.* (2019) also found a notable relationship between attitude and practice in this regard.

The last results of this KAP study were slaughterhouse worker hygienic practices. The good hygienic practices score levels of the slaughterhouse respondents were also assessed and found to be 50.0%. This result is shown below the acceptable levels of this study and identified poor hygienic practices in slaughterhouses. Poor hygiene practices require attention, as Alhaji and Baiwa (2015), identified cleaning equipment and surfaces as the most preventive hygienic

practice in meat processing in slaughterhouses. The current good hygienic practices score levels of the slaughterhouse respondents were higher than the research reports in Babich and Gedo Towns West Showa, Ethiopia 42.86% (Urgesa and Sorsa, 2023). On the opposite, the current result was lower than reports of hygienic practices in Addis Ababa, Hawassa, and Dire Dawa slaughterhouses (61.0%) (Zelalem *et al.*, 2021)

The associations of score-leveled hygienic practices with socio-demographic characteristics were given a significant association with sex (2, 7.924; P value = 0.005) and training after getting this job (2, 6.584; P value = 0.010). Giving training to meat handler practitioners is good for slaughterhouse workers and it could be seen in this study. Contrary to this, as highlighted by Seaman (2010), training may be viewed as a time-consuming endeavor for food handlers. This underscores the need for creative and cooperative training programs to improve meat safety and the hygienic practices of staff. According to Todd *et al.* (2010), hands are prone to rapid contamination from various sources during regular work duties, potentially leading to meat contamination.

The hygienic practices score level showed a significant association (χ^2 , 15.925; P value = 0.0001) with the knowledge score level (χ^2 , 8.308; P value = 0.004) and the attitude score level (χ^2 , 15.925; P value = 0.0001) among slaughterhouse workers. These indicate that the food safety knowledge score level and attitude score level of slaughterhouse workers possibly influence their hygienic practices toward meat safety interventions. These findings are supported by Al-Kandari *et al.*, (2019), who demonstrated a significant association among the three (knowledge, attitude, and hygienic practice) variables. Finally, respondents with poor knowledge ($P = 0.004$) and attitude ($P = 0.0001$) were more likely to have poor practices. These findings agreed with evidence from Italy that having good knowledge leads to good practices (Angelillo *et al.*, 2001; Al-Kandari *et al.*, 2019).

On the other hand, 58 respondents from the total 110 sample sizes in the study areas were butcher shop workers. Those were assessed for KAP score levels and found a good score level of 89.7%, 81.0%, and 82.8%, respectively. All three (KAP) butcher shop workers were above the acceptable (cut-off) level of this study. The good knowledge score level of butcher shop workers in this study was found to be above the acceptable (cut-off) levels. This 89.7% good

knowledge score level of butcher shop workers is higher than reports of 20.9% in north-western Ethiopia (Chekol *et al.*, 2019), 38.8% in Malaysia (Abdullahi *et al.*, 2016), 40% in Wollega (Gemeda *et al.*, 2018), 34.1% in Debre Markos town (Alemayehu *et al.*, 2021), 28% in Bole sub-city of Addis Ababa (Abdi *et al.*, 2020), 28.8% in Dangila town (Tessema *et al.*, 2014), 44.3% in Gondar town (Azanaw *et al.*, 2019), 58.3% in India (Mendagudali *et al.*, 2016), 39.2% in Egypt (Hamed and Mohammed, 2020), and 51.6% in Malaysia (Rosnani *et al.*, 2014), 73.8% in Tigray (Gebbru *et al.*, 2023), 72.4% in Bishoftu city (Abunna *et al.*, 2023), and 29.4% in Ghana (Akabanda *et al.*, 2017) of the respondents. This means that there was no or low meat safety awareness for the butcher shop workers in all the above-mentioned study areas compared to the current study locations. On the other hand, a comparable study conducted in north-western Ethiopia (Chekol *et al.*, 2019) and in Kenya (Murimi and Waweru, 2020) showed that 79.1% and 81.1% of the meat handlers had good food safety knowledge respectively. This difference might be due to differences in socio-demographic characteristics, community awareness, and food safety governance between the current study area and different study areas including the northwestern parts of Ethiopia, Kenya, and Ghana.

The butcher shop workers' score level of knowledge is also associated with sociodemographic factors and has a significant association with only the level of education (χ^2 , 4.2, 4.194; P value = 0.041). Respondents with a high level of education ($P = 0.041$) were more likely to have good knowledge about food safety. However, these findings contradict a report that indicated that respondents with higher educational levels do not necessarily have good knowledge and attitudes (Abdul-Mutalib *et al.*, 2012). Finally, respondents with good knowledge ($P = 0.041$) were more likely to have good attitudes and practices. These findings agreed with the evidence.

The knowledge score level of butcher shop workers did not show a significant association (χ^2 , 0.002; P value = 0.969) with the score level of hygienic practice among butcher shop workers. These findings suggest that the level of food safety knowledge among butcher shop workers may not have an impact on their practices related to meat safety. In contrast, Al-Kandari *et al.* (2019) found a significant association between these two variables.

The other butcher shop results were attitude score levels that were found to be 81.0%. In the current study, 81.0% of the respondents have a good attitude score level towards food safety interventions in butcher shops, which is higher than the results of Gebru *et al.* (2023) 64.4% in Southern Tigray, Tegegne, and Phyto (2017) 64% in Jigjiga town, Hamed and Mohammed (2020) 61.2% in Egypt, Abdi *et al.* (2020) 31% in Bole sub-city of Addis Ababa, Oumer (2019) 54.8% in Malaysia, and Hossein *et al.* (2020) 33% in Bangladesh. On the other hand, it is lower than the reports of Abunna *et al.* (2023), 94.6% in Bishoftu City, and Sharif *et al.* (2013), 88.88% in Jordan. The variation might be due to cut-off points, having unsatisfactory knowledge of food safety, and poor attitudes toward meat safety at slaughterhouses and butcher shops in different study areas.

The score level of attitudes of butcher shop workers was also significantly associated with sociodemographic factors of location (χ^2 , 8.820; P value = 0.012), sex (χ^2 , 8.777; P value = 0.003), age group (χ^2 , 16.807; P value = 0.001), and experiences (χ^2 , 20.415; P value = 0.001). Location, sex, age groups, and work experience have a good attitude toward food safety in line with the study of Fekadu *et al.* (2024) in the Lemikura sub-city of Addis Ababa. The finding from our study is opposite to the study of Abd Lataf Dora-Liyana *et al.* (2018), which did not reveal differences in attitude scores among location, sex, age, and work experience.

The attitude score levels showed a significant association (χ^2 , 13.239; P value = 0.0001) with the score level of hygienic practice among butcher shop workers. These indicate that the food safety attitude score level of butcher shop workers possibly influences their hygienic practices toward meat safety interventions. These findings of butcher shop workers are supported by Al-Kandari *et al.*, (2019), who demonstrated a significant association among the two (attitudes and hygienic practice) variables. However, it is crucial to note that, in this study, positive attitudes and a thorough comprehension of food safety did not necessarily translate into effective food safety practices. Similar results have been observed in other studies. For example, a study in the UK focusing on food handlers revealed that 63% of those who honestly assessed their grasp of food safety protocols acknowledged occasional intervals in adhering to recommended practices (Clayton *et al.*, 2002). To this effect factors such as time constraints, understaffing, and regulatory shortcomings were identified as obstacles to upholding healthy food safety measures.

Furthermore, in the Ethiopian context, challenges may arise from inadequate regulatory frameworks, enforcement issues, unsupportive behaviours within the workplace, and infrastructural deficiencies like limited resources and facilities.

The hygienic practice of good score level of butcher shop workers was 82.8%. This result is higher than what reports by Alemayehu *et al.* (2021) showed: 54% in the town of Debre Markos, (Tamiru *et al.*, 2022), 55.1% in the municipalities of Bedelle and Mettu, (Fekadu *et al.*, 2024), 55.3% in Addis Abeba's Lemikura Subcity, (Havelaar *et al.*, 2013), 54.7% in Nigeria, 67.6% in Bahir Dar (Derse *et al.*, 2017), 52.2% in Dangla (Tessema *et al.*, 2014), and 52.4% in Dire Dawa (Getachew, 2016). However, this outcome is less than the 83.7% of research performed in Bishoftu City (Abunna *et al.*, 2023). The variation might be due to cut-off points, having unsatisfactory knowledge of food safety, and poor attitudes toward meat safety at slaughterhouses and butcher shops in different study areas.

The hygienic practice score level was also significantly associated with sex (χ^2 , 10.045; P value = 0.002), age group (χ^2 , 8.578; P value = 0.014), and experiences (χ^2 , 10.697; P value = 0.005). Experience handling food at work leads to a considerable increase in excellent food-handling practices. Similar findings were observed in the towns of Debark (Fasikaw *et al.*, 2019), Woldia (Reta *et al.*, 2021), Bahir Dar (Dereso, 2017), and Gondar (Gizaw *et al.*, 2014). This improved understanding and proficiency with food handling practices.

In addition, the association between the level of hygienic practice with knowledge and attitude was observed. These indicate that the food safety knowledge and attitudes score level of butcher shop workers possibly influences their hygienic practices toward meat safety interventions. These findings of butcher shop workers are supported by Al-Kandari *et al.*, (2019), who demonstrated a significant association among the three (knowledge, attitudes, and hygienic practice) variables.

The current investigation highlights levels of bacterial contamination across various points within the meat processing chain in Modjo, Dukem, and Bishoftu towns. Consumers of food in developing countries, such as Ethiopia, are prone to foodborne diseases like bacterial infections,

particularly from *S. aureus* and *E. coli*. These illnesses are often caused by consuming a range of foods that have been contaminated with harmful microorganisms, toxins, or chemicals. All the microbial findings of the study are compared and evaluated with Ethiopian slaughterhouse laboratory guidelines for meat hygiene and safety analysis (Daba *et al.*, 2021 MOA, 2010).

The most striking finding is the exceptionally high aerobic plate count (APC) on hand swabs of butchers in Modjo, reaching 7×10^7 CFU/cm². The high bacterial counts in butcher shops and the statistically significant difference between hands and meat contamination (with hands having higher levels) suggest a systemic problem with hygiene practices. This could be due to inadequate handwashing, improper cleaning and sanitation of equipment, or a combination of factors. This suggests a significant potential for transferring diverse bacteria onto meat during handling (Brusa *et al.*, 2019).

These findings point to critical hygiene issues within the meat processing chain in Bishoftu, Dukem, and Modjo towns. The high bacterial load on hands, coupled with the presence of pathogenic bacteria on equipment, suggests a lack of proper sanitation protocols. This can pose a significant public health risk to consumers. Based on these findings, implementing stricter hygiene protocols across the entire meat processing chain is essential. This includes mandatory hand washing for butchers, proper disinfection of equipment, and maintaining cleanliness throughout the slaughterhouse environment. Training personnel on safe food handling practices is also crucial. Implementing a HACCP (Hazard Analysis and Critical Control Points) plan would ensure a systematic approach to identifying and controlling potential contamination risks throughout the process.

The presence of *S. aureus* and *E. coli* on knife swabs and cutting boards in Modjo was particularly worrying. *S. aureus* can cause a range of foodborne illnesses, while *E. coli* can cause severe abdominal cramps, diarrhea, and even kidney failure. While the *S. aureus* levels in three towns appear relatively low (1.7×10^2 CFU/cm²), the high *E. coli* counts on cutting boards (4.9×10^4 CFU/cm²) pose a significant contamination risk. These findings go against the standard of Ethiopian slaughterhouse laboratory guidelines (Daba *et al.*, 2021).

Interestingly, the investigation found comparable levels of APC, *E. coli* and *S. aureus* count in both butcher shops and slaughterhouses in all towns. This suggests a potential source of contamination upstream in the meat processing chain, possibly even at the slaughterhouse itself. These findings highlight the urgent need for stricter hand hygiene protocols for butcher shop workers to prevent cross-contamination of meat products. Regular cleaning and sanitation of equipment are also essential. By implementing stricter protocols and raising awareness about hygiene practices throughout the butchering process, butcher shops can significantly reduce the risk of bacterial contamination and protect consumers' health (Bersisa *et al.* 2019).

6. CONCLUSIONS AND RECOMMENDATIONS

This study examines food safety among meat handlers in slaughterhouses and retail meat shops in Ethiopia. Most slaughterhouse workers demonstrated good knowledge and attitudes toward meat safety, with education level and age impacting their understanding. Good knowledge and attitude were linked to better hygienic practices. Butcher shop workers also showed high levels of knowledge and attitude towards food safety, with education level playing a significant role. However, the study revealed that knowledge did not necessarily affect hygienic practices among butcher shop workers. Overall, the findings highlight the importance of knowledge and attitude in influencing food safety practices among meat handlers. The study highlights issues in food safety attitudes and practices among butcher shop workers in different areas. Factors like location, sex, age, and experience influence attitudes towards food safety. Attitude levels correlate with hygienic practices, but positive attitudes don't always guarantee good practices. The hygienic practices of butcher shop workers vary across locations, with challenges including inadequate regulation and infrastructure. Bacterial contamination was found at various points in the meat processing chain, posing risks to consumers. High bacterial counts on hands and equipment indicate hygiene problems that need strict protocols and training. Improvement in hygiene practices, including hand washing and sanitation, is crucial to prevent foodborne illnesses. Government and stakeholders are conducting a legal audit to improve food quality, meet international trade standards, and protect national health. Understanding scientific decision-making, capacity building, good governance, market surveillance, legal framework, planning, and strengthening national food control systems are essential. In line with the above conclusions, the following recommendations would be forwarded:

- Butcher shop workers were found to exceed the KAP cutoff level in this study. However, there is a misconception that training is a waste of time. Therefore, training on the importance of attitude must be provided to them.

- Providing ongoing training on hygienic practices under GHP (Good Hygienic Practices) SOPs in slaughterhouses and butcher shops.

- Regulatory Compliance: Strict enforcement of regulations related to meat safety and hygiene, especially in the butcher shop.
- Implementation of HACCP system in the slaughterhouse should be encouraged

7. REFERENCE

- Abayneh, M., Tesfaw, G., Woldemichael, K., Yohannis, M., & Abdissa, A. (2019). Assessment of extended-spectrum β -lactamase (ESBLs)–producing *Escherichia coli* from minced meat of cattle and swab samples and hygienic status of meat retailer shops in Jimma town, Southwest Ethiopia. *BMC Infectious Diseases*, **19**, 1-8.
- Abd Lataf Dora-Liyana, N. A., Mahyudin, M. R., Ismail-Fitry, A. A. Z., & Rasiyuddin, H. (2018). Food safety and hygiene knowledge, attitude, and practices among food handlers at boarding schools in the northern region of Malaysia. *Soc Sci*, **8**(17), 238-66.
- Abdi, A. M., Amano, A., Abraham, A., Getahun, M., Ababor, S., & Kumie, A. (2020). Food hygiene practices and associated factors among food handlers working in food establishments in the Bole Sub City, Addis Ababa, Ethiopia. *Risk Management and Healthcare Policy*, 1861-1868.
- Abdullahi, A., Hassan, A., Kadarman, N., Saleh, A., Baraya, Y. U. S. A., & Lua, P. L. (2016). Food safety knowledge, attitude, and practice toward compliance with slaughterhouse laws among slaughterhouse workers in Malaysia. *International journal of general medicine*, 79-87.
- Abdul-Mutalib, N. A., Abdul-Rashid, M. F., Mustafa, S., Amin-Nordin, S., Hamat, R. A., & Osman, M. (2012). Knowledge, attitude, and practices regarding food hygiene and sanitation of food handlers in Kuala Pilah, Malaysia. *Food control*, **27**(2), 289-293.
- Abebe, E., Gugsu, G., & Ahmed, M. (2020). Review on major food-borne zoonotic bacterial pathogens. *Journal of tropical medicine*, 2020.
- Abebe, G. (2017). Long-term climate data description in Ethiopia. *Data in brief*, **14**, 371-392.
- Abegaz, S. B. (2022). Food Safety Practices and Associated Factors in Food Operators: A Cross-Sectional Survey in the Students' Cafeteria of Woldia University, North Eastern Ethiopia. *International Journal of Food Science*, 2022.
- Abunna, F., Kaba, M., Mor, S., & Megersa, B. (2023). Assessment of food safety knowledge, attitudes, and practices among meat handlers in Bishoftu City, Ethiopia. *The American journal of tropical medicine and hygiene*, **108**(1), 200.

- Abunna, F., Kaba, M., Mor, S., & Megersa, B. (2023). Assessment of food safety knowledge, attitudes, and practices among meat handlers in Bishoftu City, Ethiopia. *The American journal of tropical medicine and hygiene*, **108**(1), 200.
- Addo-Tham, R., Appiah-Brempong, E., Vampere, H., Acquah-Gyan, E., & Gyimah Akwasi, A. (2020). Knowledge on food safety and food-handling practices of street food vendors in Ejisu-Juaben Municipality of Ghana. *Advances in Public Health*, **2020**, 1-7.
- Adesokan, H. K., & Raji, A. O. Q. (2014). Safe meat-handling knowledge, attitudes, and practices of private and government meat processing plants' workers: implications for future policy. *Journal of Preventive Medicine and Hygiene*, **55**(1), 10.
- Admasu, H. N., Debebe, S. B., Engida, S. A., Biru, Z. A., & Mitku, S. Y. (2023). Isolation, Identification and Antibiotic Resistance of Common Food-Borne Bacteria in Chicken Meat in Addis Ababa and Debre Zeit Areas of Central High Lands of Ethiopia.
- Admasu, M., & Kelbessa, W. (2018). Food safety knowledge, handling practice and associated factors among food handlers of hotels/restaurants in Asosa Town, Northwestern Ethiopia. *SM J Public Health Epidemiology*, **4**(1), 1051.
- Adzitey, F., Huda, N., & Shariff, A. H. M. (2021). Phenotypic antimicrobial susceptibility of *Escherichia coli* from raw meats, ready-to-eat meats, and their related samples in one health context. *Microorganisms*, **9**(2), 326.
- Agu, A. P., Onah, C. K., Umeokonkwo, C. D., Nnabu, R. C., & Una, A. F. I. (2021). Hygiene practices in slaughterhouse and slaughter slab, determinants and assessment of slaughterhouse and slaughter slab facilities in Abakaliki, Ebonyi State South-East Nigeria. *African Health Sciences*, **21**(4), 1914-23.
- Agüeria, D. A., Terni, C., Baldovino, V. M., & Civit, D. (2018). Food safety knowledge, practices and attitudes of fishery workers in Mar del Plata, Argentina. *Food Control*, **91**, 5-11.
- Akabanda, F., Hlortsi, E. H., & Owusu-Kwarteng, J. (2017). Food safety knowledge, attitudes and practices of institutional food-handlers in Ghana. *BMC public health*, **17**, 1-9.
- Alemayehu, T., Aderaw, Z., Giza, M., & Diress, G. (2021). Food safety knowledge, handling practices and associated factors among food handlers working in food establishments in Debre Markos Town, Northwest Ethiopia, 2020: institution-based cross-sectional study. *Risk Management and Healthcare Policy*, 1155-1163.

- Alemayehu, T., Aderaw, Z., Giza, M., & Diress, G. (2021). Food safety knowledge, handling practices and associated factors among food handlers working in food establishments in Debre Markos Town, Northwest Ethiopia, 2020: an institution-based cross-sectional study. *Risk Management and Healthcare Policy*, 1155-1163.
- Alemu, A., Regassa, F., Kebede, N., Ambachew, R., Girma, M., Asefa, Z., & Tsegaye, W. (2022). The magnitude and Antimicrobial Susceptibility Profile of Salmonella Recovered from Export Slaughterhouses Located in East Shewa, Ethiopia. *Infection and Drug Resistance*, 1353-1365.
- Alhaji, N. B., & Baiwa, M. (2015). Factors affecting workers' delivery of good hygienic and sanitary operations in slaughterhouses in north-central Nigeria. *Sokoto Journal of Veterinary Sciences*, 13(1), 29-37.
- Alimentarius, C. (2020). General Principles of Food Hygiene CXC 1–1969. *Revision*, 5, 2-6.
- Alimi, B. A., Lawal, R., & Odetunde, O. N. (2022). Food safety and microbiological hazards associated with retail meat at butchery outlets in north-central Nigeria. *Food Control*, 139, 109061.
- Aljamali, N. M., Najim, M., & Alabbasy, A. (2021). Review on food poisoning (types, causes, symptoms, diagnosis, treatment). *Global Academic Journal of Pharmacy and Drug Research*, 3(4), 54-61.
- Al-Kandari, D., Al-abdeen, J., & Sidhu, J. (2019). Food safety knowledge, attitudes and practices of food handlers in restaurants in Kuwait. *Food control*, 103, 103-110.
- Al-Shabib, N. A., Mosilhey, S. H., & Husain, F. M. (2016). Cross-sectional study on food safety knowledge, attitude and practices of male food handlers employed in restaurants of King Saud University, Saudi Arabia. *Food control*, 59, 212-217.
- Alves, A., Viveiros, C., Lopes, J., Nogueira, A., Pires, B., Afonso, A. F., & Teixeira, C. (2021). Microbiological contamination in different food service units associated with food handling. *Applied Sciences*, 11(16), 7241.
- Angelillo, I. F., Foresta, M. R., Scozzafava, C., & Pavia, M. (2001). Consumers and foodborne diseases: knowledge, attitudes and reported behavior in one region of Italy. *International journal of food microbiology*, 64(1-2), 161-166.

- Anihouvi, D. G., Kpoclou, Y. E., Assogba, M. F., Iko Afé, O. H., Lègba, G., Scippo, M. L., ... & Mahillon, J. (2020). Microbial contamination associated with the processing of grilled pork, ready-to-eat street food in Benin. *Journal of food safety*, **40**(1), 12731.
- Arsham, H. (2005). Questionnaire design and survey sampling. *University of Baltimore*, 114.
- Asfaw, T., Genetu, D., Shenkute, D., Shenkutie, T. T., Amare, Y. E., & Yitayew, B. (2022). Foodborne pathogens and antimicrobial resistance in Ethiopia: an urgent call for action on “one health”. *Infection and Drug Resistance*, 5265-5274.
- Asfaw, T., Genetu, D., Shenkute, D., Shenkutie, T. T., Amare, Y. E., & Yitayew, B. (2023). High Levels of Multidrug-Resistant and Beta-Lactamase-Producing Bacteria in Meat and Meat Contact Surfaces, Debre Berhan Town, Ethiopia. *Infection and Drug Resistance*, 1965-1977.
- Assefa, A., & Bihon, A. (2018). A systematic review and meta-analysis of the prevalence of *Escherichia coli* in foods of animal origin in Ethiopia. *Heliyon*, **4**(8).
- Atlabachew, T., & Mamo, J. (2021). Microbiological quality of meat and swabs from contact surface in butcher shops in Debre Berhan, Ethiopia. *Journal of Food Quality*, 2021, 1-11.
- Atnafie, B., Paulos, D., Abera, M., Tefera, G., Hailu, D., Kasaye, S., & Amenu, K. (2017). Occurrence of *Escherichia coli* O157: H7 in cattle feces and contamination of carcass and various contact surfaces in slaughterhouse and butcher shops of Hawassa, Ethiopia. *BMC microbiology*, **17**, 1-7.
- Ayelign, A., & De Saeger, S. (2020). Mycotoxins in Ethiopia: Current status, implications to food safety and mitigation strategies. *Food Control*, **113**, 107163.
- Aynewa, D., Gizaw, Z., & Haile, A. F. (2021). Assessment of bacteriological quality of sheep carcasses, effect level of 2.5% citric acid spray on bacterial contamination of meat, and hygiene practices of workers in a selected slaughterhouse in Debrezeit town, central Ethiopia. *Environmental Health Insights*, **15**, 11786302211037555.
- Azanaw, J., Dagne, H., Andualem, Z., & Adane, T. (2021). Food safety knowledge, attitude, and practice of college students, Ethiopia, 2019: a cross-sectional study. *BioMed Research International*, 2021.

- Azanaw, J., Gebrehiwot, M., & Dagne, H. (2019). Factors associated with food safety practices among food handlers: facility-based cross-sectional study. *BMC research notes*, *12*, 1-6.
- Bakhtiary, F., Sayevand, H. R., Remely, M., Hippe, B., Hosseini, H., & Haslberger, A. G. (2016). Evaluation of bacterial contamination sources in meat production line. *Journal of food quality*, *39*(6), 750-756.
- Bersisa, A., Tulu, D., & Negera, C. (2019). Investigation of bacteriological quality of meat from slaughterhouse and butcher shops in Bishoftu, Central Ethiopia. *International journal of microbiology*, 2019.
- Bohaychuk, V.M.; Gensler, G.E.; Barrios, P.R. (2011). Microbiological baseline study of beef and pork carcasses from provincially inspected slaughterhouses in Alberta, Canada. *Can. Vet. J.*; *52*, 1095
- Brusa, V., Costa, M., Padola, N. L., Etcheverria, A., Sampedro, F., Fernandez, P. S., & Signorini, M. L. (2020). Quantitative risk assessment of haemolytic uremic syndrome associated with beef consumption in Argentina. *PLoS One*, *15*(11), e0242317.
- Central Statistics Agency, 2021. *Population Size of Towns by Sex, Region, Zone and Weredas as of July 2021*. Addis Ababa, Ethiopia.
- Chekol, F. A., Melak, M. F., Belew, A. K., & Zeleke, E. G. (2019). Food handling practice and associated factors among food handlers in public food establishments, Northwest Ethiopia. *BMC research notes*, *12*, 1-7.
- Chen, Y. J., Kuo, C. Y., Kong, Z. L., Lai, C. Y., Chen, G. W., Yang, A. J., ... & Wang, M. F. (2021). Anti-fatigue effect of a dietary supplement from the fermented by-products of Taiwan tilapia aquatic waste and *Monostroma nitidum* oligosaccharide complex. *Nutrients*, *13*(5), 1688.
- Christiana Cudjoe, D., Balali, G. I., Titus, O. O., Osafo, R., & Taufiq, M. (2022). Food safety in sub-sahara africa, an insight into Ghana and Nigeria. *Environmental Health Insights*, *16*, 11786302221142484.
- Da Silva Cota, A., de Freitas, R. S. G., Lefèvre, F., & Stedefeldt, E. (2023). Food handlers' lack of knowledge, and misunderstanding of safe food temperatures: An analysis using the theory of social representations. *Food Research International*, *174*, 113486.

- Da Silva, S., & Hibdon Jr, J. E. (2022). Trends in Incidence of Zoonotic Foodborne Diseases in the United States in 2010–2019. *Economics and Mathematical Modeling in Health-Related Research*, 52.
- Da Vitória, A. G., de Souza Couto Oliveira, J., de Almeida Pereira, L. C., de Faria, C. P., & de São José, J. F. B. (2021). Food safety knowledge, attitudes and practices of food handlers: A cross-sectional study in school kitchens in Espírito Santo, Brazil. *BMC Public Health*, 21, 1-10.
- Daba G., Yohannes W., Melaku A., Fikirte L., (2021). Slaughterhouse laboratory guidelines for meat hygiene and safety analysis. Minister of agriculture: Ethiopian.
- Daniel, N., Casadevall, N., Sun, P., Sugden, D., & Aldin, V. (2020). The burden of foodborne disease in the UK 2018. *Food Standards Agency*.
- Deneke, T. T., Bekele, A., Moore, H. L., Mamo, T., Almaw, G., Mekonnen, G. A., & Berg, S. (2022). Milk and meat consumption patterns and the potential risk of zoonotic disease transmission among urban and peri-urban dairy farmers in Ethiopia. *BMC Public Health*, 22(1), 222.
- Derso, T., Tariku, A., Ambaw, F., Alemenhew, M., Biks, G. A., & Nega, A. (2017). Socio-demographic factors and availability of piped fountains affect food hygiene practice of food handlers in Bahir Dar Town, northwest Ethiopia: a cross-sectional study. *BMC research notes*, 10, 1-7.
- Dinede, G., Abagero, A., & Tolosa, T. (2020). Cholera outbreak in Addis Ababa, Ethiopia: a case-control study. *Plos one*, 15(7), e0235440.
- Dupont, N., Fertner, M., Birkegård, A. C., Andersen, V. D., Nielsen, G. B., Kruse, A. B., & de Knecht, L. V. (2017). Improving institutional memory on challenges and methods for estimation of pig herd antimicrobial exposure based on data from the Danish Veterinary Medicines Statistics Program (VetStat). *arXiv preprint arXiv:1705.08663*.
- Edget Abayneh, E. A., Dagmar Nölkes, D. N., & Biruhtesfa Asrade, B. A. (2014). Review on common foodborne pathogens in Ethiopia. *African Journal Microbiol Research*, 8: 4027–4040.
- Edwards-Callaway, L. N., & Calvo-Lorenzo, M. S. (2020). Animal welfare in the US slaughter industry—a focus on fed cattle. *Journal of Animal Science*, 98(4), skaa040.

- Eguale, T., Asrat, D., Alemayehu, H., Nana, I., Gebreyes, W. A., Gunn, J. S., & Engidawork, E. (2018). Phenotypic and genotypic characterization of temporally related nontyphoidal Salmonella strains isolated from humans and food animals in central Ethiopia. *Zoonoses and public health*, *65*(7), 766-776.
- Eguale, T., Gebreyes, W. A., Asrat, D., Alemayehu, H., Gunn, J. S., & Engidawork, E. (2015). Non-typhoidal Salmonella serotypes, antimicrobial resistance and co-infection with parasites among patients with diarrhea and other gastrointestinal complaints in Addis Ababa, Ethiopia. *BMC infectious diseases*, *15*, 1-9.
- Ehuwa, O., Jaiswal, A. K., & Jaiswal, S. (2021). Salmonella, food safety and food handling practices. *Foods*, *10*(5), 907.
- ES ISO 16649-2(2022). Microbiology of the food chain horizontal method for the enumeration of microorganism's part: colony count at 30⁰c by the four plate technique.1-8
- ES ISO 4833-1(2022). Microbiology of the food chain horizontal method for the enumeration of microorganism's part: colony count at 30⁰c by the four plate technique.1-8
- ES ISO 6888-1(2022). Microbiology of the food chain horizontal method for the enumeration of microorganism's part: colony count at 30⁰c by the four plate technique.1-8
- Espinosa, R., Tago, D., & Treich, N. (2020). Infectious diseases and meat production. *Environmental and Resource Economics*, *76*(4), 1019-1044.
- Fasikaw Adbarie Chekol, F. A. C., Melkitu Fentie Melak, M. F. M., Aysheshim Kassahun Belew, A. K. B., & Ejigu Gebeye Zeleke, E. G. Z. (2019). Food handling practice and associated factors among food handlers in public food establishments, Northwest Ethiopia.
- Fekadu, Y., Kinde, M. Z., Dagnaw, G. G., Dessalegn, B., Dejene, H., & Gessese, A. T. (2024). Knowledge, Attitude, and Practices on Food Safety among Food Handlers Working in Public Food Service Establishments in Lemi Kura Subcity, Addis Ababa, Ethiopia. *BioMed Research International*, 2024.
- Fontana Jr, A. J. (2020). D: Minimum Water Activity Limits for Growth of Microorganisms. *Water activity in foods*, *406*, 571-572.
- Gadisa Muleta, B. (2022). Perception of Stakeholders for Meat Qualities among Value Chain Actors in Ethiopia. *Veterinary Medicine International*, 2022.

- Galindo, C. D. O., Beux, M. R., da Costa, R. L., Uniat, K. C., Leobet, J., Ferreira, S. M. R., ... & Stangarlin-Fiori, L. (2021). Home-prepared enteral tube feeding: evaluation of microbiological contamination, hygiene, and the profile of the food handler. *Nutrition in Clinical Practice*, *36*(3), 704-717.
- Gallo, M., Ferrara, L., Calogero, A., Montesano, D., & Naviglio, D. (2020). Relationships between food and diseases: What to know to ensure food safety. *Food Research International*, *137*, 109414.
- Garcia, S. N., Osburn, B. I., & Jay-Russell, M. T. (2020). One health for food safety, food security, and sustainable food production. *Frontiers in Sustainable Food Systems*, *4*, 1.
- Gazu, L., Alonso, S., Mutua, F., Roesel, K., Lindahl, J. F., Amenu, K., & Grace, D. (2023). Foodborne disease hazards and burden in Ethiopia: A systematic literature review, 1990–2019. *Frontiers in sustainable food systems*, *7*, 1058977.
- Gebeyehu, D. T., & Tsegaye, H. (2022). Food safety knowledge and practice of slaughterhouse and butcher shop workers: a health risk management perspective. *One Health Outlook*, *4*(1), 14.
- Gebremedhin, E. Z., Hirpa, G., Borana, B. M., Sarba, E. J., Marami, L. M., Tadese, N. D., & Ambecha, H. A. (2020). Detection of *Listeria* species, factors associated, and antibiogram of *Listeria monocytogenes* in beef at slaughterhouses, butchers, and restaurants of Ambo and Holeta Towns, Ethiopia.
- Gebremedhin, E. Z., Soboka, G. T., Borana, B. M., Marami, L. M., Sarba, E. J., Tadese, N. D., & Ambecha, H. A. (2021). Prevalence, risk factors, and antibiogram of nontyphoidal *Salmonella* from beef in Ambo and Holeta Towns, Oromia Region, Ethiopia. *International Journal of Microbiology*, *2021*, 1-13.
- Gebru, S. B., Hailu, T. S., & Taffere, G. R. (2023). Food safety knowledge, attitude, and practice of food handlers at food service establishments in southern Tigray, Ethiopia. *Global Social Welfare*, *10*(3), 249-262.
- Gemeda, T. E., Asayehu, T. T., Abdisa, M., & Fekadu, H. (2018). Assessment of knowledge, attitude and practices of food handlers in Nekemte Referral Hospital, Wollega, Ethiopia. *J Nutr Health Food Eng*, *8*(1), 00262.
- Getachew, M. (2016). Food safety practice and associated factors among food handlers in selected types of food establishments of Dire Dawa, Ethiopia. *New York: FAO*, *41*.

- Girma, B., Shata, B., & Sisay, G. (2023). Factors and actors of urban expansion: The case of Dukem Town, Ethiopia. *European Journal of Sustainable Development Research*, *7*(1).
- Girmay, A. M., Gari, S. R., Gessew, G. T., & Reta, M. T. (2021). Determinants of drinking water quality and sanitary risk levels of water storage in food establishments of Addis Ababa, Ethiopia. *Journal of Water, Sanitation and Hygiene for Development*, *11*(5), 831-840.
- Girmay, A. M., Gari, S. R., Mengistie Alemu, B., Evans, M. R., & Gebremariam, A. G. (2020). Determinants of sanitation and hygiene status among food establishments in Addis Ababa, Ethiopia. *Environmental Health Insights*, *14*, 1178630220915689.
- Gizaw, Z., Gebrehiwot, M., & Teka, Z. (2014). Food safety practice and associated factors of food handlers working in substandard food establishments in Gondar Town, Northwest Ethiopia, 2013/14. *Int J Food Sci Nutr Diet*, *3*(7), 138-146.
- 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., Alonso, S., Bett, B. K., Lindahl, J. F., Patel, E., Nguyen-Viet, H., & Dominguez-Salas, P. (2020). Food safety and nutrition.
- Gutema, F. D., Abdi, R. D., Agga, G. E., Firew, S., Rasschaert, G., Mattheus, W., & De Zutter, L. (2021). Assessment of beef carcass contamination with Salmonella and E. coli O 157 in slaughterhouses in Bishoftu, Ethiopia. *International Journal of Food Contamination*, *8*, 1-9.
- Gutema, F. D., Agga, G. E., Abdi, R. D., Jufare, A., Duchateau, L., De Zutter, L., & Gabriël, S. (2021). Assessment of hygienic practices in beef cattle slaughterhouses and retail shops in bishoftu, ethiopia: Implications for public health. *International journal of environmental research and public health*, *18*(5), 2729.
- Haileelassie, M., Taddele, H., Adhana, K., & Kalayou, S. (2013). Food safety knowledge and practices of slaughterhouse and butchery shops and the microbial profile of meat in Mekelle City, Ethiopia. *Asian Pacific journal of tropical biomedicine*, *3*(5), 407-412.
- Hamed, A., & Mohammed, N. (2020). Food safety knowledge, attitudes and self-reported practices among food handlers in Sohag Governorate, Egypt. *Eastern Mediterranean Health Journal*, *26*(4).

- Hamed, A., & Mohammed, N. (2020). Food safety knowledge, attitudes and self-reported practices among food handlers in Sohag Governorate, Egypt. *Eastern Mediterranean Health Journal*, **26**(4).
- Hamza, M., Khera, H. U. R. A., Waqas, M. U., Muazzam, A., Tariq, S., Kaleem, Z., & Samad, A. (2023). Misuse of Antibiotics in Poultry Threatens Pakistan Community's Health. *arXiv preprint arXiv:2311.07168*.
- Havelaar, A. H., Cawthorne, A., Angulo, F., Bellinger, D., Corrigan, T., Cravioto, A., & Kuchenmüller, T. (2013). WHO initiative to estimate the global burden of foodborne diseases. *The Lancet*, *381*, S59.
- Hayek, M. N. (2022). The infectious disease trap of animal agriculture. *Science Advances*, *8*(44), eadd6681.
- Henchion, M., Moloney, A. P., Hyland, J., Zimmermann, J., & McCarthy, S. (2021). Trends for meat, milk and egg consumption for the next decades and the role played by livestock systems in the global production of proteins. *Animal*, *15*, 100287.
- Hossen, M. T., Ferdous, M. J., Hasan, M. M., Lina, N. N., Das, A. K., Barman, S. K., ... & Roy, R. K. (2020). Food safety knowledge, attitudes and practices of street food vendors in Jashore region, Bangladesh. *Food Science and Technology*, *41*, 226-239.
- Ijaz, M., Yar, M. K., Badar, I. H., Ali, S., Islam, M. S., Jaspal, M. H., & Guevara-Ruiz, D. (2021). Meat production and supply chain under COVID-19 scenario: Current trends and future prospects. *Frontiers in Veterinary Science*, *8*, 660736.
- Imathiu, S. (2020). Benefits and food safety concerns associated with consumption of edible insects. *NFS journal*, *18*, 1-11.
- Insfran-Rivarola, A., Tlapa, D., Limon-Romero, J., Baez-Lopez, Y., Miranda-Ackerman, M., Arredondo-Soto, K., & Ontiveros, S. (2020). A systematic review and meta-analysis of the effects of food safety and hygiene training on food handlers. *Foods*, *9*(9), 1169.
- Islam, R., Islam, S., & Rahman, M. (2022). Assessment of hygienic and sanitation practices among poultry butchers in selected municipality areas of Assam (India).
- Iwu, A. C., Uwakwe, K. A., Duru, C. B., Diwe, K. C., Chineke, H. N., Merenu, I. A., ... & Ohale, I. (2017). Knowledge, attitude and practices of food hygiene among food vendors in Owerri, Imo State, Nigeria. *Occupational Diseases and Environmental Medicine*, *5*(1), 11-25.

- Jacob, C., Mathiasen, L., & Powell, D. (2010). Designing effective messages for microbial food safety hazards. *Food Control*, *21*(1), 1-6.
- Jiren, T. S., Leventon, J., Jager, N. W., Dorresteijn, I., Schultner, J., Senbeta, F., & Fischer, J. (2021). Governance challenges at the interface of food security and biodiversity conservation: a multi-level case study from Ethiopia. *Environmental Management*, *67*, 717-730.
- Kanko, T., Seid, M., & Alemu, M. (2023). Evaluation of bacteriological profile of meat contact surfaces, handling practices of raw meat and its associated factors in butcher shops of Arba Minch town, southern Ethiopia-A facility based cross sectional study. *Food Safety and Risk*, *10*(1), 1.
- Kebede, M. T., & Getu, A. A. (2023). Assessment of bacteriological quality and safety of raw meat at slaughterhouse and butchers' shop (retail outlets) in Assosa Town, Beneshangul Gumuz Regional State, Western Ethiopia. *BMC microbiology*, *23*(1), 403.
- Kleyn, F. J., & Ciacciariello, M. (2021). Future demands of the poultry industry: will we meet our commitments sustainably in developed and developing economies? *World's Poultry Science Journal*, *77*(2), 267-278.
- Kyayesimira, J., Rapheal, W., Rugunda, G. K., Bunny, L. J., Andama, M., & Matofari, J. W. (2020). Microbial quality of beef and hygiene practices in small and medium slaughterhouses and butcheries in Uganda.
- Lee, H. K., Abdul Halim, H., Thong, K. L., & Chai, L. C. (2017). Assessment of food safety knowledge, attitude, self-reported practices, and microbiological hand hygiene of food handlers. *International journal of environmental research and public health*, *14*(1), 55.
- Lennard, L. B. (2020). Food microbiology and food poisoning. In *Food and Nutrition* (pp. 132-154). Routledge.
- Lie, A. L. (2023). Unpacking the politics of global public-private partnerships in global nutrition governance: Understanding the influence of the Scaling up Nutrition Movement (SUN).
- Liguori, J., Trübswasser, U., Pradeilles, R., Le Port, A., Landais, E., Talsma, E. F., & Holdsworth, M. (2022). How do food safety concerns affect consumer behaviors and diets in low-and middle-income countries? A systematic review. *Global Food Security*, *32*, 100606.

- Magouras, I., Brookes, V. J., Jori, F., Martin, A., Pfeiffer, D. U., & Dürr, S. (2020). Emerging zoonotic diseases: Should we rethink the animal–human interface? *Frontiers in veterinary science*, *7*, 582743.
- Maicas-Pérez, L., Hernández-Lougedo, J., Heredia-Elvar, J. R., Pedauyé-Rueda, B., Cañuelo-Márquez, A. M., Barba-Ruiz, M., & Maté-Muñoz, J. L. (2023). Effects of Creatine Supplementation after 20 Minutes of Recovery in a Bench Press Exercise Protocol in Moderately Physically Trained Men. *Nutrients*, *15*(3), 657.
- Matchawe, C., Ndip, L. M., Zuliani, A., Tsafack, J. J., Nsawir, B. J., Piasentier, E., & Joseph, N. (2019). Knowledge, attitude and practices (KAP) regarding meat safety and sanitation among carcass handlers operating at the Yaoundé slaughterhouse, Cameroon. *Int J Adv Res Publ*, *3*, 150-155.
- Mazhangara, I. R., Jaja, I. F., Falowo, A. B., Oguttu, J., Green, E., & Muchenje, V. (2024). Knowledge of meat safety, personal hygiene and antimicrobial resistance awareness among slaughterhouse workers in the formal and informal meat sector.
- Mendagudali, R. R., Akka, K. D., Swati, I. A., Shedole, D. T., & Bendigeri, N. A. D. (2016). Knowledge, attitude, and practices of food safety among women of Khaza bazar, the urban field practice area of KBN Institute of Medical Sciences, Kalaburagi, Karnataka.
- Mengistu, D. G., & Mahesh, G. (2020). Challenges in developing the Ethiopian construction industry. *African Journal of Science, Technology, Innovation and Development*, *12*(4), 373-384.
- Miazga, K., Kopczyńska, K., Szaluś-Jordanow, O., Moroz-Fik, A., Wilczak, J., Barszcz, K., & Cywińska, A. (2023). Metabolomic analysis indicated changes in triacylglycerols' levels as a result of training in Whippet dogs. *Scientific Reports*, *13*(1), 18223.
- Milbank, C., & Vira, B. (2022). Wildmeat consumption and zoonotic spillover: contextualising disease emergence and policy responses. *The Lancet Planetary Health*, *6*(5), e439-e448.
- Miyamoto, H., Suda, W., Kodama, H., Takahashi, H., Nakanishi, Y., Moriya, S., & Ohno, H. (2022). A novel sustainable role of compost as a universal protective substitute for fish, chicken, pig, and cattle, and its estimation by structural equation modeling. *arXiv preprint arXiv:2201.10895*.
- Mshelia, A. B., Osman, M., & Binti Misni, N. (2022). A cross-sectional study design to determine the prevalence of knowledge, attitude, and the preventive practice of food

- poisoning and its factors among postgraduate students in a public university in Selangor, Malaysia. *PLoS One*, *17*(1), e0262313.
- Muleta, B. G., Dida, M. F., Kiani, A., Mapiye, C., Bruce, H., & Ponnampalam, E. (2022). Why Ethiopian Meat is Considered Dark Cutting and Unsuitable for the Export Market: Lessons Learnt from the Livestock Chain.
- Murimi, M., & Waweru, G. (2020). Food hygiene knowledge, attitudes and practices amongst food handlers in selected hotels and restaurants in Thika town, Kenya.
- Mutua, F. K., Mutie, I., Kuboka, M., Leahy, E., & Grace, D. (2022). Literature review on foodborne disease hazards in food and beverages in Ethiopia.
- Nagel-Alne, G. E., Murphy, E., McCauslin, B., Hauge, S. J., Schröder-Petersen, D. L., Holthe, J., & Alvseike, O. (2022). Meat safety legislation and its opportunities and hurdles for innovative approaches: A review. *Food Control*, *141*, 109160.
- Nardi, V. A. M., Teixeira, R., Ladeira, W. J., & de Oliveira Santini, F. (2020). A meta-analytic review of food safety risk perception. *Food Control*, *112*, 107089.
- Ncube, F., Kanda, A., Chijokwe, M., Mabaya, G., & Nyamugure, T. (2020). Food safety knowledge, attitudes and practices of restaurant food handlers in a lower-middle-income country. *Food science & nutrition*, *8*(3), 1677-1687.
- Nurye, M., & Demlie, M. (2021). Assessment of hygienic practices and microbial quality of meat at slaughterhouses and butcher's shops in West Hararghe Zone, Ethiopia. *Abyssinia Journal of Science and Technology*, *6*(2), 32-41.
- Nyokabi, N. S., Phelan, L., Gemechu, G., Berg, S., Lindahl, J. F., Mihret, A., & Moore, H. L. (2023). From farm to table: exploring food handling and hygiene practices of meat and milk value chain actors in Ethiopia. *BMC Public Health*, *23*(1), 899.
- Nyokabi, N. S., Phelan, L., Gemechu, G., Berg, S., Lindahl, J. F., Mihret, A., & Moore, H. L. (2023). From farm to table: exploring food handling and hygiene practices of meat and milk value chain actors in Ethiopia. *BMC Public Health*, *23*(1), 899.
- Odeyemi, O. A., Alegbeleye, O. O., Strateva, M., & Stratev, D. (2020). Understanding spoilage microbial community and spoilage mechanisms in foods of animal origin. *Comprehensive reviews in food science and food safety*, *19*(2), 311-331.

- Okpala, C. O. R., Nwobi, O. C., & Korzeniowska, M. (2021). Assessing nigerian butchers' knowledge and perception of good hygiene and storage practices: A cattle slaughterhouse case analysis. *Foods*, *10*(6), 1165.
- Olumakaiye, M. F., & Bakare, K. O. (2013). Training of food providers for improved environmental conditions of food service outlets in urban area Nigeria. *Food and Nutrition Sciences*, *4*(07), 99.
- Oumer, A. (2019). Determinants of food safety practices among food handlers in selected food establishments. *International Journal of Public Health Science*, *8*(2), 229-237.
- Parikh, P., Aparo, N. O., Nordhagen, S., & De Steur, H. (2022). Food safety-related perspectives and practices of consumers and vendors in Ethiopia: A scoping review. *Food Research International*, *157*, 111376.
- Prache, S., Adamiec, C., Astruc, T., Baéza-Campone, E., Bouillot, P. E., Clinquart, A., & Santé-Lhoutellier, V. (2022). Quality of animal-source foods. *Animal*, *16*, 100376.
- Rakha, A., Fatima, M., Bano, Y., Khan, M. A., Chaudhary, N., & Aadil, R. M. (2022). Safety and quality perspective of street vended foods in developing countries. *Food Control*, *138*, 109001.
- Reta, M. A., Lemma, M. T., Gemed, A. A., & Lemlem, G. A. (2021). Food handling practices and associated factors among food handlers working in public food and drink service establishments in Woldia town, Northeast Ethiopia. *Pan African Medical Journal*, *40*(1).
- Rolfe, C., & Daryaei, H. (2020). Intrinsic and extrinsic factors affecting microbial growth in food systems. *Food Safety Engineering*, 3-24.
- Rosnani, A. H., Son, R., Mohhidin, O., Toh, P. S., & Chai, L. C. (2014). Assessment of knowledge, attitude and practices concerning food safety among restaurant workers in Putrajaya, Malaysia. *Food Science and Quality Management*, *32*(20), e27.
- Sameh, J., Wali, A., Buonerba, A., Zarra, T., Belgiorno, V., Naddeo, V., & Ksibi, M. (2020). Efficient and Sustainable Treatment of Tannery Wastewater by a Sequential Electrocoagulation-UV Photolytic Process. *arXiv preprint arXiv:2010.03285*.
- Sayuti, Y., Albattat, A., Ariffin, A., Nazrin, N., & Silahudeen, T. N. A. T. (2020). Food safety knowledge, attitude and practices among management and science university students, Shah Alam. *Management science letters*, *10*(4), 929-936.

- Scharff, R. L., McDowell, J., & Medeiros, L. (2009). Economic cost of foodborne illness in Ohio. *Journal of Food Protection*, *72*(1), 128-136.
- Seaman, P. (2010). Food hygiene training: Introducing the food hygiene training model. *Food Control*, *21*(4), 381-387.
- Sebsibe, M. A., & Asfaw, E. T. (2020). Occurrence of multi-drug resistant *Escherichia coli* and *Escherichia coli* O157: H7 in meat and swab samples of various contact surfaces at slaughterhouse and butcher shops in Jimma town, Southwest district of Ethiopia. *Infection and drug resistance*, 3853-3862.
- Semete-Makokotlela, B., Mahlangu, G. N., Mukanga, D., Darko, D. M., Stonier, P., Gwaza, L., & Pillai, G. (2022). Needs-driven talent and competency development for the next generation of regulatory scientists in Africa. *British journal of clinical pharmacology*, *88*(2), 579-586.
- Shahbaz, M., Bilal, M., Moiz, A., Zubair, S., & Iqbal, H. M. (2020). Food safety and COVID-19: precautionary measures to limit the spread of coronavirus at food service and retail sector. *Journal of Pure and Applied Microbiology*, *14*(1), 749-756.
- Sharif, L., Obaidat, M. M., & Al-Dalalah, M. R. (2013). Food hygiene knowledge, attitudes and practices of the food handlers in the military hospitals. *Food and Nutrition Sciences*, *4*(03), 245.
- Sher, A. A., Ashraf, M. A., Mustafa, B. E., & Raza, M. M. (2021). Epidemiological trends of foodborne *Campylobacter* outbreaks in the United States of America, 1998–2016. *Food Microbiology*, *97*, 103751.
- Siluma, B. J., Kgatla, E. T., Nethathe, B., & Ramashia, S. E. (2023). Evaluation of meat safety practices and hygiene among different butcheries and supermarkets in Vhembe District, Limpopo Province, South Africa. *International journal of environmental research and public health*, *20*(3), 2230.
- Singha, S., Thomas, R., Viswakarma, J. N., & Gupta, V. K. (2023). Foodborne illnesses of *Escherichia coli* O157 origin and its control measures. *Journal of Food Science and Technology*, *60*(4), 1274-1283.
- Soon, J. M., Brazier, A. K., & Wallace, C. A. (2020). Determining common contributory factors in food safety incidents—A review of global outbreaks and recalls 2008–2018. *Trends in Food Science & Technology*, *97*, 76-87.

- Soon, J. M., Wahab, I. R. A., Hamdan, R. H., & Jamaludin, M. H. (2020). Structural equation modelling of food safety knowledge, attitude and practices among consumers in Malaysia. *PloS one*, *15*(7), e0235870.
- Tamiru, S., Bidira, K., Moges, T., Dugasa, M., Amsalu, B., & Gezimu, W. (2022). Food safety practice and its associated factors among food handlers in food establishments of Mettu and Bedelle towns, Southwest Ethiopia, 2022. *BMC nutrition*, *8*(1), 151.
- Tapia, M. S., Alzamora, S. M., & Chirife, J. (2020). Effects of water activity (aw) on microbial stability as a hurdle in food preservation. *Water activity in foods: Fundamentals and applications*, 323-355.
- Teferi, S. C. (2020). A review on food hygiene knowledge, practice, and food safety in Ethiopia. *Scientific Journal of Food Science and Nutrition*, *5*(1), 023-029.
- Teffo, L. A., & Tabit, F. T. (2020). An assessment of the food safety knowledge and attitudes of food handlers in hospitals. *BMC Public Health*, *20*, 1-12.
- Tegegne, H. A., & Phyto, H. W. W. (2017). Food safety knowledge, attitude and practices of meat handler in slaughterhouse and retail meat shops of Jigjiga Town, Ethiopia. *Journal of preventive medicine and hygiene*, *58*(4), E320–E327
- Tesfaye, A., & Tegene, Y. (2020). Assessment of food hygiene and safety practices among street food vendors and its associated factors in urban areas of Shashemane, West Arsi Zone, Oromia Ethiopia, 2019. *Sci. J. Immunol. Immunother*, *4*: 1-5.
- Teshome, G., Assefa, Z., & Keba, A. (2020). Assessment of the microbial quality status of raw beef around Addis Ababa city, Ethiopia. *African Journal of Food Science*, *14*(7), 209-214.
- Tessema, A. G., Gelaye, K. A., & Chercos, D. H. (2014). Factors affecting food handling Practices among food handlers of Dangila town food and drink establishments, North West Ethiopia. *BMC public Health*, *14*, 1-5.
- Tessema, A. G., Gelaye, K. A., & Chercos, D. H. (2014). Factors affecting food handling Practices among food handlers of Dangila town food and drink establishments, North West Ethiopia. *BMC public Health*, *14*, 1-5.
- Tesson, V., Federighi, M., Cummins, E., de Oliveira Mota, J., Guillou, S., & Boué, G. (2020). A systematic review of beef meat quantitative microbial risk assessment models. *International Journal of Environmental Research and Public Health*, *17*(3), 688.

- Thoms, C., Gattinger, A., Jacob, M., Thomas, F. M., & Gleixner, G. (2010). Direct and indirect effects of tree diversity drive soil microbial diversity in temperate deciduous forest. *Soil Biology and Biochemistry*, *42*(9), 1558-1565.
- Tierney, R. (2022). Examining Health Disparities Related to Foodborne Illnesses Across Racial and Ethnic Groups.
- Todd, E. C., Michaels, B. S., Smith, D., Greig, J. D., & Bartleson, C. A. (2010). Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 9. Washing and drying of hands to reduce microbial contamination. *Journal of food protection*, *73*(10), 1937-1955.
- Tosisa, W., Mihret, A., Ararsa, A., Eguale, T., & Abebe, T. (2020). Prevalence and antimicrobial susceptibility of Salmonella and Shigella species isolated from diarrheic children in Ambo town. *BMC pediatrics*, *20*, 1-8.
- Traore, F. (2021). Analysing food systems governance in Ethiopia: The case of the Seqota Declaration.
- Urgesa, T., & Sorsa, M. (2023). Assessment of knowledge, attitude and practices on food safety of beef among meat handlers at homes and slaughter houses in and around Babich and Gedo Towns, West Shewa Zone, Ethiopia. *Zoological journal*, *3* (1), 59-68
- Wabelo, T. S. (2020). Legal and institutional frameworks regulating rural land governance in Ethiopia: Towards a comparative analysis on the best practices of other African countries. *Beijing L. Rev.*, *11*, 64.
- Waldman, L., Hrynick, T. A., Benschop, J., Cleaveland, S., Crump, J. A., Davis, M. A., & Zadoks, R. N. (2020). Meat safety in northern Tanzania: inspectors' and slaughter workers' risk perceptions and management. *Frontiers in Veterinary Science*, *7*, 309.
- Waltenburg, M. A. (2020). Update: COVID-19 among workers in meat and poultry processing facilities—United States, April–May 2020. *MMWR. Morbidity and mortality weekly report*, *69*.
- 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.
- White, A. E., Tillman, A. R., Hedberg, C., Bruce, B. B., Batz, M., Seys, S. A., & Walter, E. S. (2022). Foodborne illness outbreaks reported to national surveillance, United States, 2009–2018. *Emerging infectious diseases*, *28*(6), 1117

- WHO/UNICEF Joint Water Supply, & Sanitation Monitoring Programme. (2015). *Progress on sanitation and drinking water: 2015 update and MDG assessment*. World Health Organization.
- World Health Organization. (2015). *WHO estimates of the global burden of foodborne diseases: foodborne disease burden epidemiology reference group 2007-2015*. World Health Organization.
- Yang, L., Arnold, N. L., Drape, T., Williams, R. C., Archibald, T., Chapman, B., & Boyer, R. (2021). A survey of United States consumer awareness, purchasing, and handling of mechanically tenderized beef products. *Food Control*, *120*, 107505.
- Yemane, B., & Tamene, A. (2022). Understanding domestic food safety: An investigation into self-reported food safety practice and associated factors in southern Ethiopian households. *Environmental health insights*, *16*, 11786302221103881.
- Yenealem, D. G., Yallew, W. W., & Abdulmajid, S. (2020). Food safety practice and associated factors among meat handlers in Gondar town: a cross-sectional study. *Journal of environmental and public health*, *2020*. 7421745
- Yimana, M., & Hassen, A. (2024). Assessment of the Operational facilities and Hygienic Practices of Slaughterhouses and Butcher shops in Ethiopia: Implications for Consumer's Health.
- Young, I., Waddell, L. A., Wilhelm, B. J., & Greig, J. (2020). A systematic review and meta-regression of single group, pre-post studies evaluating food safety education and training interventions for food handlers. *Food research international*, *128*, 108711.
- Zdolec, N., & Kiš, M. (2021). Meat safety from farm to slaughter—Risk-based control of *Yersinia enterocolitica* and *Toxoplasma gondii*. *Processes*, *9*(5), 815.
- Zelalem, A., Abegaz, K., Kebede, A., Terefe, Y., & Vipham, J. L. (2023). Targeted training-based interventions to improve food safety practices in municipal slaughterhouses of Ethiopia. *Journal of Consumer Protection and Food Safety*, *18*(3), 281-290.
- Zelalem, A., Abegaz, K., Kebede, A., Terefe, Y., Schwan, C. L., & Vipham, J. L. (2021). Food Safety Knowledge, Attitudes, and Hygienic Practices of Slaughterhouse Workers in Ethiopia: A Cross-Sectional Study. *Food Protection Trends*, *41*(5).

- Zelalem, A., Koran, T., Abegaz, K., Abera, Z., Mammed, B., Olani, A., & Vipham, J. L. (2024). Hygienic status of beef butcher shop facilities and antibiotic resistance profile of *Salmonella enterica* in Ethiopia. *Brazilian Journal of Microbiology*, 1-12.
- Zeleele, T. Z., Gebreyes, D. S., Tilahun, A. T., Craddock, H. A., & Gishen, N. Z. (2019). Enteropathogens in under-five children with diarrhea in health facilities of Debre Berhan Town, North Shoa, Ethiopia. *Ethiopian journal of health sciences*, **29**(2): 203–214.
- Zhang, Y., Zhou, C., Bassey, A., Bai, L., Wang, Y., & Ye, K. (2022). Quantitative exposure assessment of *Listeria monocytogenes* cross-contamination from raw to ready-to-eat meat under different food-handling scenarios. *Food Control*, *137*, 108972.

8. ANNEXES

Annexe 1: Participant's agreement consent form

EVALUATION OF WORKERS' KNOWLEDGE, ATTITUDES, AND HYGIENE PRACTICES REGARDING FOOD SAFETY AND THE MICROBIAL LOAD ON MEAT AND ITS CONTACT SURFACES IN ABATTOIRS AND BUTCHER SHOPS IN SELECTED TOWNS OF THE EAST SHOA ZONE, OROMIA, ETHIOPIA

Dear participants of this study,

This is an MSc research work in the veterinary public health program at the College of Veterinary Medicine and Agriculture of Addis Ababa University. I would like to ask for your participation in this study by responding to the interview (filling out this questionnaire format) based on your voluntariness. This study aims to assess the food safety knowledge, attitudes, hygienic practices, and microbial load of meat and its contact surface at slaughterhouses and butcher shops in Bishoftu and Modjo, Ethiopia. There is no apparent risk to you. However, the result of this study will help us to improve actions taken in response to the well-being of the public. Filling out this questionnaire or interview may take 20-30 minutes.

Do you agree to participate in this study? Yes/ No

If yes, please indicate X above and continue filling out the remaining questionnaire. If not, don't do anything, and kindly return the format.

By taking part, you are agreeing that you have read and understood the information about the study described above. Tick your answer with X in the box or write your answers in the space provided.

Thank you!!!

Annexe 2: Food safety knowledge, attitudes, and hygiene practices at slaughterhouse

Questionnaire Code _____ Date _____ **Study area** _____

II. Name: _____

PART 1.: SOCIODEMOGRAPHIC CHARACTERISTICS	
1	Which one describes your Role? Head of the slaughterhouse B) Meat inspector C) Meat handler D) Others _____
2	Gender: Female <input type="checkbox"/> Male <input type="checkbox"/>
3	Age: 18- 20 years <input type="checkbox"/> 20-29 years <input type="checkbox"/> 30-39 years <input type="checkbox"/> 40-50 years <input type="checkbox"/> over 50 years <input type="checkbox"/>
4	Level of education: Elementary school <input type="checkbox"/> High school <input type="checkbox"/> University education <input type="checkbox"/>
5	Position Veterinarian <input type="checkbox"/> Meat inspector <input type="checkbox"/> Manager <input type="checkbox"/> Assistant veterinarian <input type="checkbox"/> Others (Unqualified
6	Experience as a meat handler: ≤ 5 years <input type="checkbox"/> 6- 10 years <input type="checkbox"/> ≥ 11 years <input type="checkbox"/>
7	Participation in training since starting this job: < three times <input type="checkbox"/> > four times or more <input type="checkbox"/>
8	Time of the previous training attended: Last 3 months <input type="checkbox"/> Last 6 months <input type="checkbox"/> 1 year or more <input type="checkbox"/>
Part 2: Knowledge of hygienic handling and food safety interventions at the slaughterhouses or slaughterhouse	

	Question	Yes	No	I don't know
1	Noncompliance means failure to act according to the rules and regulations set by the government			
2	Compliance with slaughterhouse laws helps to minimize the spread of diseases to the general public.			
3	Noncompliance does not result in the transmission of disease from animal to human beings			
4	If meat processing is done properly and hygienically, it can spread pathogens to the general public.			
5	Good personal hygiene by slaughterhouse workers can result in contamination of the processed carcass.			
6	All equipment used during meat processing should be properly washed and sterilized after each usage.			
7	Disposal of solid waste, blood, and effluents into the nearby river does not cause water pollution.			
8	Providing practical knowledge on meat hygiene standards for producers, transporters, retailers, and consumers is a key food safety intervention.			
9	Do you know the correct application of cleaning and disinfecting procedures of equipment to reduce the risk of contamination of disease transmission to people?			
10	Do you know washing hands before handling meat reduces the risk of meat contamination?			
11	Do you know the use of caps, masks, protective gloves, and adequate closing reduce the risk of meat contamination?			
12	Is it important to know the temperature of the chiller/cooler to reduce the risk of meat/carcass contamination?			
13	Do you know the production service workers with cuts and abrasions on their hands should not touch/handle meat/carcass?			
14	Food handlers who do not adopt good hygiene practices could be a cause of food contamination			
15	Do you know the current food safety legislation?			

16	Do you know what HACCP means?			
PART 3: ATTITUDE OF HYGIENE AND FOOD SAFETY INTERVENTIONS AT THE SLAUGHTERHOUSE				
Questions for face-to-face interviews about attitudes towards food safety interventions at the slaughterhouse		Yes	No	I do not know
1	Do you think all those slaughterhouses be required to register and operate in accordance with regulations established by the Ministry of Agriculture and Ministry of Trade?			
2	Do you think all facilities being established to meet the standards set by the government?			
3	Does Ethiopian food law provide a legal basis for regulating meat and meat products intended for domestic consumption?			
4	Do you think all meat inspectors and veterinarians have sufficient practical knowledge and skills in their respective municipalities?			
5	How would you rate your knowledge of meat inspection activities?			
6	Do you think the food handlers responsible for preventing food borne diseases?			
7	Do you think that food safety needs a prerequisite program?			
8	Do you think all personnel working in the slaughterhouse must wear protective cloth during operation procedure in slaughter processing?			
9	Do you think compliance with the slaughterhouse laws during meat processing and waste disposal can only be achieved if all proper measures are taken and followed?			
10	Do you think clean and safe water should be used to wash all carcasses in the slaughterhouse?			
11	Do you think training and learning about meat hygiene is an important for you?			
12	Do you think Washing and disinfecting hands prevents Meat contamination?			

Part 4: Slaughterhouse hygiene practices safety intervention practices		Never	Rarely	Sometimes	Often
1	Do you only receive animals that appear healthy from farms or markets?				
2	Does food hygiene knowledge allow you to do your job correctly?				
3	Do veterinarians or meat inspectors regularly perform their duties?				
4	Do you wear protective clothing daily before starting work in the slaughterhouse?				
5	Is an ante mortem examination conducted before the slaughter of each animal?				
6	Are carcasses condemned either totally or partially if found unfit for human consumption?				
7	Is potable water used for washing carcasses after processing?				
8	Are all solid, blood, and any form of effluent from the slaughterhouse properly disposed of as required by the regulation/law?				
9	Is the slaughterhouse environment clean and hygienically maintained regularly?				
10	Can poor hygiene practices among food handlers can lead to food contamination?				

PART FIVE: Good hygiene practice (GHP), Good management practice (GMP), Sanitation Standard Operating Procedures (SSOPs) Hazard analysis critical control point (HACCP) for professional only		Yes	No
11	Do you know the principles of HACCP?		
12	Do you respect the objectives of the HACCP plan?		
13	The HACCP system is a method to ensure food safety		

14	The HACCP system applies to the quality of the final product and not to the preparation procedures		
15	Does food hygiene knowledge allow you to do your job correctly?		
16	Do you know the principle of GHP?		
17	Do you work on GHP implementation at your level?		
18	Do you follow the implementation of GHP?		
19	Do you know the principle of GMP?		
20	Do you work on GMP implementation at your level?		
21	Do you follow the implementation of GMP?		
22	Do you know the principle of SSOPs?		
23	Do you work on SSOPs implementation at your level?		
24	Do you follow the implementation of SSOPs?		

Remarks:

What are the main challenges encountered with respect to the implementations of:

GHP: _____

GMP: _____

SSOPs: _____

Annexe 3: Food safety knowledge, attitudes, and hygiene practices at *butcher shop*

Questionnaire Code _____ Date _____ Study area _____

I. Name: _____

Part One: SOCIODEMOGRAPHIC CHARACTERISTICS			
1	Which one describes your Role? A) Head of the slaughterhouse B) Meat inspector C) Meat handler D) Others _____		
2	Gender: Female <input type="checkbox"/> Male <input type="checkbox"/>		
3	Age: 18- 20 years <input type="checkbox"/> 20-29 years <input type="checkbox"/> 30-39 years <input type="checkbox"/> 40-50 years <input type="checkbox"/> over 50 years <input type="checkbox"/>		
4	Level of education: Elementary school <input type="checkbox"/> High school <input type="checkbox"/> University education <input type="checkbox"/>		
5	Position Butcher <input type="checkbox"/> Manager <input type="checkbox"/> Assistant butcher <input type="checkbox"/> Cashier <input type="checkbox"/>		
6	Experience as a meat handler: ≤ 5 years <input type="checkbox"/> 6- 10 years <input type="checkbox"/> ≥11 years <input type="checkbox"/>		
7	Participation in training since starting this job: < three times <input type="checkbox"/> > four times or more <input type="checkbox"/>		
8	Time of the previous training attended: Last 3 months <input type="checkbox"/> Last 6 months <input type="checkbox"/> 1 year or more <input type="checkbox"/>		
PART TWO: knowledge of hygienic handling and food safety interventions at the Butcher shops			
	Questions	Yes	No

1	Have you ever received any training on the hygienic handling of meat?		
2	Do you have refrigerator vehicle for the means of transporting meat from the slaughterhouse to the retail shop?		
3	Do you wash your hands before handling meat?		
4	Do you know about the shelf life of red meat?		
5	Do you wash your hands after handling meat?		
6	Do you wash your hands after handling waste/garbage?		
7	Do you wash your hands after using the toilet?		
8	Do you remove your rings, and watch while handling meat?		
9	Do you handle/process meat while you are ill?		
10	Do you handle the meat when you have cuts, wounds, or injuries on your hands?		
11	Do you have routine control of flies in your butcher shop?		
12	Is the water used in your butcheries potable?		
13	Does the meat stay in your butchery for over one day?		
14	Do you use a refrigerator for storage of the meat that remains from a daily sale?		
15	Do you collect money while handling or selling meat?		
16	Do you have a separate cashier for collecting money?		
PART THREE: Attitudes of butcher shop worker on food safety interventions			
1	Do you believe being medically examined every six months is important for a red meat handler's health?		
2	Do you think improper/unhygienic meat storage is dangerous to health		

3	Do you think wearing watches, earrings, and rings will increase the risk of red meat contamination		
4	Do you think wearing protective clothing/aprons, gloves, caps, shoes, and masks for safe meat handling to avoid contamination and diseases is a prerequisite of meat handlers' job responsibilities		
5	Is it important to use potable water to wash working surfaces, cutting tools, knives, and hooks after disinfection?		
6	Do you think that your responsibility as a food handler is to ensure that the meat sold is safe?		
7	Do you think washing hands with soap can reduce meat contamination or food poisoning?		
8	Did you expect regular training and awareness programs improve meat safety and hygiene practices?		
9	Are you willing to change your food-handling behaviors when you know that they are incorrect?		
10	Do you believe that your butchery need some improvement for better handling?		
PART FOUR: Hygienic practice towards food safety interventions at the butcher shop			
1	Do you wash your hands with soap and wear an apron, gloves, cap, shoes, and masks during meat handling?		
2	Do you always use sanitizer when washing service utensils (knives, hooks, cutting tools, etc.)?		
3	Do you remove personal items such as rings, necklaces, and watches during the meat handling period?		
4	Do you wash raw meat before cutting or preparing it?		
5	Do proper cleaning and handling of instruments reduce the risk of food contamination?		

6	Do you wash and disinfect working surfaces and tools for handling meat?		
7	Do you use a hair cover on the head while you are in meat cutting time?		
8	Do you use a hair cover on the head while you are in meat cutting time?		
9	Do you wash hands and equipment after handling waste/garbage?		
10	Do you use different storage and display cabinets for offals and meat?		
11	Do you use the same equipment while handling meat and the green offals?		
12	Do you practice training given to improve your butcher shop?		

Remarks: If a respondent wants to add any commentary or message related to the butcher shop handling practice, hygiene, etc.?

5. Checklist for observations of butcher shops		Yes	No
1	Is there any cover on the display case?		
2	Is the Butcher shop floor made of wood?		
3	Is the Butcher shop floor made of concrete?		
4	Is the Butcher shop floor made of other specific material? (Specify the materials)_____		
5	Is the wall painted with white color?		
6	If yes, is there a sign of dirt on the wall?		
7	Rate the ventilation status of the display case and butchery.		
8	Is there a use of bulbs in the display case?		
9	Presence of a meat cooling facility at the display cabinet		

10	Protective material <ul style="list-style-type: none"> • Apron/white coat • Headcover • Gloves 		
11	Is there a toilet nearby?		
12	Is there a sink for washing hands?		
13	Types of meat cutting board ;		
14	Is the cutting board used made of wooden?		
15	Is the cutting board used made of plastic?		
16	Is the cutting board used made of Metal?		
17	Is the cutting board used made of marble?		
18	Is there hot water baths for dipping knives?		
19	Is there a material to wrap meat for sale?(If 'Yes' with this question proceed to the next question but skip if the response will be 'No')		
20	Is the wrapping material for meat for sales are from Newspaper?		
21	Is the wrapping material for meat for sales are from plastic?		
22	Is the wrapping material for meat for sales are from 'Used paper'?		
23	Is the wrapping material for meat for sales are from _____ (Other, specify)?		

Thank you!!

Annexe 4: Steps in EC and SA count on TEMPO count

- Stomach the Sample and primary diluents in the TEMPO bag
- Dispense 3ml of secondary diluent (distilled water) into vial of culture medium
- Transfer 1ml of sample into vial of culture medium
- Associate the card and culture medium vial together in the TEMPO rack
- Insert the rack into the TEMPO Filler and press on the start
- Incubate Filled cards at 37C° for 24hrs
- After incubation insert the cards into the TEMPO reader and check the status and read the result.

Steps in APC

- Measure a 10ml sample into a sterile homogenizing bag containing 90ml Buffer Peptone Water respectively and homogenize it very well.
- formulate into 1:10 sample solution (serial dilution 10⁻¹-10⁻⁶)
- 1ml from each dilution(sample) dispensed to a sterile Petri dish and mixed with APC agar
- Incubate at 30±1°C for 72h±3h.
- Select the plates for total plate count with colony number between 10-300CFU
- For each dilution degree, the average number of two plates shall be applied

$$N = \frac{\sum c}{[(1 \times n_1) + (0.1 \times n_2) \times (d)]}$$

Where N = Number of colonies per ml or g of product

Σ c = Sum of all colonies on all plates counted

n1 = Number of plates in the first dilution counted

n2 = Number of plates in the second dilution counted

d = Dilution from which the first counts were obtained

Specification

Aerobic Plate Count-ES ISO 4833-1 10⁶CFU/g

E-coli Count – ES ISO 16649-2 10²CFU/g

Coagulase Positive *Staphylococcus aureus* – ES ISO 6888-1 10²CFU/g

Annexe 5: Research ethical clearance

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ADDIS ABABA UNIVERSITY
College of Veterinary Medicine
and Agriculture
Bishoftu

Animal Research Ethical Review Committee

Ethical clearance certificate

Certificate Ref. No: VM/ERC/17/03/15/2023

Name and affiliation of applicant: **Teferi Atlaw (DVM, MSc student)**
Department of Microbiology, Immunology and Veterinary
Public Health, College of Veterinary Medicine and Agriculture,
Addis Ababa University

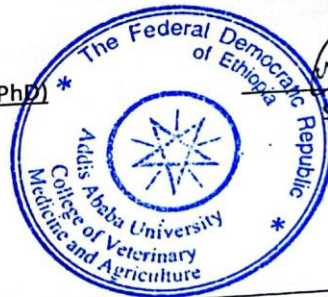
Title of the project: *Food safety intervention knowledge, attitude and hygienic practices at
abattoirs and butcher shops in Bishoftu and Modjo*

Date of application: **December, 2022**
Nature of the project: **Questionnaire survey**
Target animal species: **No animal use**
Number of animals involved: **None**
Study area: **Bishoftu and Modjo towns, Ethiopia**

Minutes No. and date of review: **VM/ERC/03/15/022, 25/01/2023**

The Animal Research Ethical Review Committee of the College of Veterinary Medicine and
Agriculture of Addis Ababa University has reviewed the above research project and unanimously
approved the application of Teferi Atlaw.

Professor Getachew Terefe (DVM, PhD)
Chairman



[Signature]
Signature

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Please quote Our Ref. No. When replying

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Annexe 6: Status of plagiarism reports

FOOD SAFETY KNOWLEDGE, ATTITUDE, HYGIENIC PRACTICES AND MICROBIAL LOAD OF MEAT AND ITS CONTACT SURFACE AT SLAUGHTERHOUSE AND BUTCHER SHOPS IN BISHOFTU MOJO, AND DUKEM by Teferi Atlaw

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