MICROBIAL RISK ASSESSMENT OF STREET VENDED POULTRY PRODUCTS IN THE INFORMAL SETTLEMENTS OF NAIROBI COUNTY

BY

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BSc. FOOD SCIENCE AND TECHNOLOGY

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I, **BEATRICE BIRGEN JERUTO**, hereby declare that this dissertation is my original work and has not been submitted for a degree in any other institution.

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DEDICATION

I dedicate this work to my dear husband Martin Omondi for his support and prayers.

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To my parents Mr. Isaac Birgen and Mrs. Miriam Birgen for their support, prayers, love and encouragement they gave me during my study.

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ACRONYMNS

ALOP	Acceptable level of protection
ANOVA	Analysis of variance
CFU	Colony forming units
DALY	Disability-Adjusted Life Year
FAO	Food and Agriculture Organization
FSO	Food safety objective
ISO	International Organization for Standardization
MRA	Microbial risk assessment
QRA	Quantitative risk assessment
RTE	Ready to Eat
SVF	Street-Vended Foods
SVP	Street-Vended Poultry
WHO	World Health Organization

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF EQUATIONS

GENERAL ABSTRACT

With the increasing urbanization, street vended foods (SVF) have become popular in the developing countries especially in the areas of low-income status such as the informal settlements. In as much as SVF contributes significant portion of daily diet of the urban population, it remains largely unregulated. Thereby, the SVFs poses great food safety risks to consumers. This study focused on the Street vended poultry products. Poultry products have a myriad of microbial safety challenges and the need for their safety assessment cannot be overlooked. The street-vended poultry (SVP) have much affordability thus the huge consumption levels in the informal settlement. The current study sought to establish the hygiene and food safety knowledge and practices of the vendors and consumers of the SVP. Additionally, the study also evaluated the determinants of microbial safety and the risk rank of these products. A cross-sectional survey was done in the Korogocho and Kariobangi North slums among the consumers and vendors of the SVP to assess their food safety knowledge and practices. Swab samples of the cooking equipment, utensils, and personnel, raw and cooked portions of poultry were collected for microbial quality evaluation. The most prevalent microorganism was assessed for its qualitative risk rank using the Risk Ranger software.

The results showed that both the vendors and consumers had acceptable food safety knowledge scores averaging at 79.79 ± 13.89 and 60.51 ± 12.01 %, respectively. The male vendors (75.56 ± 10.18%) had significantly higher knowledge score than their females counterparts (56.00 ± 8.43 %) at $p<0.05$. Religious affiliation, employment status and residence of the consumers significantly ($p<0.05$) predicted their knowledge scores with an effect of 16.2% in the variation. The vendors (60.51 ± 12.01 %) had poor food safety scores as compared to the consumers (68.0 ± 16%). The education status and the residence of the

consumers significantly ($p<0.05$) affected their food safety practices. Less than half (<50 %) of the consumers purchased packaged products, did not handle displayed product with bare hands and purchased from vendor who covered the displayed products. The residence of the consumer was significantly ($p<0.05$) associated with whether they checked the hygiene status of the vending place. Covering of the displayed products and cooking utensils were the least practiced hygiene measures by the vendors at 23.1 % and 38.5 %, respectively.

The level of contamination of the street vended poultry with *E. coli* ranged from 6.60 ± 1.25^{a} $\pm$ 2.67 ± 1.98^{b} $\log_{10}$ $CFUg^{-1}$, *Salmonella spp* 6.42 ± 1.64^{a} to 2.22 ± 1.88^{b} $\log_{10}$ $CFUg^{-1}$, *Staphylococcus aureus* 6.92 ± 1.32^{a} to 2.86 ± 1.61^{c} $\log_{10}$ $CFUg^{-1}$ and *Campylobacter jejuni* 8.95 ± 0.94^{a} to 4.66 ± 2.67^{d} $\log_{10}$ $CFUg^{-1}$ in raw and cooked poultry samples, respectively. The predictors of E.coli contamination were presence of pests and flies, unclean vending place, vending environment littered with waste, washing of hands by the vendor and lack of appropriate clothing among the vendors at R^2 of 0.33. The vendor practices and environmental hygiene of the vending place would not significantly ($p>0.05$) predict contamination with campylobacter and staphylococcus contamination.

The probability of contamination of raw street-vended poultry was found to be 48.96 %. The mean weekly intake of the poultry was reported 140.0 g per person. The probability of the campylobacter infection in an individual consumer was found as 7.12×10^{-3} with the predicted illnesses among the population found as 1.11×10^{6} cases. The qualitative risk estimate from the study was reported as 67, above the limit of 48 for medium risk. The study concluded that, the most prevalent microorganism, *C. jejuni*, posed high food safety risks resultant from consumption of street-vended poultry. Food safety knowledge, attitude and practices of the vendors and consumers of street-vended poultry aggravated this situation.

The creation of awareness and improvement of food hygiene and preparation practices are essential in reversing the current situation.

CHAPTER ONE: INTRODUCTION

1.1 Background Information

Street vending is a common in most of the cities and urban centres in developing countries, especially in Africa, Asia and South America (Alimi, 2016). This could be as a result of less employment opportunities in most developing countries towards the formal sector while most of their populations have little capital to start large-scale businesses. This has given rise to street vendors, who all over the developing countries have been an integral part of the food supply chain. They are estimated to be feed close to 50 % of urban population (Indira, 2014; Okojie and Isah, 2014). In addition, most countries have no regulatory measures and framework for street vending, thus it is mostly not regulated and is disorganized (Rane, 2011).

In Kenya, street vending is an important economic activity providing sustenance as most of the vendors earn above the minimum wages (Okojie and Isah, 2014). Another study done in Viwandani, Kenya, showed that street vending is a major economic activity in Kenya with women making the majority of the vendors (Githiri *et al.*, 2016). Street vending in urban areas in Kenya are out of both national and county government control. Street vending in Nairobi City ranges from food to non-food materials. Vended foods in the streets of Nairobi range from cooked to uncooked food of which some are to be eaten raw. Street foods are also deemed to be cheap and easily and readily available for most of the population. This has not failed to come with its share of challenges for the local governments that are tasked to regulate this economic activity (Roever and Skinner, 2016).

Street foods are defined as ready-to-eat foods and beverages prepared and sold by vendors and hawkers in the streets of either towns or cities and other similar places (Fellows and Hilmi,

2011). Some of the street foods vended in Nairobi street include meat, fruits and vegetables, milk and cooked food (Githiri *et al.,* 2016). Meat vending including street vending of poultry products is also on the increase with studies done in Kenya urban area of Viwandani estimating that it is practiced to the proportion of 10 % of all vending activities (Githiri *et al.*, 2016). Vending of poultry products is done on stalls and by the roadsides. The street vending of poultry products along the roadside and unhygienic areas poses food safety concerns.

The informal nature of the sector raised concerns including public health and food safety (Global Forum on Food Security and Nutrition, 2011). This is because street foods pose a great risk to spread of food borne illnesses due to poor hygienic conditions during food preparation and handling both by food handler and consumer (Githaiga *et al.*, 2013). WHO estimates that food poisoning illnesses were about 600 million cases of about 31 microbial hazards (WHO, 2014). Food handlers may introduce food pathogens into the food which may result into food poisoning (Muhonja and Kimathi, 2014). Moreover, the food contact surfaces have also been noted as potential carriers of microbial contaminants into street foods (Patel *et al*., 2017). The microorganisms which have posed concerns in street foods are *Staphylococcus aureus, Escherichia coli, Campylobacter spp., Bacilus cereus, Listeria monocytogenes* and *Salmonella spp.* among many others (Rane, 2011).

The microbial contamination of street vended poultry and poultry products can be due to unhygienic practices by the food handler, unhygienic preparation and serving, storage of the products and lack of formal training in food handling (Muhonja and Kimathi, 2014). Studies done in the Tswane Metropole in South Africa found out that most of the poultry products vended in the informal sector were exposed to food hazards especially microbial (Oguttu *et al.*,

2014). The unsuspecting consumers take in the vended poultry products without knowing the fact that the microbial safety of these products are not guaranteed. Some reports have established link of foodborne disease with regular consumers of street food as they have been found to suffer from food borne diseases such as cholera, typhoid fever, diarrhoea and food poisoning (Rane, 2011). This is an indication that the safety of these foods is not assured and there is a need for all stakeholders have a role to play to ensure food safety of these products.

Codex Alimentarius Commission food hygiene and sanitation guidelines of 1997 contained the general hygienic requirements and practices to be followed by the vendors which were to be translated into Codes of Practices by the relevant authorities (Nurudeen, Lawal and Ajayi, 2013). This was seen as cost effective and efficient tools for the control of street foods as it took into account local conditions including specific risk factors that are relevant to each operation. The guidelines were aimed at ensuring that all stakeholders must take responsibility in ensuring the suitability and safety of food for human consumption (Monney *et al.*, 2014). WHO also recommends the strengthening and capacity building of health authorities to be a control strategy for hygiene and safety of street foods (Makelele *et al.*, 2015). But the effectiveness of these strategies in ensuring food safety of especially the poultry in the Nairobi city needs to be evaluated to help provide information on how to seal any gaps in the efforts to ensure food safety and hygienic preparation of these foods.

1.2 Statement of the Problem

Food borne illnesses pose a serious problem in food supply chain and overall public health. Vended poultry in Nairobi is of great concern because they act as media for growth of a wide range of microbial contaminants which may be hazardous to the health of consumers Latest

studies have alluded to the fact that the vending of meat products including poultry in Nairobi is on a larger scale (Githaiga *et al.,* 2013). The street-vended poultry have a high level of consumption especially in the informal settlements as they are affordable, ready-to-eat and easily available.

Most of the street vendors of poultry are largely drawn from the unskilled and semi-skilled labour force, thus may compromise food safety in these businesses. The consumers are also at risk and mostly without knowledge of the safety of these products. Thereby, the efficiency and effectiveness of this sector in alleviating food security problems is questionable. The study seeks to establish food safety risks in terms of microbial safety that the consumers of these products are exposed to and the mitigating actions that can be put in place to ensure safety of these foods.

1.3 Justification

Street vended foods such as poultry are consumed by a large proportion of the urban population in Kenya (Muhonja and Kimathi, 2014). Cases of compromised food safety of these products will thereby affect a significant proportion of the population. Food poisoning which is a result of compromised food safety is a public health concern especially in this age where great efforts are being put to achieve the third goal of the Sustainable Development Goals (SDGs) that seeks to promote and improve global health (Salam *et al.*, 2016). According to WHO statistics in 2014, food borne illnesses affect more than half a billion people (WHO, 2014), but most of the cases in Kenya go unreported or underreported (Delia, 2015). Biological food hazards are rated as having the greatest burden of food borne illnesses (Abdul-Mutalib et al., 2015)**.** The fact that Nairobi is a city thus has less space for production of poultry consumed within the city has

resulted into further risks of contamination of the poultry due to the food distribution and travel involved (Mensah *et al.*, 2012). The busy traffic and other activities with building and construction included are also potential sources of contamination of these foods.

It is important to investigate the vendors' food safety and hygiene practices as it has been established that the unhygienic handling of food is one of the mode of transmission of microbial and other contaminants into food (Cortese *et al*., 2016). The fact that most of the handlers in this sector are semi-skilled and unskilled, lacking prior training in food handling, exposes the food to contamination due to inappropriate food handling by the vendors thus posing additional risks (Nkere *et al.*, 2011: Khairuzzaman et al., 2014). This prompts the need to look into the operations of these vendors to ascertain whether their hygienic practices compromise food safety.

Consumer practices have also been noted as sources of contamination of street foods (Alimi, 2016). Most of the consumers have less concern on food safety and hygiene, either because of ignorance or just overlooking. The study focused on consumers to help evaluate conclusively the potential threats to food safety and hygiene. This is by the fact that a consumer driven awareness on food safety goes a long way to ensure food safety.

1.4 Aim

The aim of this study was to contribute to the reduction of foodborne illnesses associated with street vended poultry products.

1.5 Purpose

The purpose of this study was to identify the associated risk factors of consumption of street vended poultry products.

1.6 Objectives

1.6.1 General objectives

To assess the microbial risks of consuming street vended poultry products in the informal settlements of Nairobi County.

1.6.2 Specific objectives

1. To evaluate the level of food safety knowledge and practices of vendors and consumers.
2. To determine the risk factors of microbial contamination of street vended poultry products.
3. To determine the food safety risks of consumption of street-vended poultry products.

1.7 Hypothesis

1. The consumers' and vendors' level of food safety knowledge and practices are not potential risks of microbial contamination of street vended poultry.
2. The food handling and practice do not pose any risk of contamination of poultry products.
3. Street vended poultry products do not pose any significant food safety risk to the consumers.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Food safety is a scientific discipline that gives approaches in the handling, preparation, and storage of food in order to prevent food-borne illness (Shehbaz, 2016). Food producers and governments are faced with task of ensuring that the food consumed is safe from hazards; with minimal risks. To establish the safety of foods, it is vital to undertake risk analysis (Czernyszewicz, 2015). Risk analysis serves as the basis for food laws though exceptions of the same exist as a result of circumstances or nature of the food.

Risk assessment (RA) is one of the three components of risk analysis and entails a process of estimation of probability and severity of an illness resulting from a hazard present in a specific commodity. Other components of Risk analysis include risk management and risk communication (FAO and WHO, 2006a). Together with risk assessment, the three components of risk analysis are independent but linked. Risk assessment as per Food and Agriculture Organization (FAO) of the United Nations can be either chemical and microbial (WHO and FAO, 2011). Risk assessment is the scientific component of risk analysis where the hazards and the risks they pose are identified and estimated, at this stage deep scientific information on hazard, commodity and consumer is gathered and evaluated (Duffy *et al.*, 2006).

Risk assessment of human exposure to hazards exposure adopts an integrative approach of establishing the probability of human illness due to consumption of food with a given hazard (Jeong *et al.*, 2013). In food safety, risk assessment involves characterization of a product and its ingredients and raw materials at each stage of production process and value chain including handling and production equipment involved that may lead to occurrence of hazards

(Chernukha, Kuznetsova and Sysoy, 2015). Risk assessment is broadly divided into risk identification, hazard characterization, exposure assessment and risk characterization; these comprise the four stages of risk assessment (FAO/WHO, 2009a). In as much as various food products and various countries differ in their value chains for these foods, the principles for application of risk assessment largely remain the same.

Meat is considered one of the products that is of high risk of contamination thus lots of studies aimed at improving its safety have been done (Wahyuni, Vanany and Ciptomulyono, 2018). Meat and its products exist both in unprocessed and processed form, subjected to various processing techniques ranging from traditional to modern processing (Larsson and Orsini, 2014). Risk assessment of meat can employ either qualitative or quantitative risk assessment. Quantitative risk assessment provides a quantitative risk estimate whereas qualitative risk assessment ranks the likelihood of occurrence of the risk in various levels ranging from negligible to very high (Snary *et al.*, 2012). In as much as meat is ranked one of the high risk foods in terms of its spoilage, less risk assessment studies have been conducted in Kenya with the aim of improving the food safety situation in this sector. Even with the challenges currently experienced in Kenya and other developing countries in terms of capacity and systems in place to conduct risk assessment in the meat industry, opportunities still exist that can be exploited for the benefit of food safety situation

This review of literature focuses on the risk assessment of meat products, merits that would render qualitative risk assessment studies more tenable than quantitative risk assessment in resource-limited settings and future prospects for Kenya in terms of using risk assessment tools to improve the food safety situation.

2.2 Risk Assessment of Meat and its Products

Consumers take meat from both the small and large animals. Foods of animal origin include beef, poultry, fish, pork, veal, lamb and their derivative products (Keeton and Dikeman, 2017; Pouokam *et al.*, 2017). In the Developing countries like Kenya meat is subjected to either modern or traditional processing methods. These methods may predispose meat to contaminants with possibility of causing diseases. Contamination of meat and its products is reliant on various factors. Intrinsic factors in food such as nutrient content, pH value, redox potential and antimicrobial substances; extrinsic factors such as storage temperature; implicit factors including interaction of microorganism with other microorganisms and the food; and processing factors and the interaction of the four affect microbial growth, thus affecting food contamination (Hamad, 2012).

Microbial risk assessment always follows the food-pathogen combination along the agri-food chain until consumption. In such cases, important aspects such as level of contamination of the raw material and its impact on the contamination level of the products are missed. Based on set standards and controls, risk assessment also helps to evaluate the adherence of products to the set standards (regulations). A study by Syne et al. (2013) on bacon retailed in Trinidad, found that the 65 % of the products had a microbial contamination that exceeded acceptable limits for aerobic counts. Strengthening of the food controls to reduce contamination levels to acceptable levels through quality assurance programmes aims at ensuring consumer safety and minimization of risks. Quality assurance ensures the food is nutritious and free of hazards (Petrović *et al.*, 2017)

2.3 Microbial Risk Assessment of Meat and its Products

Microbial risk assessment (MRA) seek to provide understanding on the public health risks the population are exposed to through ingestion of a particular pathogen in food (Fedoruk, 2011). Product handling and processing are known to be the major sources of microbial contamination of meat and its products (Gallagher *et al.*, 2016). Meat and its products are succeptible to microbial spoilage by biohazards such as *Clostridium perfringens, Campylobacter jejuni, Salmonella*, enterohaemorrhagic *Escherichia coli* and *S. aureus* (Chernukha, Kuznetsova and Sysoy, 2015). In the case of ready to eat meat products such as cured meats, *Listeria monocytegenes* has been a concern too (Foerster, Figueroa and Evers, 2015). Any strategy in place to assure the microbial safety of these products would need a scientific justification, generated through risk assessment, for effective action.

The outcome of MRA on meat can be expressed in various forms ranging from number of cases of illnesses to economic impact of a disease (Cassini *et al.*, 2016). Studies seek to establish the overall risk posed by these pathogens in the products based on their handling across the food chain, as fluctuations are largely evidenced. Pradhan et al. (2010) reported that the retailing of ham and turkey accounts for as high as 83-84 % of listeriosis deaths among consumers of these products. This helps establish the correct controls to avert the situation and develop most efficient and effective strategies (FDA/CFSAN, 2012). Correct implementation of HACCP improves the microbial status of meat and other meat products (Kelly *et al.*, 2003).

In as much as thermal treatment of meat tends to lower microbial counts, but spore-forming microoganisms such as *C. perfringens* can easily survive the temperatures, germinate to vegetative cells that are infectious (Golden *et al.*, 2009). Both the food-borne infections and

intoxications are subject of investigation in microbial risk assessment. Foodborne infections results from ingestion of live bacteria in food whereas the foodborne intoxication is as a result of ingestion of bacterial toxin, and not necessarily the bacterial cell. MRA establishes the risk of infection resultant from both microbial live cell or toxins in food (Lammerding and Fazil, 2000).

2.4 Chemical Risk Assessment

Chemical risk assessment follows the four integrative steps of risk assessment as outlined by Codex Alimentarius. Just like biohazards, the chemical contaminants can occur in meat and its products through multiple routes along the food chain as shown in **Figure 2.1** (Pavesi *et al.*, 2017)**.** The chemical contaminants range from naturally occurring contaminants to adulteration (Tuyet-Hanh *et al.*, 2017). Tyokumbur (2016) established that the intestines were the most contaminated chicken offal with cadmium at 0.713ppm, way above a WHO set guideline limit of 0.05ppm. Another study by Darwish et al. (2015) also found kidney to be the most contaminated with cadmium at 0.226 ± 0.027 and 0.337 ± 0.0106 ppm/g and lead at 0.609 ± 0.868 and 0.502 ± 0.076 ppm/g bot for aged cattle and sheep, respectively. This point to a variation in the risk posed due to consumption of different meat products. Such information is integral in generating controls and regulation with regard to chemical contaminants in food.

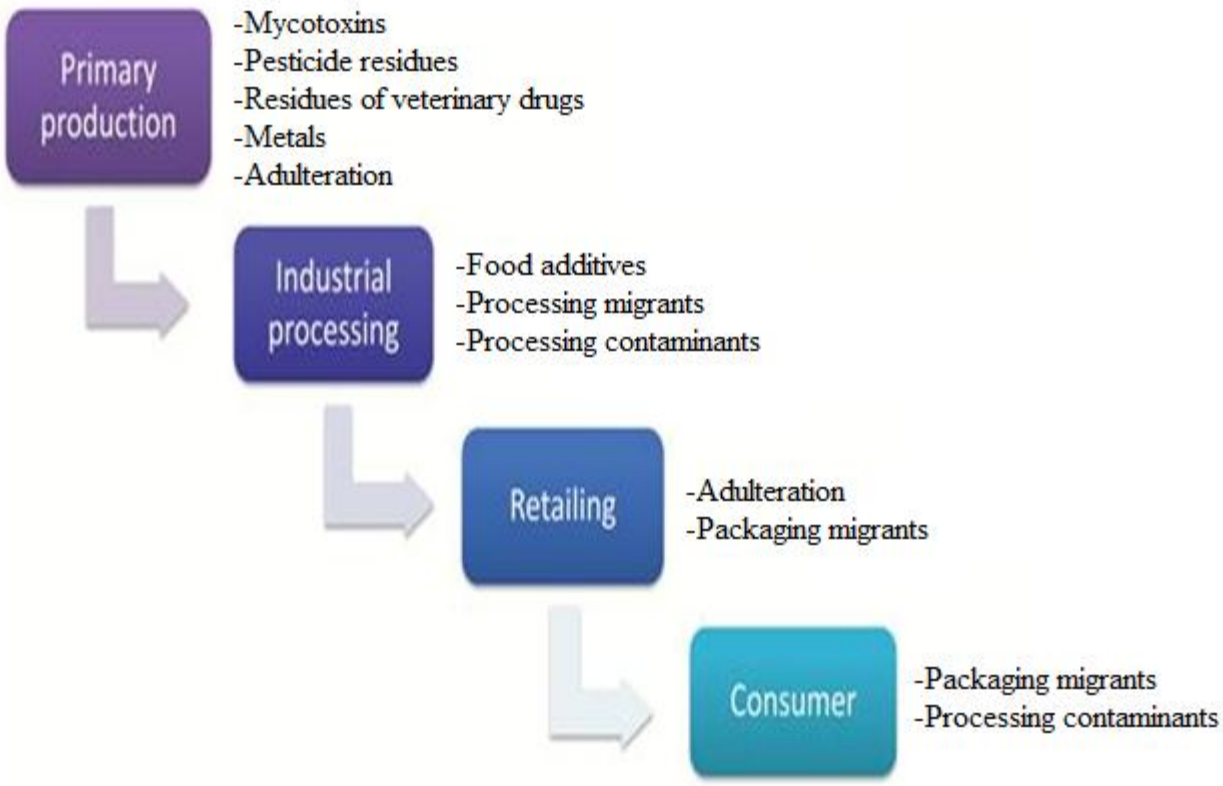

Figure 2.1: Possible roots that may result in the occurrence of chemical contaminants meat and its products. Adapted from Pavesi et al. (2017)

2.5 Stages of Risk Assessment in Meat

Both chemical and microbial risk assessment adhere to the four stages of risk assessment as outlined by Codex Alimentatrius: Hazard identification, Exposure Assessment, Hazard characterization and Risk Characterization.

2.5.1 Hazard identification

This is the first stage in risk assessment studies. Hazard characterization of a known microbial pathogen or a chemical agent is done based on known microbial analysis or established epidemiologic linkages (Duffy *et al.*, 2006). This stage is majorly qualitative as information can be obtained even from secondary sources (Fedoruk, 2011). It can be informed by relevant scientific literature from other studies on the microorganisms or chemical contaminants

(Zaitseva *et al.*, 2014). Pathogen-product or chemical contaminant-product association related information is gathered with a view to finding hazards with potential of being present in a product and causing harm to the consumers.

2.5.2 Exposure assessment

It establishes the number of cells that a consumer will have when they consume products. It takes into consideration the frequency of consumption, quantity of food consumed and the number of microbes per unit of food. It helps predict the survival of a hazard along the agri-food chain (Smith, Fazil and Lammerding, 2013). This step uses a scenario approach with consideration of the level and amount of consumption of a food product to establish the qualitative and quantitative terms and routes, frequency and duration of exposure of a hazard (Zaitseva *et al.*, 2014). Upon establishing the concentration of a particular microorganism in food along the agri-food chain, the probability of occurrence and the level of concentration of that microorganism during consumption must also be determined (Fedoruk, 2011). For exposure assessment in any risk assessment studies to be successful, probability and extent of contamination of a specific microorganism at any stage of production along the agri-food chain (**Figure 2.2)** must be established. Occurrence of these microorganisms may differ from one product to the other. In a study by FAO/WHO (2009a) , it was established that contamination of broiler chicken with *Campylobacter* jejuni can occur in four different stages which included the farm and transportation, processing, storage and preparation. In a separate study on risk assessment of *Capylobacter jejuni* in chicken by Wang et al. (2013), a slightly different result was found by identifying the stages as transporting, slaughtering, processing and cooking. The difference on these critical points depends on the specific product and raw material.

In quantitative microbial risk assessment, exposure assessment quantifies changes in the prevalence of microorganisms in meat throughout the production chain to consumption (Evers *et al.*, 2017). Along the agri-food chain, changes in microbial population usually occur in the meat for instance. Syne et al. (2013) reported a decline of 57.04 % and 56.11 % in franks and bologna, respectively through thermal processing. Corbellini et al. (2017) also relates a 3 log cycle reduction in the level of contamination of salami with *Salmonella* due to the fermentation process. It is therefore important to assess the effect of the various production and preparatory processes of the various meat products on the level of contamination by a specific pathogen or chemical hazard. In this stage, it is also important to establish the consumption patterns and serving sizes of the population.

2.5.3 Hazard characterization

This step establishes the severity and duration of adverse effects resultant from ingestion of the hazard in food (Fedoruk, 2011). The stage entails the qualitative and quantitative, where possible, description of a hazard that would potentially cause adverse health effects (Barlow *et al.*, 2015). Epidemiologic data from previous studies that have been documented form the backbone of this stage. In areas where there are little documented studies, great uncertainties would exist during risk characterization.

The dose response model for a hazard is created at this stage of risk assessment studies (WHO/FAO, 2009). Dose-response relationship identifies the amount of the hazard sufficient to elicit adverse effects (FSANZ, 2013). However, factors such as the host susceptibility and strain variability in microbial risk assessment (MRA) results into uncertainty. This is because the growth and survival or inactivation of different microorganisms in different foods may also

differ. It is also noteworthy, that the frequency of consumption and consumer susceptibility must also be established (Wang, Guo and Li, 2013).

Points in Agri-Food Chain	Variables affecting dose		
	Consumption	Concentration in contaminated units	Prevalence of contaminated units
Raw Ingredients		Environmental sources affecting concentration in ingredients	Season, harvest area, fodder and feeding regimes, irrigation water, etc.
⇩			
Processing		*Volumetric changes:* Mixing with other ingredients, changes due to dilution or concentration steps (e.g. evaporation, removal of whey) *Growth or inactivation changes* Brining, heating steps, holding times and temperatures,	Cross-contamination, mixing with other bulk ingredients, splitting into smaller units for retail or food service
⇩			
Transport and Storage		Time, temperature, product composition	
⇩			
Retail Sale		Time, temperature, product composition, breakdown to smaller units	Packaging and cross-contamination, portioning, breakdown to smaller units
⇩			
Home/food service		Time, temperature, product composition	Cross-contamination, combination with other foods
⇩			
Consumption	Frequency and amount consumed affected by: season, wealth, age, sex, culture/region, etc.	Heating; mixing with other components (e.g. vinegar in salads); breakdown to smaller units	Breakdown to smaller units/serving portions

Figure 2.2: A generic exposure assessment model for microbial hazards in foods. Adapted from FAO/WHO (2004)

2.5.4 Risk characterization

The first three steps are summarized to come up with a risk estimate at this point (Fedoruk, 2011). QRA generates a quantitative measure for risk whereas qualitative risk assessment generates a descriptive outcome. Risk estimate is obtained after generation of different

scenarios that are compared to the baseline (WHO/FAO, 2009). For meat and its products, the risk estimate depends on estimate number of servings, level of contamination per serving and the quantity of each serving (González *et al.*, 2016). Risk per serving of the meat or its products can then be easily established.

2.6 Risk Assessment in Developing countries

The food sector in the developing countries is divided into formal and informal sector (Rani *et al.*, 2017). Food safety is a pertinent problem in the developing countries to date (Pavesi *et al.*, 2017). The greatest hazard for foods in the developing countries is the microbiological hazard, thus microbiological risk assessment (MRA) is the greatest step in managing risks. The risk assessment models can adopt a quantitative, qualitative, semi-probabilistic or probabilistic model. Qualitative risk assessment are also based on numerical data from the hazard characterization and exposure assessment, however, the risk characterization is usually categorical or descriptive in nature (FAO/WHO, 2009b).

Risk perception are overly influenced by a myriad of factors globally (Barlow *et al.*, 2015). Great awareness of risk and precautionary measure prevail across most of the European countries. The greatest challenge for advocacy in food safety in most developing countries is lack of awareness. But some unique cases have been noted among these developing countries, an example being Brazil, where consumer awareness has been improving occasioning improved food controls and standards (Pavesi *et al.*, 2017). Risk perception greatly influences the reaction evoked as result by a risk in any given setting. However, other environmental influences such as moral or ethical concerns may play a greater role in determining the response (Kaptan, Fischer and Frewer, 2017). The role of consumers also in reducing risks is much pronounced as they too

play a role in food handling and preparation. A study by Golden et al. (2009) found that the retail and consumer handling of ready to eat meat products accounted for as high as 90 % of the *C. perfringens* illnesses. Similar findings were reported by (Ciekure *et al.*, 2016) where consumer handling and preparation practices were largely blamed for incidences of food-borne illnesses including salmonellosis, listeriosis and food-borne intoxication.

Documented studies done in developing countries reveal higher levels of contamination of meat products as compared to the developed countries (**Table 2.1**). This points to a situation that needs to be reversed. The fact that there are very few documented risk assessment studies in most of the developing countries, partly contributed to by low consumer advocacy and poor food controls, hasn't done the situation much good (Kiilholma, 2010). In Kenya, relevant authorities use the informal risk assessment in evaluating risks through the agri-food chain (Jabbar and Grace, 2012). The system relies greatly on the traceability systems of large organizations like Farmer's choice and supermarkets. The shortfall of this system currently is its lack of a centralized archiving system for data. The resource intensive-nature of risk assessment studies has also not been that favourable factor to countries such as Kenya (WHO/FAO, 2009). Possible cost-cutting measure but with a valid and accurate risk characterization would serve to bridge this gap.

Table 2.1: Microbial Contamination of meat products in different countries as documented by various studies

Country	Type of meat product	Hazard	Proportion of meat products that was unsafe	Standard of reference	References
Nigeria	Beef	Total viable count	98 %	International standard	(Grace *et al.*, 2015)
India	Pork	Enterobacteriaceae	89 %	International standard	(Fahrion *et al.*, 2013)
Kenya	Chicken	*E.coli*/Coliform counts	76 %	International standard	(Odwar *et al.*, 2014)
Rwanda	Beef	Total aerobi count	100 %	European Microbiological standards (2.5 log CFU)	(Niyonzima, Bora and Ongol, 2013)
Germany	Poultry import	*S. aureus*	0.2 %	European Union	(Jansen *et al.*, 2018)
	Turkey meat imports	*S. aureus*	0 %	European Union	

2.7 Contribution of Risk Assessment of Meat and Meat Products to Public Health Status of Developing Countries

Risk assessment provides the scientific justification for food safety controls by governmental bodies and authorities through legislations and food legislation. Appropriate level of protection (ALOP) and food safety objective (FSO) aim to make food safety control transparent and

quantifiable (Gkogka *et al.*, 2013). The ALOP points out the current food safety status achieved by the food controls in place (FAO and WHO, 2006b). MRA is the mechanism that quantifies the impact of food controls in place on the risk resultant from a specific microbial hazard and provides the numerical description of protection due to the current food safety control system, thus contributing to the setting of the ALOP. On the other hand, food safety objectives (FSO) links the ALOP in place to the performance objective (PO) that are in place to control occurrence of microbial hazard in food (Walls, 2006). Food controls such as hazard analysis critical control point (HACCP) and good manufacturing practices (GMPs) are then instituted to ensure FSO is met contributing to the realization of the ALOP and public health goals. For instance, in the case of Salmonellosis due to consumption of burgers in France, it was identified that the initial microbial load in frozen burgers was the main cause of the illnesses (Guillier *et al.*, 2013). Risk assessment also informs concerted, efficient and cost-effective interventions in the public health. The developed world has continually relied on the input of risk assessment studies to inform their policies in the public health, but the practice in the developing countries is limited.

The markets in the developed countries are integral to the economies of Developing countries (Wahidin and Purnhagen, 2018). The strict food laws of the developed countries serve as a major call for upgrade of the food safety and public health status of the developing countries. Lack of resources among the developing countries has been a major setback in the efforts to ensure food safety in the meat industry in these countries (Rahmat, Cheong and Hamid, 2016). Poor traceability systems and presence of informal sectors in the meat industry that are largely unregulated has resulted into a poor food safety status in these developing countries (Jabbar and Grace, 2012). Food safety regulations and legislations in these countries are at times outdated or

non-existent, thus the great risk are posed due to consumption of poultry and other meat products (Kiilholma, 2010). Low awareness has also been blamed for the poor food safety situations in these countries (Adesokan and Raji, 2014). The overall contribution of scientifically generated evidence through risk assessment studies to public health status in these developing countries tend to be low due to the constraints limiting such studies.

2.8 Constraints of Conducting Quantitative Risk Assessment (QRA)

The prevalence of pathogens at each point of the agri-food chain must be established for QRA studies. This has been a challenge in most cases as noted in a study by Hathaway et al. (Hathaway, Davies and Ashby, 2007). Establishing the prevalence of Salmonella in meat at the point of slaughter was challenging and the data was largely missing. In resource-limited settings like in developing countries where fewer studies are conducted, limited, unreliable and missing data would greatly hinder quantitative risk assessment. A QRA study in Chile on listeriosis on unprocessed meat resulted in great uncertainties during the study as a result of limited epidemiologic data (Foerster, Figueroa and Evers, 2015). In some cases qualitative risk assessment is preferred for its simplicity as compared to QRA that requires quantification and comparisons for accurate risk estimates to be developed thus a very difficult approach (FSANZ, 2013).

QMRA also tends to be time consuming and sometimes impossible in case of limited data (EFSA, 2008). EFSA reports limited use of especially QMRA in the international and national levels by risk managers as a result of this limitation. As in the case of WHO/FAO (2009) study where they reported missing epidemiologic and surveillance data for *Campylobacter* infections

in most of the developing countries. This limits the scope of the QMRA studies that can be conducted in these countries as the estimate would have a lot of uncertainties.

In MRA studies, there are usually no set values thus a lot of modeling techniques including qualitative can be used (FSANZ, 2013). In some cases, qualitative risk assessment serves as an initial study with the intention of carrying out a more expansive QRA (FAO/WHO, 2009b). In emergencies, qualitative risk assessment serves as the best suited study to generate data within a short time.

In as much as QMRA is considered the best tool for development of food standards, it is also known to be resource-intensive thus very expensive (WHO/FAO, 2009). This may not make it tenable for most of the developing countries who have limited resources employed in such studies. At times qualitative studies are carried out to demonstrate no need for an extensive and more expensive QMRA (FAO/WHO, 2004). This serves to make risk assessment more cost-effective and efficient. Even with QMRA, the deterministic model tends to be less expensive than the probabilistic model (FASFC, 2011). However, the deterministic model has a similar shortfall as the qualitative risk assessment of at times being too simplistic.

2.9 Regulation and Limits of Microbial Risk Assessment in Kenya

Global regulations generated by the Codex Alimentarius are in place to provide guidance on standards that different foods and food systems need to comply with. With the ever increasing consumption rates of meat and its products in the developing countries including Kenya, this presents a great challenge in terms of assuring the safety of these products (Thornton, 2010). The regulatory framework for meat and its products comprises of a multiple agencies just like other food products (Oloo, 2010). The Meat Control Act sets the regulatory baseline for the

regulation of the meat industry in Kenya (Government of Kenya, 2012). The tenets of Meat Control Act of Kenya has provisions for the proper equipment for slaughter facilities, meat inspection, disposal of meat, additives permitted for use in meat and certification of meat for export; aims to ensure safety of meat for both local and export markets (Farmer and Mbwika, 2012).

Kenya adopts its food standards from the International Organization for Standardization (ISO) and the Codex Alimentarius standards (Oloo, 2010). Global standards established by Codex Alimentarius have the aim of regulating the international trade. Other international bodies with regulations for the meat industry that are applicable to Kenya include hazard analysis critical control point (HACCP) by Codex Alimentarius, Terrestrial Animal Health Code by World Organization for Animal Health (OIE), Sanitary and Phyto-Sanitary Framework (SPS) by World Trade Organization (WTO) and good manufacturing practices (GMPs), good agricultural practices (GAPs) and good hygiene practices (GHPs) by Codex Alimentarius (Kiilholma, 2010).

Regulation of the meat industry in Kenya has both governmental and non-governmental players. The Standards body that largely affects the food standards within the country is the Kenya Bureau of Standards (Oloo, 2010). Other governmental players include government ministries such as Ministries of Agriculture and Health, Kenya Dairy Board, Kenya Meat Commission, Pest Control and Product's Board (Jabbar and Grace, 2012). Linkages would be necessary for such multi-agency team to work effectively.

2.10 Future Prospects of Food Safety in Kenya

The ever expanding informal sector that deal in meat products pose another great challenge (Githiri *et al.,* 2016). The greatest challenge that has been overlooked overtime is the street-vended meat products. The sector largely operates with no set food standards and with none or there be just minimal regulation. With this fact, the risk posed by these meat products considering that globally meat and its products have been ranked as high risk foods. Codes of Practices have been adopted by various authorities worldwide from the Codex Alimentarius Commission food hygiene and sanitation guidelines of 1997 that stipulate the general hygienic requirements and practices to be followed by the vendors (Nurudeen, Lawal and Ajayi, 2013). This was seen as cost effective and efficient tools for the control of street foods as it took into account local conditions including specific risk factors that are relevant to each operation. Without risk assessment, regulation of such sector would be quite difficult and inefficient. Possible controls would rely on risk assessment for best outcome.

Various gaps still persist in the regulation of meat industry in the country with massive gaps even in the epidemiological data (Odhiambo, Kebira and Nyerere, 2017). Microbial pathogens are known to have sophisticated survival mechanisms in food products and with less care taken, can transmit diseases (Olaoye, 2011). The Developing countries often underreport these cases as often very few people seek medical attention. Such situation has largely made quantitative risk assessment as an unlikely option. A more appropriate, cost-effective and less time-consuming option would be preferred.

2.11 Gaps in Knowledge

The food safety risks posed by the consumption of street-vended products in Kenya and other developing countries is yet to be established using either the qualitative or quantitative techniques. This is as a result of the cost implications of such a study as well as the expertise.

The extent of intake and contribution of street-vended poultry to the daily diet of the people living in the informal settlements is also not documented. In as much as the product is widely consumed in these areas, no study has focused on establishing their contribution to the diet of these people.

The extent of adherence to public health and food safety regulations and the determinant factors of such practices among street food vendors is also yet to be established. The value-chain of these street vended poultry in the informal settlements is also yet to be established from farm to fork.

CHAPTER THREE: STUDY DESIGN AND RESEARCH METHODOLOGY

3.1 STUDY AREA

A cross sectional study was conducted in the informal settlements; Korogocho (1.2504° S, 36.8909° E GPS coordinates) and Kariobangi North (1.2534° S, 36.88815° E GPS coordinates), Nairobi County (1.2921° S and 36.8219° E GPS coordinates) of Kenya (**Figure 3.1**). The 2009 national population census estimated the population of Nairobi County to be over three million, with over half of the population living in slums (Kenya National Bureau of Statistics, 2015). Street vended foods were collected in the following regions within Korogocho; Gitathuru, Nyayo, Kisumu Ndogo, Paradise and Kariobangi North.

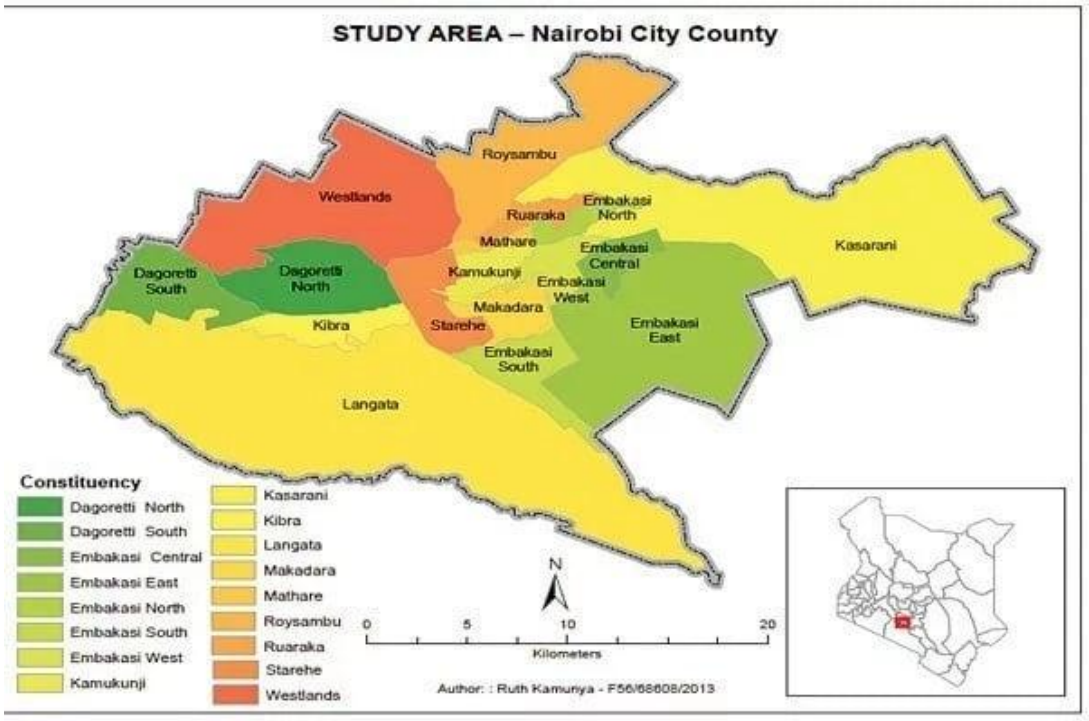

Figure 3.1: Map of Nairobi County

The large population in Nairobi County bore the challenge of housing and employment. Nairobi County has a very high poverty level and over 100 slum and informal settlements spread across the county (African Population and Health Research Center (APHRC), 2014). The slums have a poor hygiene, water and sanitation systems, thus worse health indicators (Amendah, Buigut and Mohamed, 2014). The housing systems and sanitary facilities in these areas are poor

aggravating the unhygienic conditions. The study focused mainly on the impact of hygiene practices by vendors and consumers of street foods on the food safety status of vended foods. A three stage sampling technique involving purposive sampling and randomized sampling was used to obtain samples for microbial analysis.

3.2 ASSESSMENT OF FOOD SAFETY KNOWLEDGE AND PRACTICES

3.2.1 Study design

The study design was a cross sectional study design where five low income areas were included in the study. Evaluation of the food safety knowledge and practices of street vendors making ready-to-eat (RTE) poultry products was done in triplicate. Swab of the personnel, equipment and poultry meat were taken and subjected to laboratory microbial analysis to determine the microbial contamination in terms of total aerobic count (TAC), Enterobacteriaceae, *Listeria monocytogenes*, *Staphylococcus aureus*, *Salmonella spp*, *Campylobacter spp* and *Escherichia coli.*

3.2.2 Sampling

3.2.2.1 Sample size determination

A total of thirty vendors, six from five low income areas, were part of the study as the number is sufficient to make scientific conclusions. Swabs were be collected from personnel, equipment and RTE poultry meat and be subjected to microbial analysis.

The consumer population to be interviewed was determined using Fisher's formula as used by Kariuki, Ng'ang'a and Wanzala (2017).

$$n = \frac{z^2(pq)}{d^2}$$

Where;

n= the desired sample size for target population > 10,000,

z = corresponding to 95% confidence interval, that is 1.96,

p = Proportion of the population with the desired characteristics, assuming homogeneity as the data of the population who were consumers could not be obtained from any trusted sources, p was 0.5

q = 1 - p, 0.5

d = degrees of accuracy desired (0.05) used in a similar study by Kariuki, Ng'ang'a and Wanzala (2017) in Githurai.

5% attrition was added

n=404 subjects.

3.2.2.2 Sampling procedure

The study setting was purposively sampled as the low income area (slums) in Nairobi County. An exhaustive sampling of vendors was done where all the vendors in Korogocho slum were located using the snowballing technique.

3.2.2.3 Exclusion and inclusion criteria

Only vendors who were involved in chicken vending were included in the study. The vendor must be over eighteen years of age. The vendor, no matter the area he/she comes from but sells her products in the study area, was be sampled.

Only consumers of street vended chicken were sampled. The consumer must have been a resident of the area for at least six months and must be over the age of eighteen years.

3.2.3 Data collection procedures

The semi-structured questionnaires used for the assessment of food safety knowledge and the practices of vendors and consumers of street foods were adopted from Ansari-Lari *et al.* (2010), and Bolton *et al.* (2008). They were then pretested with 80 respondents at Kawangware slums in Nairobi County to confirm that the questions were properly and clearly structured. The final version of the questionnaires was validated after some slight modifications determined by the comments of respondents involved in pilot testing. The questionnaires were arranged into 4

main sections which included socio-demographic information, food safety knowledge and hygienic practices.

The demographic characteristics included location, gender, educational level, occupation, age and food safety training. The food safety knowledge questions were structured to help in evaluation of awareness of consumers and vendors about food hygiene, proper cleaning, food pathogens and groups at high risk. The expected answers were either 'yes', 'no' or 'do not know'. The correct scores were allocated one mark while the 'do not know' and incorrect ones were added zero points. All the scores were transformed into 100. Scores below 50 were considered to show poor knowledge of food safety, 50-75 scores indicated average knowledge and >75 scores showed good knowledge of food safety.

The consumers and vendors were selected by positioning the researcher at places such as parks, highly frequented streets, markets, areas around universities and schools frequented by consumers in the seven communes. The objective of the study was explained to both vendors and consumers before those who volunteered signed the ethical consent forms and filled the questionnaires.

3.2.4 Statistical analysis

The data was analyzed in SPSS version 21. Descriptive statistics such as mean ± standard deviation, frequencies, minimum and maximum for the socio-demographic and food safety knowledge scores were obtained. Linear regression test was used to test predictability of food safety knowledge by the socio-demographic factors. ANOVA analysis was used to test mean differences in the knowledge scores. LSD was used to separate the statistically different means. Chi-square test of association was used to establish associated factors determining food safety knowledge and hygiene practices. Statistical significance was tested at $p<0.05$.

3.3 DETERMINATION OF THE RISK FACTORS OF MICROBIAL CONTAMINATION OF STREET VENDED POULTRY PRODUCTS

3.3.1 Data collection tools and procedure

Semi-structured questionnaires and direct observation were employed as data collection tools. Content of the questionnaire included issues addressing socio-demographic characteristics, health status and personnel hygiene, food handling practices and food safety knowledge of the vendors and access to hygienic water supply and other sanitary facilities.

3.3.2 Sampling and sample collection

Nairobi County was purposively selected for the study because of its populous nature. Korogocho and Kariobangi North areas were also purposively selected for the study as they are largely informal settlements with the population being those of low-income. A total of fifteen vendors were exhaustively sampled and included in the study with the food safety and hygiene practices evaluated using a food safety checklist. The snowballing sampling technique was used to locate all the vendors. Swabs were collected from personnel, equipment and chicken meat products subjected to microbial analysis. The respondents were purposely selected from the villages to include all the vendors selling the RTE chicken products. All samples were collected in sterile polythene bags followed by transportation to the laboratory of the Department of Food Science and Technology of the University of Nairobi. The samples were stored at a temperature of 4 $^{\circ}$C and analyzed within 24 hours of collection.

3.3.3 Food handling practices checklist

Food safety practices of all the vendors in the streets were assessed using a checklist that was adapted from checklists used by previous researchers (Muinde and Kuria, 2005b; Samapundo *et al.*, 2016). The demographic data included location, sex, educational level, age and occupation. The hygienic practices were evaluated using ‘yes’, or ‘no’ which were also scored based on the

same approach as in the knowledge section. The selection of participants for this part of the study was based on the same methodology as for the selection of vendors for the food safety knowledge and practices questionnaire. The aim of the study was clearly elaborated to respondents after which the volunteers signed the consent form and filled the questionnaire.

3.3.4 Microbial analysis

3.3.4.1 Determination of *Escherichia coli*

Based on ISO method 9308-1:2000 (ISO, 2000), the *E. coli* was accordingly enumerated. About 10g of sample was homogenized in 90ml peptone water. Decimal serial dilutions of the homogenized solution in sterile peptone water were prepared and plated in duplicate on the selective agar media. Blue green colonies for *E. coli* were counted after 48 hours of incubation at 44°C. The number of colony forming units (CFU) of presumptive *E.coli* per gram of sample was calculated.

3.3.4.2 Determination of *Salmonella*

The ISO method ISO 6579 (ISO, 2002) was used to enumerate the *salmonella* species. A sample of 10 g was weighed, homogenized in buffered peptone water and incubated at 37 ± 1°C for 18 ± 2 hours. From pre-enrichment broth, the inoculums were transferred to Rappaport-Vassiliadis broth and selenite cysteine broth and then incubated at 41.5 ± 1°C and 37 ± 1°C for 24 hours for selective enrichment. A loopful of the selective enrichment was streaked onto solid selective media: xylose lysine desoxycholate agar (XLD). XLD agar was incubated at 37 ± 1°C and observed after 24 ± 3 hours for typical *salmonella* transparent red halo and a black centre.

3.3.4.3 Determination of Staphylococcus aureus

EN ISO method ISO 6888-1:1998 (ISO, 1999) was used for the detection and enumeration of *Staphylococcus aureus.* In a sterile pipette, 0.1ml of the appropriate sample test dilutions were

transferred in duplicate onto the Baird Parker agar (BPA). The plates were then incubated at 35-37^{o}C for 24 ± 2 hours, then re-incubated for further 24 ± 2 hours. Observation ensued for typical colonies appearing black or grey, shining and convex, 1-1.5mm in diameter after 24hours and 1.5-2.5mm after 48 hours of incubation, surrounded by a clear zone but partially opaque zone. The coagulase positive staphylococci were then expressed as CFU/g of sample.

3.3.4.4 Determination of Campylobacter jejuni

Analysis was conducted according to ISO 10272-1:2017 (ISO, 2017) procedures which specifies a horizontal method for the detection and enumeration of Campylobacter spp.

3.3.5 Statistical analysis

The data was analyzed in SPSS version 21. The frequencies and descriptive statistics such as mean, standard deviation, minimum and maximum for the socio-demographic and food practices scores were obtained. Linear regression test was used to test predictability of food safety knowledge by the socio-demographic factors. The microbial counts were transformed into log CFU. ANOVA tests was used to test for statistical difference in the microbial counts with statistically different means separated using the Tukey's test. Statistical significance was tested at $p<0.05$.

3.4 Determination of the food safety risks of consumption of street-vended poultry products

3.4.1 Sampling and sample collection

The microbial data obtained in Chapter four was used in this chapter to conduct the qualitative risk assessment. *Campylobacter jejuni* which was the most prevalent microorganism was selected for assessment of the risk estimate.

3.4.2 Risk assessment tools

Data generated from secondary sources from published articles in renowned databases including Science direct, Elsevier, Springer, Hindawi and reports by global bodies like FAO and WHO were used. The data was used to respond to a set of eleven questions posed by the risk ranger and risk rank obtained (FAO, 2004). The risk estimate was generated in a risk ranger software which represented the relative risk of campylobacteriosis due to consumption of street-vended poultry. The spreadsheet uses its in-built functions to convert qualitative responses into numerical values that it uses to generate a risk rank (Ross and Sumner, 2002). The risk estimate generated by the Risk Ranger is usually on a scale of 0-100.

3.4.3 Data analysis

Genstat version 15 was used to analyse the microbial data. ANOVA was used to establish significant differences in the mean log counts of the microbial pathogens. The LSD was used to separate means that were significantly different. Descriptive statistics including mean and SD of the mean microbial contamination levels were also generated. The risk estimate was generated from the risk ranger (Ross and Sumner, 2002). The risk estimate generated was on a scale of 0-100.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 EVALUATION OF FOOD SAFETY KNOWLEDGE AND PRACTICES OF VENDORS AND CONSUMERS IN NAIROBI CITY, KENYA

4.1.1 Demographic characteristics of street food vendors and consumers

The social economic and demographic characteristics of 15 vendors who took part in this study are summarized in **Table 4.1**. Three quarters (76.9 %) of participants in street food vending business were female while the remaining (23.1 %) were male. This is in reflection to our direct personal observation that most stalls along the streets were run by women. The present findings are in line with the observations made by several researchers in other studies in Brazil (Soares *et al.*, 2012), Thailand, Vietnam (Samapundo *et al.*, 2016) and Ghana (Danikuu *et al.*, 2015). On the contrary, some researchers found that street food vendors are mostly male, without education or the highest educational level being primary (Nurudeen *et al.*, 2013; Bamidele *et al.*, 2015). There was a big similarity in educational backgrounds of poultry meat street vendors in Nairobi and those reported for street vendors in Ghana (Danikuu *et al.*, 2015), Sudan (Abdalla, Suliman and Bakhiet, 2009) and India (Choudhury *et al.*, 2011). However, most female vendors (69.3 %) were educated to at least secondary level but the illiteracy level was still very high. Majority of poultry street vendor resided in Kariobangi North (38.5 %), Gitathuru and Nyayo regions (23.1 %) of Nairobi city. This can be attributed to the high population of slum dwellers hence ready market, presence of many poultry farmers and high cases of unemployment for the learned and skilled hence causing the educated to engage in self-employment activities such as street food vending in to earn a living (Iwu *et al.*, 2017). The mean age of the street vendors of poultry was 39.45 ± 8.62 years with a maximum and minimum age of 53 and 22 years, respectively. The vendors earned an average daily income of KES. 790 ± 136.12 with a maximum and minimum of KES. 3000 and KES. 200, respectively.

Table 4.1: Socio-demographic Characteristics of street vendors of poultry

Socio-demographic characteristics		Proportion (n=15)
Residence	Gitathuru	23.1
	Nyayo	23.1
	Kisumu Ndogo	7.7
	Paradise	7.7
	Kariobangi North	38.4
Gender	Male	23.1
	Female	76.9
Marital status	Married	84.6
	Widowed	7.7
	Single	7.7
Level of education	College/University	30.8
	Completed Secondary	23.1
	Completed primary	7.6
	In primary	15.4
	In secondary	7.7
	Illiterate	15.4

In developing countries, the economic environment has become harsh and more difficult causing the street food vending business to expand rapidly in urban areas where it serves as a major accessible and available way to complement families' income. This has also served as a common source of employment for women perhaps because of established gender bias and orientation of cultures in the society (Iwu *et al.*, 2017).

The socio-demographic features of the consumers who voluntarily took part in this study are as summarized in **Table 4.2**. Seven in every ten (70.3 %) of consumers in the survey were female while three in every ten (29.7 %) were male. In regard to the educational level, majority (57 %) of the consumers had either attained secondary education or had completed the primary level while 8 % of the consumers were still in the university. Majority of the consumers were either married (62.2 %) or single (21.1 %) and were also Christians (96.3 %). With regards to occupation, most consumers were either in self-employment (31.7 %) or worked as casual laborers (24.6 %). These findings are in agreement with the reports of Maroko (2016) and Samapundo *et al.* (2016) about the street vended foods in Kenya and Vietnam, respectively. The mean age of the consumers of street-vended poultry was 33.67 ± 12.72. The minimum age was 17 with a maximum age being 87 years. The mean age brackets of vendors and consumers in this study are consistent with the findings of a similar study conducted in Haiti by Samapundo *et al.* (2015) of street vendors in the city.

Table 4.2: Socio-demographic characteristics of consumers of street vended poultry

Socio-Demographic factors	Frequency (%) n=350
Gender	
Male	29.7
Female	70.3
Marital status	
Married	62.6
Separated	7.4
Widowed	7.7
Single	21.1
Divorced	1.2
Level of education	
College/University	8.0
Completed Secondary	23.4
Completed primary	34.0
Dropped from primary	19.7
In primary	0.6
In secondary	3.4
Literate e.g. Adult Education	1.1
Illiterate	4.9
Pre-primary	4.9
Occupation	
Salaried employee	9.4
Farmer	1.1
Self-employment	31.7
Casual labourer	24.6
Student	4.0
Housewife	11.7
Unemployed	17.4
Religion	
Christian	96.3
Muslim	2.0
Traditionist	1.7
Household size (persons)	
2-3	18.0
4-6	47.4
>6	34.6

4.1.2 Food safety knowledge of street food vendors and consumers

The vendors had a mean score of 60.51 ± 12.01 % in their overall food safety knowledge which was significantly lower ($p<0.05$) than the consumers (79.79 ± 13.89). The results generated from repeated measures ANOVA showed no significant ($p<0.05$) differences in the mean knowledge scores of the vendors in general food safety knowledge (56.92 ± 24.28 %), food handling, preparation and storage (66.67 ± 13.61 %) and food borne illnesses (55.77 ± 23.17 %). Only gender resulted into statistical difference ($p<0.05$) in the knowledge scores (**Table 4.3**). Annor and Baiden (2011) and Mcintyre *et al.* (2013) reported the same findings in Ghana and Canada, respectively after conducting a survey on food handlers. However, the current study revealed that street food vendors who had been trained on safe ways of handling foods showed significantly greater ($p<0.05$) food safety knowledge compared to untrained vendors. Males had significantly ($p<0.05$) higher mean food safety knowledge scores (75.56 ± 10.18 %) as compared to the females (56.00 ± 8.43 %). In comparison with previous studies in Malaysia by Rosnani *et al.* (2014), in Haiti by Samapundo *et al.* (2015) and in Malaysia by Rahman *et al.* (2012) vendors in Nairobi had higher levels of food safety knowledge. Nevertheless, the vendors had an average level of food safety knowledge since the scores were greater than 50 but less than 75 points on a 100 points scale. This is attributable to the fact that most respondents in this survey were educated with either a secondary or tertiary educational level that help them in comprehending the information on food hygiene and hence enhanced knowledge (Iwu *et al.*, 2017).

Table 4.3: Mean square values for vendors' knowledge scores based on socio-demographic data

Variation	Gender	Marital status	Education status	Occupation	Religion	Income	Age
Between subjects	882.51*	109.40	192.65	212.74	ND	178.06	103.85
Error	77.04	151.11	109.52	137.93	ND	141.08	152.22

*Values are statistically significant at $p<0.05$. ND-not done.

The results of evaluation of food safety knowledge of street vended foods by consumers in the seven communes within Nairobi are shown in **Table 4.4**. The mean food safety knowledge scores of consumers of street-vended poultry were 79.79 ± 13.89 implying that they had a sufficient level of knowledge of food safety. These results corroborate with the findings of Samapundo *et al.*, (2016) who found that consumers of street vended foods had adequate knowledge on food safety with a mean of 67. The mean knowledge scores for general food safety and food handling, food preparation and storage and food-borne illnesses were 84.80 ± 18.91, 74.40 ± 24.80 and 80.17 ± 10.21, respectively.

Table 4.4: General linear model of predictor factors of overall food safety knowledge of consumers

Socio-demographic characteristics		Beta coefficients	P-value
Gender	Sex of the respondent	0.06	0.230
Age	Age of the respondent	-0.04	0.570
Residence	Nyayo	-0.22	0.000
	Kisumu ndogo	-0.11	0.090
	Korogocho A	-0.14	0.030
	Korogocho B	-0.06	0.240
	Highridge	-0.01	0.860
	Grogan A	-0.04	0.470
	Grogan B	-0.12	0.020
Marital status	Married	0.27	0.250
	Separated	0.07	0.580
	Widowed	0.08	0.550
	Single	0.27	0.190
Education status	Tertiary education (university or college)	0.11	0.070
	Secondary education	0.07	0.220
Employment status	Salaried employee	0.12	0.040
	Self employed	0.12	0.050
Religion	Christian	0.21	0.010
	Muslim	0.19	0.010

R^2=0.162, $p<0.05$

Results from linear regression analysis found that residence, employment status and religion of the consumers significantly ($p<0.05$) predicted and affected the overall food safety knowledge scores. This is in contrast to the findings of Samapundo *et al.,* (2015) who reported that there is no statistical difference ($p<0.05$) between the customers' food safety knowledge and their gender, religion, employment status, location, age and training on food safety. However, other studies showed that the knowledge of food safety statistically ($p<0.05$) increased with age and

that men have lower food safety levels compared to women (Bruhn and Schutz, 1999). The R^2 is 0.162. The linear regression model was as shown in **Equation 4.1**.

Equation 4.1:Linear model for predictors of food safety knowledge

$y = 55.18 - 0.22a - 0.14b - 0.12c + 0.12d + 0.21e + 0.19f,$

where *y* is the dependent for overall food safety knowledge scores, with *a*, *b*, *c*, *d*, *e* and *f* are independent variables residence at Nyayo, residence at Korogocho A, residence at Kisumu Ndogo, residence at Grogan B, salaried employment, Christianity and Muslim, respectively.

Being a resident of Nyayo and Korogocho A with beta coefficients of -0.22 and -0.14, respectively; single marital status and Christianity and Muslim religions with beta coefficients of 0.27, 0.21 and 0.19 significantly ($p<0.05$) predicted the consumer's scores on general food safety and food handling up to a level of 16.2 % of the variation.

Regression analysis also fitted residence at Nyayo and Grogan B, tertiary and secondary education and salaried and self-employment with beta coefficients -0.22, -0.04, 0.11, 0.07, -0.12 and 0.12, respectively as predictor socio-demographic factors of consumer's score of knowledge on food preparation and storage ($p<0.05$). The factors accounted for 11.9 % of the variation in the dependent variable. The socio-demographic factors did not significantly ($p<0.05$) predict the consumers' scores on food-borne illnesses. Regarding the educational level, the results showed that the higher the level of education, the better the levels of food safety knowledge. Comprehensively, consumers who had attained the tertiary and university education got higher scores compared to their counterparts who had only received either primary or high school education. These results are in line with the findings of Samapundo *et al.*, (2016) who also reported relatively higher food safety knowledge scores for more educated consumers compared with the consumers who had only received the primary or no education in Vietnam.

4.1.3 Consumption of street vended poultry among vendors and consumers

The consumption and intake of street vended poultry among consumers who participated in this study are shown in **Tables 4.5-4.9**. Test of association between socio-demographic factors and food safety practices of the consumers, revealed that criteria for deciding to buy among the consumers were significantly ($p<0.05$) associated with their education status and occupation (**Table 4.6**). The study also revealed that fewer of the male gender (25.93 %) would be willing to purchase from the same vendor who had previously sold to them a spoilt street-vended poultry than the females (43.41). Marital status, education status, gender and occupation of the consumers had a significant ($p<0.05$) association with the likely event that children in these households were also fed on street-vended poultry **(Table 4.7)**. The above results are in accordance with the findings of Samapundo *et al.* (2016) and Samapundo *et al.* (2015) who found that age, occupation, education, marital status and location significantly ($p<0.05$) affected consumers' hygiene practices when buying street vended foods in the streets of Vietnam. Nevertheless, they found food safety hygiene practices scores were not significantly ($p>0.05$) affected by the gender of consumers in the same study. Majority of the interviewed consumers (49.1 %) consumed street foods more than twice a week while a greater percentage also reported cases of food borne illnesses (52.9 %). 87.5 % of the interviewed consumers fed their children on street vended poultry while only 12.5 % denied feeding their children on street foods. This could be attributed to convenience and inexpensive nature of street foods hence makes them affordable to several people (Iwu *et al.*, 2017).

The consumers also had their criteria of perception of food safety of street-vended poultry significantly ($p<0.05$) associated with their residence and occupation **(Table 4.8).** Based on organoleptic characteristics of the poultry, salaried employees had poor food safety hygiene

practices while those in self-employment and not involved in income generating activities reported better hygiene practices. However as far as hygienic handling and preparations of the poultry is concerned, salaried employees got better hygiene practices compared to other occupations. With regards to hygiene handling and preparation of the poultry, salaried employees received higher scores compared to people in self-employment and non-income generating activities. These results are in agreement with findings of studies done in Vietnam by Samapundo *et al.* (2016) and in Haiti by Samapundo *et al.* (2015) concerning street vended foods where street-food consumers in employment practiced better hygiene than the others.

Table 4.5: Food safety practices of the consumers of street-vended poultry

Food safety practices		Proportion of respondents in % (n=438)
Frequency of consumption of street vended poultry	More than twice a week	49.1
	Once a week	33.7
	Rarely in a month	17.1
Vending places street-vended poultry is purchased	By the road side	91.4
	Anywhere	2.6
	In a stall	6.0
Incidence of food-borne illnesses	Yes	52.9
	No	47.1
Action taken during incidences of food-borne illnesses	Nothing	13.3
	Went to hospital	60.5
	Bought over the counter medicine	19.5
	Took bitter herbs	6.2
	Changed vendors	0.5
Purchase of spoilt street vended poultry	Yes	52.2
	No	47.8
Action taken for spoilt street-vended poultry	Threw it away	82.4
	Returned to vendor	16.4
	Picked out the palatable parts and ate	0.6
	Sought spiritual intervention	0.6
Frequency of purchase of spoilt street-vended poultry	Once	31.9
	More than once	68.1
Purchase from same venders who sold the spoilt vended poultry	Yes	38.3
	No	61.7
Criteria used in selecting preferred vendors	No criteria	8.2
	Food safety criteria	46.6
	Non-food safety criteria	45.2
Feeding of children on street-vended poultry	Yes	87.5
	No	12.5
Criteria for ascertaining safety of street-vended poultry	basing on organoleptic properties	54.3
	Hygienic preparation and handling	42.4
	I don't know	3.3
Quantity of street-vended poultry taken in a household (grams)	0-100	2.6
	101-300	52.9
	301-600	19.7
	601-1000	8.9
	1000+	16.0

Table 4.6: Association between socio-demographic factors and decision-making criteria for purchasing street-vended poultry

Socio-demographic factors		Decision-making criteria to buy street vended poultry (%)			P-value
		No criteria	Food safety criteria	Non-food safety criteria	(df, χ^2)
Education status	Attained tertiary education	17.86	69.14	25	0.007
	Attained secondary education	9.76	58.54	31.71	(8, 19.1)
	Attended only primary or lower levels	7.01	42.68	50.3	
Occupation	Salaried employee	15.15	42.42	42.42	0.002
	In self-employment	10.95	56.72	32.34	(4, 20.1)
	Not involved in any income generating activity	4.41	37.25	58.33	

Table 4.7: Association between consumer perception of safety of street-vended poultry to children and socio-demographic factors

Socio-demographic factors		Likely event that children are fed on street-vended poultry		P-value (df, χ^2)
		Yes	No	
Gender	Female	92.1	7.9	0.001
	Married	92.6	7.4	(2, 17.7)
Marital status	Separated	92.3	7.7	0.08
	Widowed	85.2	14.8	(3, 24.2)
	Single	71.2	28.8	
	Divorced	100.0	0.0	
Level of education	Attained tertiary education	75.0	25.0	<0.001
	Attained secondary education	82.3	17.7	(2, 27.3)
	Attended only primary or lower	90.8	9.2	
Occupation	Salaried employee	84.9	15.2	0.034
	In self-employment	90.9	9.1	(2, 48.1)
	Not involved in any income generating activity	82.5	17.5	

Table 4.8: Association between socio-demographic factors and perceived safety of street-vended poultry

Socio-demographic factors		Criteria for perceived safety of street-vended poultry (%)			P-value (df, χ^2)
		Basing on organoleptic properties	Hygienic preparation and handling	I don't know	
Residence	Nyayo	59.09	36.36	4.55	0.003
	Kisumu Ndogo	55.81	34.88	9.3	(16, 13.2)
	Korogocho A	69.23	30.77	0	
	Korogocho B	100	0	0	
	Highridge	35.38	61.54	3.08	
	Grogoan A	62.5	37.5	0	
	Grogoan B	100	0	0	
	Gitathuru C	64.1	35.9	0	
	kariobangi North	0	100	0	
Occupation	Salaried employee	35.29	64.71	0	<0.001
	In self-employment	57.14	37.3	5.56	(4, 56.7)
	Not involved in any income generating activity	53.73	46.27	0	

Frequency of consumption and the point of purchase of street-vended poultry were both significantly ($p<0.05$) associated with the residence and education status of the consumers (**Table 4.9**). The frequency of consumption of street vended poultry showed that residents of Korogocho A, Grogan A and Grogan B and Kisumu Ndogo had good food safety hygiene practices based on the higher scores they posted. The rest communes posted poor scores of food

safety hygiene practices. In regards to the point of purchase, only residents of Highridge, Gitathuru C and Kariobangi North had the privilege of buying their poultry from established stalls while the rest purchased their poultry mostly by the roadside. The proportion of people buying poultry by the road side constitute of people who attended the primary or lower level of education. This group lacks adequate food safety knowledge which ultimately affects their hygiene practices. According to Akabanda *et al.,* (2017), knowledge determines and influences the formation of hygiene practices and this can be linked to past personal experiences and beliefs and these perhaps can describe the aforementioned observations. The present findings are consistent with the results of similar studies conducted in Nigeria (Bamidele *et al.*, 2015) and Malaysia (Rahman *et al.*, 2012) where knowledge and hygiene practices were reported to have direct relationships where good knowledge resulted to better food safety hygiene practices and vice versa.

Table 4.9: Association between socio-demographic factors and frequency of consumption and point of purchase of street-vended poultry

Socio-demographic factors		Frequency of consumption of street-vended poultry (%)			Point of purchase of street-vended poultry (%)		
		More than twice a week	Once a week	Rarely in a month	By the road side	Any-where	In a stall
Residence	Nyayo	56.25	37.5	6.25	93.75	6.25	0
	Kisumu Ndogo	62.35	24.71	12.94	98.82	1.18	0
	Korogocho A	67.5	30	2.5	100	0	0
	Korogocho B	25	50	25	100	0	0
	Highridge	24.74	41.24	34.02	81.44	4.12	14.43
	Grogoan A	78.95	5.26	15.79	100	0	0
	Grogoan B	60	40	0	100	0	0
	Gitathuru C	45.76	45.76	8.47	94.92	3.39	1.69
	Kariobangi North	44.44	11.11	44.44	33.33	0	66.67
	P-value (df, χ^2)	<0.001(16, 71.3)			<0.001 (16, 90.5)		
Level of education	Attained tertiary education	42.86	42.86	14.29	85.71	7.14	7.14
	Attained secondary education	40.24	45.12	14.63	82.93	3.66	13.41
	Attended only primary or lower	52.92	28.75	18.33	95	1.67	3.33
	P-value (df, χ^2)	0.015 (18, 33.2)			0.025 (18, 18.3)		

4.1.4 Food safety practices of street vended poultry consumers and vendors

The vendors (46.2 %) just displayed their poultry where they were prone to dust and other environmental contaminants (**Table 4.10**). Dust potentially harbors pathogenic microorganisms and hence can act as a vector of transferring them to poultry products displayed by vendors. Training and awareness creation has been reported as an intervention measure that can help improve food hygiene practices such as proper display of foods by these vendors (Umar *et al.*,

2018). Flies and pests could also be observed in the poultry vending sites which further exacerbates the hygiene of the vended products. Evidence of unavailability of waste disposal facilities (69.2 %) and closed bins for disposal of wastes (76.9 %) as well as hand washing facilities (76.9 %) was noted in the vending sites under study. Most vendors could also not wash hands during preparations of poultry products, could not package poultry during sale (**Table 4.11**) and also lacked potable water at vending sites. This poor personal hygiene can increase chances of outbreak of diseases due to cross-contamination (Liu *et al.*, 2014). Insufficient quantities of potable water can hinder proper implementation of hygiene and sanitary practices among vendors. Similar observations were made in Uganda by Muyanja *et al.* (2011), Kenya by Muinde and Kuria Muinde and Kuria (2005) and in India by (Choudhury *et al.*, 2011). In contrary, a survey conducted in Nigeria found that only 9.5 % of street vendors raised complaints about lack of adequate portable water (Chukuezi, 2010). Unhygienic working conditions of street vendors resulted in food borne illness cases (23.1 %) reported by customers in the study regions which also translated to 38.5 % of interviewed customers going for medical checks.

Table 4.10: Storage of poultry products

Storage of poultry products on sale	Proportion of vendors (%)
Displayed	46.2
Frozen	15.4
Bucket	15.4
Refrigerated	23.1
Storage of poultry that remain after sale	
Frozen	46.2
Refrigerated	38.5
Bucket	7.7
No remains	7.7

Table 4.11: Responses for hygiene practices of the street vendors of poultry

Vendor practices	Proportion of respondents (%)
Owns the business	92.3
Licensed business	38.5
Multiple poultry products	10 0
Sells other products besides poultry	7.7
Packages poultry during sale	61.5
Received complaints on foodborne illnesses from customers	23.1
Go for medical checks	38.5
Washing of hands during food preparation	76.1
Washing of utensils with hot water and detergent	69.2
Washing of utensils with cold water and detergent	30.8
Has specific suppliers of poultry products	69.2

The hygiene practices of the vendors was not significantly ($p<0.05$) different by age, gender and level of education.

Majority of vendors did not have proper storage facilities for their poultry. Only 23.1 % had refrigeration facilities to extend the shelf-life and minimize wastage while 15.4 % stored their poultry in buckets (**Table 4.11**). More than four in every ten (46.2 %) vendors displayed them in open air while 46.2 % had freezing facilities to store the poultry that remained after sale. 7.7 % of vendors stored and sold other products besides poultry which increased the risk of cross-contamination. These results are similar to the findings of Samapundo *et al.* (2016) who

reported that about 32.5 % of vendors displayed food openly on their street sites while 50 % stored in wheelbarrows and did not separate other cooked or raw products from the ones being sold. They also reported that 70 % of the interviewed vendors stored their foods under refrigeration for vending the next day which is way higher compared to only 38.5 % in the present study who stored their remaining poultry under refrigeration after sale. According to a survey by Giritlioglu *et al.* (2011) most respondents (29.3 %) do not understand that storing cooked and raw products together is the major cause of food poisoning in most street vended foods. Improper cooling of meat and poultry products has been associated with several outbreaks of food poisoning diseases (Lues *et al.*, 2006; Liu *et al.*, 2014).

The results for hygienic practices of consumers of street vended poultry products are summarized in **Table 4.12**. Majority of consumers (74.0 %) could not purchase packaged street-vended poultry while 26.0 % could. This could cause contamination of the poultry by the microbes and the dust leading to food borne illnesses (Muinde and Kuria, 2005). It is recommended that street food on display for sale be kept in clean utensils which are well covered and protected to prevent penetration of dirt and subsequent contamination of food (Cortese *et al.*, 2016). The highest percentage of consumers (85.1 %) consumed the purchased poultry at home where 94.9 % of them washed their hands before consumption. With regards to handling of poultry during purchase from the vendor, 31.1 % of consumers used bare hands which also handled money. These observations were a big concern due to the fact that hands can act as a transmission vector for disease causing pathogens such as *Staphylococcus aureus*. Food safety and hygiene practices dictate that consumers should not handle foods using bare hands and touch money simultaneously (Mjoka and Selepe, 2017). Nine in every ten (91.4 %) consumers further prepared the purchased street vended poultry at home which was an

important finding as this could help in killing the remaining microbes on the poultry especially when the vendor had not cooked the poultry properly. More than half (53.3 %) of the consumers bought poultry from vendors who did not cover their products while 9.2 % did not consider hygienic handling of poultry before purchasing which threatened the safety of the products. The present findings are in accordance with the observation made by Sani and Siow (2014) who reported that consumers had generally good hygiene practices and used clean equipment to minimize contamination of the street vended foods. Proper food handling that can be promoted through awareness creation and training, enhances the safety of the streets foods, thus reducing risks of food borne illnesses (Umar *et al.*, 2018).

The test for association between socio-demographic characteristics and hygiene practices of the consumers revealed significance ($p<0.05$) between display of food at the point of purchase and marital status and residence; likelihood of preferring packaged food and occupation and residence; further preparation of the food and residence; washing of the street-vended poultry and residence; verification of the hygienic status and preparation of the street-vended poultry and residence.

Table 4.12: Hygiene practices of consumers of street-vended poultry

Hygiene practices		Proportion in % (n=350)
Purchases packaged street-vended poultry	Yes	26.0
	No	74.0
Place where the purchased vended poultry is consumed	At the site	10.0
	At home	85.1
	both at home and site	4.9
Washing of hands during consumption of street-vended poultry	Yes	94.9
	No	5.1
Handling of poultry during purchase from the vender	Using bare hands	31.1
	Using a piece of paper	35.7
	I don't pick for myself	9.7
	By pointing	14.0
Further preparation of purchased street-vended poultry at home	Yes	91.4
	No	8.6
Considers hygiene status of the vending place before purchase	Yes	86.8
	No	13.2
Purchases from vendors who cover their products	Yes	46.7
	No	53.3
Considers hygienic handling of the poultry before purchase	Yes	90.5
	No	9.2
	Sometimes	0.3

The association between the area of residence and hygiene revealed that all residents of the communes under study checked the hygiene status of the poultry products before purchasing (**Figure 4.1**). This could be attributed to dissemination of information by the Kenyan

government to the public through media as well as trainings by non-governmental and research institutions. Trainings impart knowledge which directly influences hygiene practices hence it is essential in any food hygiene system (Rahman *et al.*, 2012).

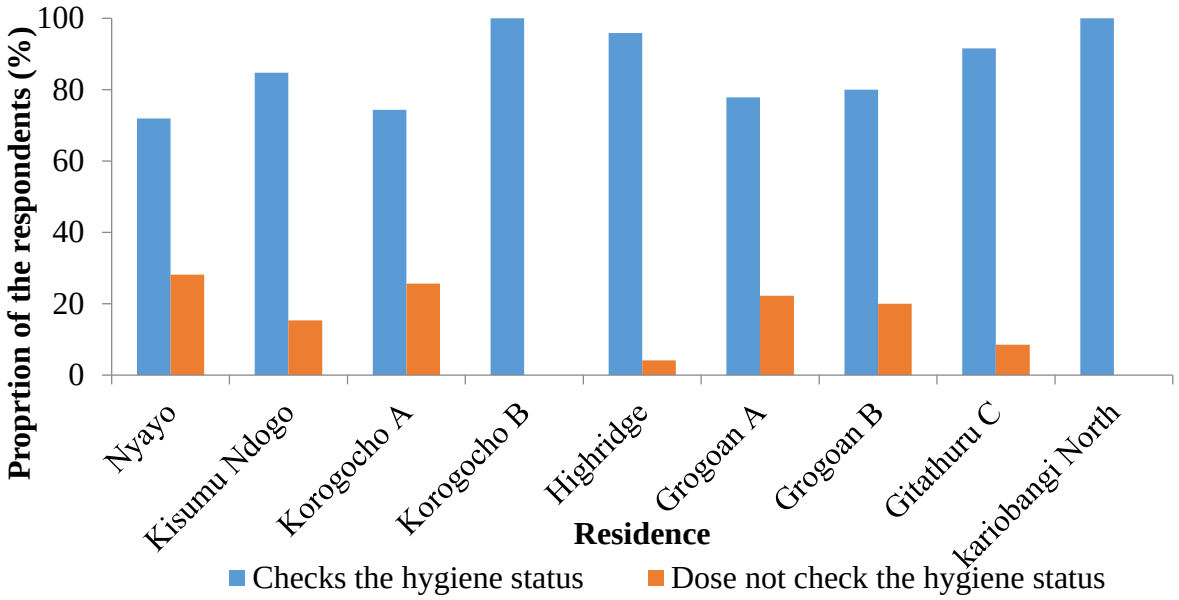

Figure 4.1: Association between residence of the consumer and the practice of checking hygiene status of the street vended chicken poultry products. P<0.05, df=8, χ^2=20.2

4.2 DETERMINANTS OF MICROBIAL CONTAMINATION OF STREET VENDED POULTRY PRODUCTS SOLD IN NAIROBI COUNTY, KENYA

4.2.1 Personnel hygiene practices of vendors

The hygiene and food handling practices that determined the microbial safety of poultry products vended in Nairobi city are shown in **Table 4.13**. In the study, only 30.8 % of the vending places were sheltered while 61.5 % of them were not clean. In other studies conducted by Chukuezi (2010), it was reported that only 28.5 % of the vending sites had a canopy which is consistent with this study. These conditions allow the dust and exhaust fumes to find their way into most products causing contamination. Holding foods at ambient temperature beyond 4-6 hours poses a great risk to public health as these conditions can contribute to high microbial

counts of the foods (Deriba and Mogessie, 2001). According to Muinde and Kuria (2005), these kind of structures do not adequately protect street foods from vehicles' smoke and surrounding dust which carries many pathogenic microbes hence a health hazard to consumers of such foods. In contrast to the present findings where 84.6 % of vendors prepared their chicken products on site, only 14 % of street foods in Mauritius and 10% in South Africa were prepared on the vending sites (Subratty *et al.*, 2004; Lues *et al.*, 2006). Lack of clean clothing (61.5 %), lack of appropriate clothing for food preparation (46.2 %) and long nails by some vendors increased chances of cross-contamination and posed a health hazard to consumers of street vended poultry products. Personal hygiene is crucial while handling food because human beings have been reported to be the major contamination sources of foods (Chukuezi, 2010; Tafesse *et al.*, 2014). Proper Personal cleanliness, hygiene and safe handling practices of food should be maintained by all the food handlers to avoid microbial contamination of food. The hands should be kept clean, fingernails short, working garments clean and the hair should be covered with nets or cover to ensure safety of prepared food (Zeru and Kumie, 2007).

Table 4.13: Hygiene practices of the street-vendors of the poultry

Hygiene practices	Yes (%)
Vendor having appropriate clothing for food preparation	53.8
Vendor having clean clothing	38.5
Vendors nails kept short	92.3
Vendor handles food with bare hands	100
Sheltered vending place	30.8
Preparation of food on site	84.6
Evidence of pests and flies	33.3
Clean vending place	38.5
Presence of hand washing facilities	23.1
Availability of waste disposal facilities	30.8
Availability of closed bins for waste disposal	23.1

4.2.2 Environmental hygiene of the food preparation premises

Six in every ten (61.5 %) of the studied vending places were not clean and 33.3% had pests and flies in the surroundings. Over three quarters (76.9 %) and seven in every ten (69.2 %) lacked hand washing and waste disposal facilities. These poor handling practices can be attributed to lack of potable water and washing facilities on the sites and lack of awareness about food

handling and safety (Tafesse *et al.*, 2014). These findings corroborates the findings of Badrie *et al.* (2015) and Muyanja *et al.,* (2011) in Trinidad and Uganda, respectively. Lack of waste disposal facilities prompts the vendors to discard their wastes behind the vending sites and in the streets which attracts flies and pests that act as vectors for pathogenic microorganisms (Samapundo *et al.*, 2015). The current survey showed that the health risk of consuming street vended poultry products is high due to the unhygienic practices which affected the overall safety. However, the study of Holy and Makhoane (2006) found out that vendors of street foods have the potential to prepare comparatively hygienic and safe products with lower microbial counts to curb the spread of food borne diseases. The observations in this study also differs with the survey conducted in Philippines by Azanza *et al.* (2000) that reported proper hand washing and food handling practices due to availability of adequate hand washing facilities within the vending sites and relatively higher knowledge levels among the vendors.

4.2.3 Food handling practices of the vendors

The survey also revealed that none of the interviewed street vendors handled food with any special equipment or disposable gloves and 23.1% did not wash their hands during handling and preparation of poultry. It was also observed that all the vendors served chicken products while at the same time handled money. These findings are in agreement with the observations made by (Muinde and Kuria, 2005) in Kenya and Omemu and Aderoju (2008) in Nigeria who noted that street vendors handled money as well as food with bare hands. Hands are potential vectors for transmitting pathogenic microbes such as *Staphylococcus aureus* hence the above practices are major concerns to the safety of consumers of street vended foods (Samapundo *et al.*, 2016). According to European commission (1997), food handlers should not handle food with bare hands and handle money simultaneously to avoid incidences of cross-contamination that can be

health risk. Moreover, WHO/FAO, (1999) recommends use of disposable gloves, clean tongs, forks or spoons during handling of food. About six in every ten (61.5 %) of the vendors also did not cover their utensils while only 23.1 % covered poultry products awaiting sale (**Table 4.14**). This is in line with findings of Samapundo *et al*., (2014) who observed that street vendors in Haiti were not covering their foods hence exposed them to dust containing microbes which contaminated the foods.

Most vendors used dirty water to clean the utensils which was normally recycled and re-used severally hence increasing chances of cross-contamination and subsequent transfer of pathogens to the products. Re-used water contains diffused organic materials which act as a culture medium that allows proliferation of several pathogenic microorganisms hence a food safety threat (Yah et al., 2009) These findings are in accordance with the observations of Chukuezi (2010) who reported that all street vendors in Owerri, Region in Nigeria handled money and foods concurrently, 47.62 % washed utensils with dirty water and handled foods with bare hands which compromised the food microbial safety. Preparation of street foods under the aforementioned unsanitary and unhygienic conditions poses great health risks to consumers as the conditions predisposes them to outbreaks of food borne diseases (Omemu and Aderoju, 2008).

Table 4.14: Food handling practices of street vendors of poultry

Vendor practices	Yes (%)
Vendor washes hands during food handling and preparation	76.9
Food awaiting sale is covered	23.1
Utensils used by the vendor a clean	69.2
Utensils used by the vendor are covered	38.5

4.3 Determinants of microbial contamination of street vended poultry products

The microbial results are as summarized in **Table 4.14**. Raw portions of poultry products had the highest contamination with all the four tested microorganisms ($p<0.05$). The presence of such high microbial counts can be attributed to improper handling of raw chicken products and inadequate storage conditions (Jay *et al.*, 2005). Regression analysis showed that the presence of pests, unclean vending place, littered vending, appropriate clothing, clean clothing and covering of utensils environment with beta values of 2.6, 4.2, 1.9, 2.2, 2.2 and 2.4, respectively as positive predictors of salmonella contamination with R^2 of 0.22 ($p<0.0$) as shown in **Equation 4.2**.

Equation 4.2: Linear model for the predictors of Salmonella contamination

$$y = 7.3 + 2.6a + 4.2b + 1.9c + 2.2d + 2.2e + 2.4f,$$

where a, b, c, d , e and f represent the variables presence of pests, unclean vending place, littered vending, appropriate clothing, clean clothing and covering of utensils environment, respectively.

The predictors of E.coli contamination were presence of pests and flies, unclean vending place, vending environment littered with waste, washing of hands by the vendor and lack of appropriate clothing among the vendors at R^2 of 0.33 (**Equation 4.3)**.

Equation 4.3: Linear model for the predictors of E. coli contamination

$$y = 13.5 + 2.4a + 3.8b + 2.9c - 1.6d + 1.6e,$$

where a, b, c, d and e represent the variables presence of pests and flies, unclean vending place, vending environment littered with waste, washing of hands by the vendor and lack of appropriate clothing, respectively. The vendor practices and environmental hygiene of the vending place would not significantly ($p>0.05$) predict contamination with campylobacter and staphylococcus contamination.

The level of E. coli ranged from 6.60 ± 1.25^{a} $\log_{10}$ CFU/g in raw poultry to 2.67 ± 1.98^{b} $\log_{10}$ CFU/g in cooked chicken products. On other investigated samples, hands, knives, surfaces and storage containers the microbial counts were still high with operating surfaces having the highest number of counts (3.68 ± 1.82^{b} $\log_{10}$ CFU/g) showing that most of the chicken products were a potential risk to public health. However, there was no significant ($p<0.05$) difference among cooked samples, knives, surfaces, containers and hand. The high microbial counts in these samples is attributable to temperature and time abuse during street vending and cross contamination as a result of poor handling and improper vending practices as well as lack of cold storage facilities during sale (Tafesse *et al.*, 2014). Since these microorganisms are indicators in the assessment of food safety, high counts show the likely presence of pathogenic microbes due to unhygienic handling of food (Jay *et al.*, 2005). Comparable findings were reported by Haranisho *et al*., (2005) and Mohammed, (2017) who reported high counts of E.coli

in street vended food products indicating inappropriate holding temperatures. The results are also in line with the findings of Gitahi *et al.,* (2012) who observed 3.45 $\log_{10}$ CFU/g in raw meat sold along the streets of Nairobi Kenya. E.coli usually proliferates in the humans GIT and is also found in faeces hence its presence in food also indicates fecal contamination either from materials used or at some point during preparations (Yeboah-Manu *et al.*, 2010). In contrary, Mafune *et al.* (2016) reported absence of E.coli in the sampled street vended foods and attributed this to adequate processing, good quality of water used, and personal hygiene and storage temperatures.

Salmonella spp was detected in cooked poultry products (2.22 ± 1.88^{b} $\log_{10}$ CFU/g), on hands, knives, working surfaces and storage containers (**Table 4.15**). However, the difference in *Salmonella spp* counts were not statistically significant ($P<0.05$). The presence of *Salmonella* in these poultry products and working areas can be considered potentially hazardous to vendors and customers and hence are not acceptable for consumption (Cheung *et al.*, 2007). Their presence is attributable to poor hygiene by vendors and unsanitary facilities on the vending site (Sandel and Mckillip, 2004). Comparable results were observed by Tesfaye *et al.* (2016) when he examined the microbial safety of street vended foods in Jigjiga city of Ethiopia. Similar results were also reported by Tambekar *et al.* (2008) in India and Tassew *et al.* (2010) in Ethiopia when street vended foods were examined. The current findings disagree with the observations of Kariuki (2018) who did not detect *Salmonella* in foods vended in the streets of Gikomba and Githurai in Nairobi, Kenya. Other studies reported no *Salmonella* in the entire street-vended ready to eat food samples that were analyzed Qatar (Elobeid, Aziz and Mousa, 2014; Kwiri *et al.*, 2014).

Table 4.15: Microbial Counts (log CFU/g) of street-vended poultry and handling hands and equipment

Portion	*Salmonella*	*Escherichia coli*	*Campylobacter jejuni*	*Staphylococcus aureus*
Raw poultry	6.42 ± 1.64^{a}	6.60 ± 1.25^{a}	8.95 ± 0.94^{a}	6.92 ± 1.32^{a}
Cooked poultry	2.22 ± 1.88^{b}	2.67 ± 1.98^{b}	4.66 ± 2.67^{d}	2.86 ± 1.61^{c}
Hand	3.53 ± 2.17^{b}	3.74 ± 1.92^{b}	6.48 ± 0.99^{b}	4.85 ± 1.00^{b}
Knife	2.26 ± 1.63^{b}	2.42 ± 1.48^{b}	5.36 ± 0.43^{cd}	4.00 ± 0.55^{b}
Surface	3.68 ± 1.82^{b}	3.10 ± 1.92^{b}	6.84 ± 0.71^{b}	4.83 ± 0.88^{b}
Storage container	3.37 ± 1.75^{b}	3.77 ± 1.54^{b}	6.11 ± 1.04^{bc}	4.24 ± 0.95^{b}

Value with different superscripts along a column are statistically different at $p<0.05$. Each data point represent mean ± SD of triplicates

Staphylococcus aureus counts ranged from 2.86 ± 1.61^{c} log CFU/g in cooked poultry products to 4.85 ± 1.00^{b} $\log_{10}$ CFU/g on hands of street food vendors. The high *Staphylococci* counts in poultry products and vending site indicated the presence of poor hygienic and food handling practices as well as cross contamination, which is associated with discharges from clothing and human beings, human skin, dirty hands, mouth, nose and utensils (Tesfaye *et al.*, 2016). These results are in line with the observations of Badrie *et al*. (2003) who reported 4.2 log CFU/g of *Staphylococcus aureus* counts in meat on a survey conducted in Trinidad and Tobago. Similar results were reported by Williamson *et al*. (2006) who noted 2.0 log CFU/g in vegetable salads in Preston, North West Province of South Africa. On contrary, Mafune *et al.* (2016) and Ng *et*

al. (2013) reported absence of *Staphylococci counts* in ready to eat street vended foods in Thohoyandou, South Africa and Hong Kong, respectively. Absence of Staphylococcal counts indicates lack of contamination in street vended foods. It also denotes hygienic and proper handling practices of foods (Gitahi *et al.*, 2012).

Campylobacter jejuni counts ranged from 4.66 ± 2.67 log CFU/g in cooked products to 6.84 ± 0.71^{b} $\log_{10}$ CFU/g on the working surfaces. The counts on the storage container, working surfaces and hands did not differ significantly ($p<0.05$) (Table 3). The counts on the knives and cooked poultry were also not statistically significant ($p<0.05$). This can be attributed to cross contamination especially through hands and unsanitary conditions on the vending sites. According to the WHO (1999), hands are the most vectors for transmitting microorganism from skin, noses and faeces to the ready to eat foods. Epidemiological studies about *Campylobacter jejuni* have revealed that they are capable of surviving on surfaces and finger tips for differing periods and at times even after washing hands (Tafesse *et al.*, 2014). Hands should therefore be washed thoroughly before the work is started, instantly after visiting washrooms or after handling any materials with the potential of transmitting diseases (Green *et al.*, 2006). In this study however, washing of hands during and after the aforementioned activities was not practiced and the vending sites lacked portable water and washing facilities which can account for the high number of Campylobacter jejuni in the poultry products. According to Tesfaye *et al.* (2016), *Campylobacter jejuni* can be isolated from vendors of street foods with poor sanitary practices and control and they can transfer these pathogenic and hazardous microbes to foods. The present findings are also in agreement with the observations of Cardinale *et al.* (2005) Cardinale *et al.,* (2005) and Haileselassie *et al.* (2013) who reported that *Campylobacter* contaminated poultry products sold on the streets of Darkar city in Senegal and they attributed

this to unhygienic and unsanitary conditions on the vending sites. Poultry is also a known source of *Campylobacter species* and the handling in slaughter houses is also a source of contamination of the meat (Banu *et al.*, 2012; Marotta *et al.*, 2015). With improper handling of cooked and uncooked poultry, cross contamination occurs.

4.4 QUALITATIVE RISK ASSESSMENT OF STREET VENDED POULTRY IN NAIROBI COUNTY

4.4.1 Hazard identification

Campylobacter jejuni which was the most prevalent microorganism in both raw and cooked poultry products at 8.95 ± 0.94 log $CFUg^{-1}$ and 4.66 ± 2.67 log $CFUg^{-1}$, respectively; as compared to *Salmonella*, *E. coli* and Staphylococcus which had contamination levels of 6.42 ± 1.64 log $CFUg^{-1}$, 6.60 ± 1.25 log $CFUg^{-1}$ and 6.92 ± 1.32 log $CFUg^{-1}$ in raw poultry, respectively and 2.22 ± 1.88 log $CFUg^{-1}$, 2.67 ± 1.98 log $CFUg^{-1}$ and 2.86 ± 1.61 log $CFUg^{-1}$ in cooked poultry, respectively ($p<0.05$). These finding are different from those established in another study done on street-vended poultry in Egypt where *Staphylococcus aureus* was found to be the most prevalent food pathogen (Abd-El-Malek, 2017). Cardinale et al. (2015) in his study on street vended poultry in Madagascar established that there was no contamination of the products with *C. jejuni* as proper heat treatment of the products addressed the problem.

Campylobacter jejuni is a gram-negative, non-spore forming and motile microorganism (Kaakoush *et al.*, 2015). The microorganism also has flagella which is serves a role in its invasion (Quetz *et al.*, 2012). The microorganisms accounts for about 90% of all human infections by *Campylobacter sp.* in human beings (James *et al.*, 2014). In recent times, the microorganism has been associated with enteritis and gastroenteritis in both the adult and

paediatric patients (Facciolà *et al.*, 2017). About 30% of the cases of campylobacteriosis has been attributed to consumption of poultry (Chlebicz and Śliżewska, 2018).

The microorganism induces food poisoning through intake of contaminated water or food (Quetz *et al.*, 2012). Campylobacter isolation in patients suffering from diarrhea in Kenya was reported as 12 %, higher than for both Salmonella and Shigella (Carron *et al.*, 2018). Additionally, the prevalence of *Campylobacter spp.* in chicken in the informal settlements of Kenya was reported as 60-64 % in the retail market. Mageto *et al.* (2018) reported that 32.5-76.5 % of the campylobacter isolates from chicken in Nairobi County were *C. jejuni*. Another study by Nguyen *et al.* (2016) reported that 61.3 % of the *C. jejuni* isolates from chicken in Kenya showed multi-drug resistance.

4.4.2 Hazard Characterization

The clinical manifestation of the infection are gastroenteritis, meningitis and acute cholecystis (Kaakoush *et al.*, 2015). The severity of the illness due to the infection by the microorganism was established as low as it was reported by Smith (1985) that the overall fatalities were 0.059 per 100,000 population. (WHO, 2018) reported that the illnesses would at times result into death thus rarely medical attention due to the diarrheal episodes. Other diseases that are resultant from campylobacter infection include Guillain-Barré syndrome (GBS) and Miller Fisher syndrome.

Gastroenteritis due to campylobacter infection is as usually occasioned by diarrhea, malaise, fever and abdominal pain and sometimes vomiting, inflammation of the intestinal mucosa, presence of blood in faeces and disruption of the epithelial cells (Quetz *et al.*, 2012). The incidence of food borne illnesses with diarrheal symptoms was found to be 52.9 %. A study

done in informal settlements in Younde, Cameroon, found that 59.5 % of the diarrheal cases there were attributed to infectious microorganisms like *C. jejuni.* Deogratias *et al.* (2014) also reported a prevalence of 9.7 % of campylobacter infection among under-five year old children in Tanzania with diarrheal infection. The global burden of campylobacteriosis in 2013 was reported as 7.5 million DALY (WHO *et al.*, 2013).

The global data on GBS and Miller Fisher syndrome are so limited (WHO *et al.*, 2013). The GBS is characterized with sensory symptoms including sensation in the legs, rapidly progressive distal weakness, loss of vibration and proprioception and respiratory symptoms. WHO (2014) reported the disability weight of GBS at 0.445, lower than the one for gastroenteritis and enteritis. The illness, however, has life-long disability.

4.4.3 Exposure Assessment

Contamination of the poultry occurs at any given stage of the process of preparation of the poultry. The process of handling and preparation of the street vended poultry in the informal settlements was established to follow the schematic illustration shown in **Figure 5.1.** More than eight in every ten (87.5 %) of the households in the informal settlements had the whole family as consumers of the street vended. Similar findings were reported in the informal settlements in India where both the adults and children were found to be consumers of street-vended (Selvan and Preethi, 2018). The consumption of the street-vended chicken is either with or without further processing. Eight in every ten (82.8 %) of these consumers had an intake of at least once a week. Namugumya and Muyanja (2011) also reported that poultry and meat products were one of the most frequent dishes of urban communities in Uganda. All the raw and cooked samples which were sampled were contaminated with *C. jejuni.* The microbial load of *C. jejuni* on raw and cooked portion of chicken was reported as 8.95 ± 0.94 log $CFUg^{-1}$ and 4.66 ± 2.67

log $CFUg^{-1}$ in this study. Another study that evaluated the raw portions of chicken in Burma and Ngara that were reported by the vendors as the sources of the chicken found that they had a microbial load of >4 log $CFUg^{-1}$ (Odhiambo, Kebira and Nyerere, 2017). The high level of contamination in raw poultry was attributed to handling whereas undercooking was found to be responsible for the contamination in the cooked portions.

The informal settlements of the Nairobi County host majorly the low economic class. The informal settlements in Nairobi that would be of greatest interest including Kibera, Mukuru kwa Njenga, Mathare and Korogocho slums have an estimated population of 1.7 million people (Mutisya and Yarime, 2011). The low income status of this area occasions the largest proportion of the residents to opt for compromised quality of products. The study established that street food consumption in the area stood at 86 %, which involved intake by the general household including children under the age of five years.

Through derivation from studies by Carron *et al.* (2018) and Mageto *et al.* (2018), the occurrence of *C. jejuni* in street vended raw poultry in the informal settlements was established as 48.96 %. The high level of contamination in theses raw portions are due to the poor food handling practices (Alimi, 2016). The raw portions of poultry are usually roasted or deep-fried before sale. Proper heat treatment has been proven as an effective strategy in eliminating the microbial counts of *C. jejuni* to undetectable levels (Josefsen *et al.*, 2010; de Jong *et al.*, 2012). However, roasting as one of the fast heat techniques has been indicated as one of the improperly practiced food preparation techniques that enhance the food safety risks and heat resistance in microbes (de Jong *et al.*, 2012). Karoki *et al.* (2018) in his study showed that roasting would not reliably reduce the microbial counts in meat. Heating temperatures of ≥70 ^{o}C for about two

minutes would reliably eliminate *C. jejuni*, though the cooking at the informal settlements is highly questionable.

The cooked samples of poultry had an average *C. jejuni* count of 4.66 ± 2.67 log CFU which was above the infective dose for *c. jejuni*; The infective dose of *C. jejuni* has been indicated to be low, 2.7-2.9 log CFU (Epps *et al.*, 2013). The average weekly consumption sizes of poultry were found to be 140.0 g per person. The intake levels found in this study were lower than those reported for both the children and adults who were reported to have consumption levels of 300 g and 450 g, respectively (Selvan and Preethi, 2018). Further contamination of the cooked poultry products has been attributed to the poor post processing handling that included contamination from the display surfaces and hands. This study established that all the display surfaces of the vendors were contaminated with *C. jejuni* averaging at 6.84 ± 0.71 log CFU. Three quarters of the vendors (76.9 %) did not cover their food on display. There were no systems for control against post process contamination. In as much as 72.1 % of the vendors had been oriented on food safety issues, none of them had any formal training or expertise in food handling. Food safety training improves the food safety of processed food (Adesokan, Akinseye and Adesokan, 2015).

4.4.4 Risk characterization

No study has established the quantitative estimate of the risk posed by consumption of street vended poultry in the informal settlements. There is also no documented information on the process controls of the preparation of street foods. The information from the three previous steps of qualitative risk assessment was combined in the Risk Ranger software for generation of a risk estimate (**Figure 5.1**). The probability of illness per day in a considered consumer was found as 7.12×10^{-3}. Another study that evaluated the risk of *Campylobacter infection* due to

consumption of ham reported that the probability of illness in an individual was 2.2×10^{-12} (Lee *et al.*, 2015). Predicted illnesses in the population were found to be 1.11E06.

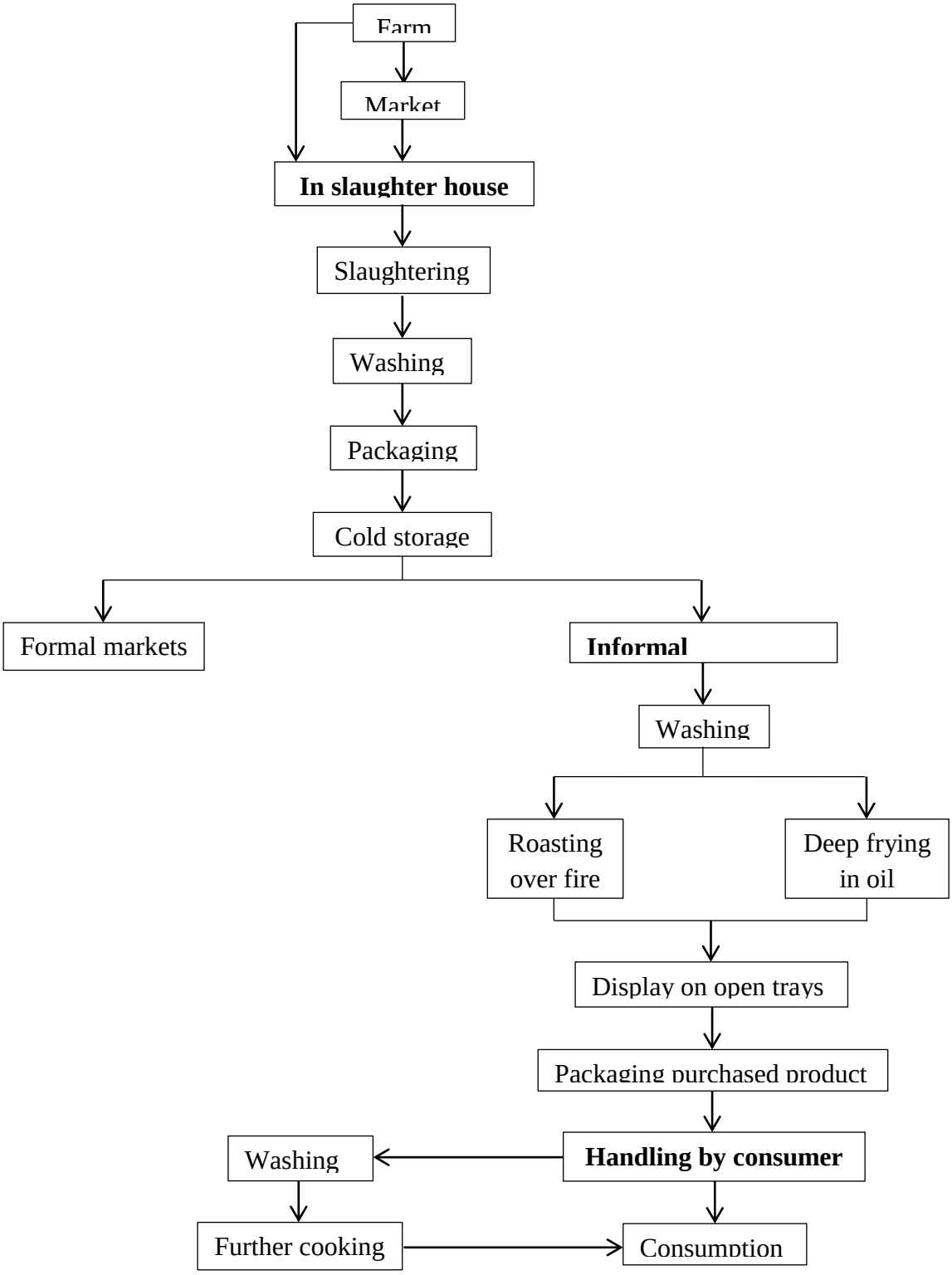

Figure 4.2: Process of preparing street vended poultry in informal settlements

The risk estimate generated for consumption of found to be 67. The level of risk posed is interpreted as to be a high risk, >48 (FAO, 2004). The risk estimate is also higher than that posed by chicken consumed either in rural or urban china which were 52 and 49, respectively (Jun, Chang and Ning, 2013). Another study in South Korea agreed that the outdoor eating of chicken and other poultry feeds poses additional risks than the indoor (Jeong *et al.*, 2017). This calls for better controls to be put in place to manage the current risk. Proper cooking of the food and that which will reliably eliminate all hazards will reduce the risk posed in the consumption of street-vended poultry.

Table 4.16: Summary of Risk Ranger input and output data

Risk criteria	General population
Dose and severity	
Hazard severity	Mild hazard
Susceptibility	General, all members of the population
Probability of exposure	
Frequency of consumption	Weekly
Proportion consuming	Most (75 %)
Size of population	1.7 million
Probability of consumption	
Probability of raw product contamination	48.96 %
Effect of processing	The process usually (99 % of cases) eliminates hazards
Possibility of recontamination	Yes- Major (50 % frequency)
Post-process control	Not controlled-no systems, untrained staff (10-fold increase)
Increase to infective dose	Slight (10 fold increase)
Further cooking before eating	Meal preparation usually eliminates (99 %) hazards
Probability of illness per day in the considered consumer	7.12×10^{-3}
Predicted cases of illnesses in the population	1.11×10^{6}
Risk ranking (0-100)	67

CHAPTER FIVE: GENERAL CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In as much as the consumers and vendors displayed sufficient nutrition knowledge, their food hygiene practices were greatly questionable. The study revealed that these practices greatly increase the likelihood of the consumers to food-borne illnesses. A lot of disregard of hygiene and quality as a parameter of preference in the purchase of the street-vended poultry by the consumers also aggravates the risks. The population is greatly vulnerable to food-borne illnesses due to this great disregard and negative attitude.

The environmental hygiene of the premises and food handling practices under which the vendors operate influence the microbial quality of the poultry product. The quality of the products purchased in the informal settlements is largely questionable considering that both the raw and cooked portions of the poultry are contaminated with hazardous microorganisms beyond the recommended safe levels. The detected microorganisms point to the greatest gap in the food-handling and equipment hygiene which elevated the level of contamination. The controls and measures in place to improve the safety of the produce are also so minimal making the consumer prone to infections.

These findings demonstrate that chicken products sold in the streets of Nairobi constitutes a potential health hazard to consumers because of high pathogenic bacterial counts such as *E. coli, S. aureus, Salmonella spp and C. jejuni* isolated from the products that rendered them microbiologically unsafe and unacceptable. Their presence in ready to eat foods indicates a great risk to handlers and consumers and degrades quality of the food rendering it unfit and unsafe for consumption by humans.

5.2 Recommendation

This study recommends the creation of awareness on positive practices of hygiene and health are essential in improving the food safety quality of the products vended in the streets. Proper and cost-effective measures are an easier way for adoption that is recommended to this area and similar settings considering the low income status of the residents of the area. The consumers also tend to disregard the hygiene and food safety measures to the detriment of their health. Greater awareness on food-borne illnesses is required for the proper prevention of these diseases.

Additionally, improving the environmental hygiene which is so much affordable and applicable would also serve to improve the quality of the products. Regulation of the sector is still a challenge, but preference in addressing the safety of the poultry products should be instituted due to the contamination levels that have been proved by this study.

There is also need for a more broad and extended quantitative microbial risk assessment that will have an input in the policy making. This study has already proved that the risk posed by these street-vended products needs to be managed, however, the farm to fork approach of risk mitigation must be adopted and this is only possible with a broader quantitative risk assessment. In the meantime, consumers of the products need to ensure proper cooking of the products to help minimize on the risks posed.

REFERENCES

Abd-El-Malek, A. M. (2017). Cooked poultry meat and products as a potential source of some food poisoning bacteria. *IOSR Journal of Environmental Science, Toxicology and Food Technology*, *11*(06), 23–29. https://doi.org/10.9790/2402-1106032329

Abdalla, M., Suliman, S., & Bakhiet, A. (2009). Food safety knowledge and practices of street foodvendors in Atbara City (Naher Elneel State Sudan). *African Journal of Biotechnology*, *8*(24), 6967–6971. https://doi.org/10.5897/AJB09.1103

Abdul-Mutalib, N. A., Syafinaz, A. N., Sakai, K., & Shirai, Y. (2015). An overview of foodborne illness and food safety in Malaysia. *International Food Research Journal*, *22*(3), 896–901.

Adesokan, H. K., Akinseye, V. O., & Adesokan, G. A. (2015). Food safety training is associated with improved knowledge and behaviours among foodservice establishments workers. *International Journal of Food Science*, *2015*, 1–8. https://doi.org/10.1155/2015/328761

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), 10–16.

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), 1-9. https://doi.org/10.1186/s12889-016-3986-9

Alimi, B. A. (2016). Risk factors in street food practices in developing countries: A review. *Food Science and Human Wellness*, *5*(3), 141–148. https://doi.org/10.1016/j.fshw.2016.05.001

Annor, G. A., & Baiden, E. A. (2011). Evaluation of food hygiene knowledge attitudes and practices of food handlers in food businesses in Accra, Ghana. *Food and Nutrition Sciences*, *2011*, 830–836. https://doi.org/10.4236/fns.2011.28114

Ansari-Lari, M., Soodbakhsh, S., & Lakzadeh, L. (2010). Knowledge, attitudes and practices of workers on food hygienic practices in meat processing plants in Fars, Iran. *Food Control*, *21*(3), 260–263. https://doi.org/10.1016/j.foodcont.2009.06.003

Asiegbu, C. V, Lebelo, S. L., & Tabit, F. T. (2015). The food safety knowledge and microbial hazards awareness of consumers of ready-to-eat street-vended food. *Food Control*, *60*, 422–429. https://doi.org/10.1016/j.foodcont.2015.08.021

Azanza, M. P. V, Gatchalian, C. F., & Ortega, M. P. (2000). Food safety knowledge and practices of streetfood vendors in a Philippines university campus. *International Journal of Food Sciences and Nutrition*, *51*, 235–246.

Badrie, N., Joseph, A., & Chen, A. (2003). An observational study of food safety practices by street vendors and microbiological quality of street-purchased hamburger beef patties in Trinidad , West Indies. *Internet Journal of Food Safety*, *3*, 25–31.

Bamidele, J. O., Adebimpe, W. O., Oladele, E. A., & Adeoye, O. A. (2015). Hygiene practices among workers in local eateries of Orolu Community in South Western Nigeria. *Annals of Medical and Health Sciences Research*, *5*(4), 235–240.

Banu, S., Rejab, M., Zessin, K., & Fries, R. (2012). Campylobacter in chicken carcasses and slaughterhouses in Malaysia. *Southeast Asian J Trop Med Public Health*, *43*(1), 96–104.

Barlow, S. M., Boobis, A. R., Bridges, J., Cockburn, A., Dekant, W., Hepburn, P., Bánáti, D. (2015). The role of hazard- and risk-based approaches in ensuring food safety. *Trends in Food Science and Technology*, *46*(2), 176–188. https://doi.org/10.1016/j.tifs.2015.10.007

Begari, P. (2017). Education Level of Street Vendors and Its Impact on Performance of the Activity: A Case Study of Hyderabad, Telangana. *International Journal of Research in Economics and Social Sciences (IJRESS)*, *7*(7), 436–443. R

Bereda, T. W., Emerie, Y. M., Reta, M. A., & Asfaw, H. S. (2016). Microbiological safety of street vended foods in Jigjiga City, Eastern Ethiopia. *Ethiopian Journal of Health Sciences*, *26*(2), 161. https://doi.org/10.4314/ejhs.v26i2.10

Bolton, D. J., Meally, A., Blair, I. S., McDowell, D. A., & Cowan, C. (2008). Food safety knowledge of head chefs and catering managers in Ireland. *Food Control*, *19*(3), 291–300. https://doi.org/10.1016/j.foodcont.2007.04.006

Bruhn, C. M., & Schutz, H. G. (1999). Consumer food safety knowledge and practices. *Journal of Food Safety*, *19*, 73–87.

Cardinale, E., Abat, C., Bénédicte, C., Vincent, P., Michel, R., & Muriel, M. (2015). Salmonella and Campylobacter contamination of ready-to-eat street-vended pork meat dishes in Antananarivo, Madagascar: A risk for the consumers? *Foodborne Pathogens and Disease*, *12*(3), 197–202. https://doi.org/10.1089/fpd.2014.1864

Cardinale, E., Gros-Claude, J. P., Tall, F., Gueye, E. F., & Salvat, G. (2005). Risk factors for contamination of ready-to-eat street-vended poultry dishes in Dakar, Senegal. *International Journal of Food Microbiology*, *2*, 157–165. https://doi.org/10.1016/j.ijfoodmicro.2004.12.023

Carron, M., Alarcon, P., Karani, M., Muinde, P., Akoko, J., Onono, J., … Rushton, J. (2017). The broiler meat system in Nairobi, Kenya: Using a value chain framework to understand animal and product flows, governance and sanitary risks. *Preventive Veterinary Medicine*, *147*, 90–99. https://doi.org/10.1016/j.prevetmed.2017.08.013

Carron, M., Chang, Y. M., Momanyi, K., Akoko, J., Kiiru, J., Bettridge, J., Häsler, B. (2018). Campylobacter, a zoonotic pathogen of global importance: Prevalence and risk factors in the fast-evolving chicken meat system of Nairobi, Kenya. *PLoS Neglected Tropical Diseases*, *12*(8), 1–18. https://doi.org/10.1371/journal.pntd.0006658

Cassini, A., Hathaway, S., Havelaar, A., Koopmans, M., Koutsoumanis, K., Messens, W., Scheutz, F. (2016). Microbiological risk assessment. *EFSA Journal*, *14*(1), 1–10. https://doi.org/10.2903/j.efsa.2016.s0507

Chernukha, I., Kuznetsova, O., & Sysoy, V. (2015). Hazard Analysis and Risk Assessment in Meat Production Practice in Russian Federation. *Procedia Food Science*, *5*(2015), 42–45. https://doi.org/10.1016/j.profoo.2015.09.011

Cheung, P., Kwok, K. K., & Kam, K. M. (2007). Application of BAX system , Tecra Unique TM Salmonella test , and a conventional culture method for the detection of Salmonella in ready-to-eat and raw foods. *Journal of Applied Microbiology*, *103*, 219–227. https://doi.org/10.1111/j.1365-2672.2006.03210.x

Chlebicz, A., & Śliżewska, K. (2018). Campylobacteriosis, Salmonellosis, Yersiniosis, and Listeriosis as zoonotic foodborne diseases: A review. *International Journal of Environmental Research and Public Health*, *15*(5), 863. https://doi.org/10.3390/ijerph15050863

Choudhury, M., Mahanta, L., Goswami, J., Mazumder, M., & Pegoo, B. (2011). Socio-economic profile and food safety knowledge and practice of street food vendors in the city of Guwahati, Assam, India. *Food Control*, *22*(2), 196–203. https://doi.org/10.1016/j.foodcont.2010.06.020

Chukuezi, C. O. (2010). Food safety and hyienic practices of street food vendors in Owerri , Nigeria. *Studies in Sociology of Science*, *1*(1), 50–57.

Ciekure, E., Siksna, I., Valciņa, O., Vīksna, L., & Krūmiņa, A. (2016). Microbiological quality of ready-to-eat products and potential risks for consumers in Latvia. *Proceedings of the Latvian Academy of Sciences, Section B: Natural, Exact, and Applied Sciences*, *70*(4), 245–251. https://doi.org/10.1515/prolas-2016-0038

Climat, R. (2013). *Microbial safety aspects of street foods in Haiti*. Universiteit Gent.

Corbellini, L. G., Costa, E. de F., Cardoso, M., & Nauta, M. (2017). Quantitative microbial risk assessment of Salmonella in dry fermented sausage (salami) in Southern Brazil. *Microbial Risk Analysis*, *6*, 31–43. https://doi.org/10.1016/j.mran.2017.02.001

Cortese, R. D. M., Veiros, M. B., Feldman, C., & Cavalli, S. B. (2016). Food safety and hygiene practices of vendors during the chain of street food production in Florianopolis, Brazil: A cross-sectional study. *Food Control*, *62*, 178–186. https://doi.org/10.1016/j.foodcont.2015.10.027

Czernyszewicz, E. (2015). Risk analysis as a basis for food safety strategy. *Finanse Journal of Management and Finance*, *13*(4), 105–117.

Danikuu, F. M., Baguo, F. B., & Azipala, O. (2015). Hygiene practices among street food vendors in Tamale Metropolis. *Journal of Medical and Biomedical Sciences*, *4*(3), 25–30. https://doi.org/10.4314/jmbs.v4i3.4

Darwish, W. S., Hussein, M. A., El-Desoky, K. I., Ikenaka, Y., Nakayama, S., Mizukawa, H., & Ishizuka, M. (2015). Incidence and public health risk assessment of toxic metal residues (cadmium and lead) in Egyptian cattle and sheep meats. *International Food Research Journal*, *22*(4), 1719–1726.

de Jong, A. E. I., van Asselt, E. D., Zwietering, M. H., Nauta, M. J., & de Jonge, R. (2012). Extreme heat resistance of food borne pathogens Campylobacter jejuni, Escherichia coli , and Salmonella typhimurium on chicken breast fillet during cooking. *International Journal of Microbiology*, *2012*, 1–10. https://doi.org/10.1155/2012/196841

Delia, G. (2015). Food safety in low and middle income countries. *International Journal of Environmental Research and Public Health*, *12*(9), 10490–10507. https://doi.org/10.3390/ijerph120910490

Deogratias, A. P., Mushi, M. F., Paterno, L., Tappe, D., Seni, J., Kabymera, R., … Mshana, S. E. (2014). Prevalence and determinants of Campylobacter infection among under five children with acute watery diarrhea in Mwanza, North Tanzania. *Archives of Public Health*, *72*(1), 1–6. https://doi.org/10.1186/2049-3258-72-17

Duffy, G., Cummins, E., Nally, P., O' Brien, S., & Butler, F. (2006). A review of quantitative microbial risk assessment in the management of Escherichia coli O157:H7 on beef. *Meat Science*, *74*(1), 76–88. https://doi.org/10.1016/j.meatsci.2006.04.011

EFSA. (2008). A quantitative microbiological risk assessment on Salmonella in meat: Source attribution for human salmonellosis from meat. *EFSA Journal*, *625*(2), 1–32. https://doi.org/10.2903/j.efsa.2008.625

EFSA. (2014). The European Union summary report on trends and sources of zoonoses, zoonotic agents and food-borne outbreaks in 2017. *EFSA Journal*, *16*(12). https://doi.org/10.2903/j.efsa.2018.5500

El-Shenawy, M., El-Shenawy, M., Mañes, J., & Soriano, J. M. (2011). Listeria spp. in Street-Vended Ready-to-Eat Foods . *Interdisciplinary Perspectives on Infectious Diseases*, *2011*, 1–6. https://doi.org/10.1155/2011/968031

Elobeid, T., Aziz, H. A., & Mousa, R. (2014). Survey on the Microbial Quality of Traditional Foods Sold by Street Vendors in Qatar. *Austin Journal of Nutrition & Metabolism Open*, *1*(2), 2–5.

Epps, S. V. R., Harvey, R. B., Hume, M. E., Phillips, T. D., Anderson, R. C., & Nisbet, D. J. (2013). Foodborne Campylobacter: Infections, metabolism, pathogenesis and reservoirs. *International Journal of Environmental Research and Public Health*, *10*(12), 6292–6304. https://doi.org/10.3390/ijerph10126292

Eromo, T., Tassew, H., Daka, D., & Kibru, G. (2016). Bacteriological quality of street foods and antimicrobial resistance of isolates in Hawassa, Ethiopia. *Ethiopian Journal of Health Sciences*, *26*(6), 533–542.

Evers, E. G., Pielaat, A., Smid, J. H., Van Duijkeren, E., Vennemann, F. B. C., Wijnands, L. M., & Chardon, J. E. (2017). Comparative exposure assessment of ESBL-producing Escherichia coli through meat consumption. *PLoS ONE*, *12*(1), 1-9. https://doi.org/10.1371/journal.pone.0169589

Facciolà, A., Riso, R., Avventuroso, E., Visalli, G., Delia, S. A., & Laganà, P. (2017). Campylobacter: from microbiology to prevention. *Journal of Preventive Medicine and Hygiene*, *58*(2), E79–E92. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/28900347%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC5584092

Fahrion, A. S., Jamir, L., Richa, K., Begum, S., Rutsa, V., Ao, S., … Grace, D. (2013). Food-safety hazards in the pork chain in Nagaland, north east India: Implications for human health. *International Journal of Environmental Research and Public Health*, *11*(1), 403–417. https://doi.org/10.3390/ijerph110100403

FAO/WHO. (2004). Risk assessment of Listeria monocytogene s in ready-to-eat foods. *FAO/WHO Microbiological Risk Assessment Series.*, *4*, 1–48. Retrieved from http://apps.who.int/iris/bitstream/10665/42875/1/9241562625.pdf?ua=1

FAO/WHO. (2009a). Risk assessment of Campylobacter spp. in broiler chikens: Interpretative summary. In *Microbial Risk Assessment Series*. Retrieved from http://www.who.int/foodsafety/publications/micro/MRA11_En.pdf

FAO/WHO. (2009b). Risk Characterization of Microbiological Hazards in Food: Guidelines. *Microbiological Risk Assessment Series 17*, 116. https://doi.org/http://dx.doi.org/10.1111/j.1539-6924.2012.01825.x

FAO. (2004). Application of risk assessment in the fish industry. Retrieved June 3, 2019, from http://www.fao.org/3/y4722e/y4722e08.htm

FAO, & WHO. (2002). *Risk assessment of Campylobacter spp . in broiler chickens and Vibrio spp . in seafood Report of a Joint FAO / WHO Expert*. Retrieved from http://www.who.int/foodsafety/publications/micro/en/aug2002.pdf

FAO, & WHO. (2006a). Food Safety Risk Analysis: A guide for national food safety authorities. *Food and Nutrition Paper*, 2006. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:No+Title#0

FAO, & WHO. (2006b). Risk Assessment outputs to develop practical risk management strategies : Metrics to improve food safety. In *Agriculture*. FAO/WHO.

Farmer, E., & Mbwika, J. (2012). End Market Analysis of Kenyan Livestock and Meat. In *USAID*. Retrieved from https://www.microlinks.org/site s/microlinks/files/ resource/ files/Kenya_Livestock_End_Market_Study.pdf

FASFC. (2011). Applications of microbiological risk assessment in the food chain. In FASFC (Ed.), *Symposium SciCom FASFC 2011*. Brussels, Belgium: FASFC.

FDA/CFSAN. (2012). *DRAFT Qualitative Risk Assessment Risk of Activity / Food Combinations for Activities (Outside the Farm Definition) Conducted in a Facility Co-Located on a Farm*. Washington D.C., USA.

Fedoruk, A. (2011). *Development of a Quantitative Microbial Risk Assessment Model for Foodborne Pathogens in Herbs and Spices* (The University of Guelph). Retrieved from https://dspace.lib.uoguelph.ca/xmlui/bitstream/handle/10214/7687/Fedoruk_Andrew_201102_MASc.pdf?sequence=1&isAllowed=y

Fellows, P., & Hilmi, M. (2011). Selling street and snack foods. In *FAO Diversification Booklet 18*.

Foerster, C., Figueroa, G., & Evers, E. (2015). Risk assessment of Listeria monocytogenes in poultry and beef. *British Food Journal*, *17*(2), 779–792. Retrieved from http://dx.doi.org/10.1108/BFJ-03-2014-0131

Food Standards Australia New Zealand. (2005). *Scientific assessment of the public health and safety of poultry meat in Australia*.

FSANZ. (2013). *Risk Analysis in Food Regulation*. Retrieved from http://www.foodstandards.gov.au/publications/riskanalysisfoodregulation/Documents/risk-analysis-food-regulation-full-pdf.pdf [Accessed on 24/10/2015]

Gallagher, D., Pouillot, R., Hoelzer, K., Tang, J., Dennis, S. B., & Kause, J. R. (2016). Listeria monocytogenes in Retail Delicatessens: An Interagency Risk Assessment—Risk Mitigations. *Journal of Food Protection*, *79*(7), 1076–1088. https://doi.org/10.4315/0362-028X.JFP-15-336

Giritlioglu, I., Batman, O., & Tetik, N. (2011). The knowledge and practice of food safety and hygiene of cookery students in Turkey. *Food Control*, *22*(6), 838–842. https://doi.org/10.1016/j.foodcont.2010.09.016

Gitahi, M. G., Njage, P., & Wangoh, J. L. (2012). Microbial safety of street foods in Industrial Area , Nairobi. *Research Journal of Microbiology*, *7*(6), 297–308. https://doi.org/10.3923/jm.2012.297.308

Gitahi, M. G., Wangoh, J., & Njage, P. M. K. (2012). Microbial Safety of Street Foods in Industrial Area, Nairobi. *Research Journal of Microbiology*, *7*(6), 297–308.

Githaiga, M., Gitahi, P., & Murigu, J. (2013). Microbial safety of Selected Food Borne Pathogens in Relation to Hygienic Practices in Industrial area , Nairobi Kenya. *Internet Journal of Food Safety*, *15*, 39–47.

Githiri, G., Ngugi, R., Njoroge, P., & Sverdlik, A. (2016). *Nourishing livelihoods Recognising and supporting informal settlements*.

Gkogka, E., Reij, M. W., Gorris, L. G. M., & Zwietering, M. H. (2013). The application of the Appropriate Level of Protection (ALOP) and Food Safety Objective (FSO) concepts in food safety management, using Listeria monocytogenes in deli meats as a case study. *Food Control*, *29*(2), 382–393. https://doi.org/10.1016/j.foodcont.2012.04.020

Global Forum on Food Security and Nutrition. (2011). Street foods : the way forward for better food safety and nutrition. *Street Foods: The Way Forward for Better Food Safety and Nutrition Summary of Discussion No. 73 From 26 September to 21 October 2011*, (73).

Golden, N. J., Crouch, E. A., Latimer, H., Kadry, A.-R., & Kause, J. (2009). Risk Assessment for Clostridium perfringens in Ready-to-Eat and Partially Cooked Meat and Poultry Products. *Journal of Food Protection*, *72*(7), 1376–1384. https://doi.org/10.4315/0362-028X-72.7.1376

González, M., Mikkelä, A., Tuominen, P., Ranta, J., Hakkinen, M., Hänninen, M., & Llarena, A. (2016). *Campylobacter spp. in the food chain and in the environment*. Helsinki.

Government of Kenya. (2012). *Meat Control Act*. Nairobi, Kenya: National Council for Law Reporting.

Grace, D., Roesel, K., Kang'ethe, E., Bonfoh, B., & Theis, S. (2015). *Gender roles and food safety in 20 informal livestock and fish value chains*. Washington, DC.

Green, L. R., Selman, C. A., Radke, V., Ripley, D., Mack, J. C., Reimann, D. W., … Bushnell, L. (2006). Food worker hand washing practices : An observation study. *Journal of Food Protection*, *69*(10), 2417–2423.

Guillier, L., Danan, C., Bergis, H., Delignette-Muller, M. L., Granier, S., Rudelle, S., Brisabois, A. (2013). Use of quantitative microbial risk assessment when investigating foodborne illness outbreaks: The example of a monophasic Salmonella Typhimurium 4,5,12: I : - Outbreak implicating beef burgers. *International Journal of Food Microbiology*, *166*(3), 471–478. https://doi.org/10.1016/j.ijfoodmicro.2013.08.006

Haileselassie, M., Taddele, H., Adhana, K., & Kalayou, S. (2013). Food safety knowledge and practices of abattoir and butchery shops and the microbial profile of meat in M ekelle City, Ethiopia F ood. *Asian Pacific Journal of Tropical Biomedicine*, *3*(5), 407–412. https://doi.org/10.1016/S2221-1691(13)60085-4

Hamad, S. H. (2012). Factors affecting the growth of microorganisms in food. In R. Bhat, A. K. Alias, & G. Paliyath (Eds.), *Progress in Food Preservation* (pp. 405–427). https://doi.org/10.1002/9781119962045.ch20

Hathaway, S., Davies, P., & Ashby, K. (2007). *Quantitative risk assessment model for Salmonella in sheep meat in New Zealand : Report of Gore Technical Meeting Final Report Risk management goals*.

Holy, A. Von, & Makhoane, F. M. (2006). Improving street food vending in South Africa : Achievements and lessons learned. *International Journal of Food Microbiology*, *111*, 89–92. https://doi.org/10.1016/j.ijfoodmicro.2006.06.012

Indira, D. (2014). A Study of Street Vending Across the Globe. *International Journal of Advanced Research in Computer Science and Software Engineering*, *4*(9), 514–519.

ISO. (1999). *Microbiology of Food and Animal Feeding stuffs- Horinzotal method for enumeration of coagulase positive staphylococci (Staphylococcus aureus and other species)* (1st ed., Vol. 1999). https://doi.org/10.1088/0957-4484/25/12/125707

ISO. (2000). *Water quality—Detection and enumeration of Escherichia coli and coliform bacteria* (Vol. 2000).

ISO. (2002). ISO 6579. Microbiology of food and animal feeding stuffs. Horizontal method for the detection of Salmonella spp. 4 ed. 2002. The International Organization for Standardization, amendment 1: 15 Jul. 2007. In *International Standard* (Vol. 2002). Geneva, Switzerland: ISO.

ISO. (2017). *Microbiology of food chain: Horizontal method for detection and enumeration of Campylobacter spp.*

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*, 11–25. https://doi.org/10.4236/odem.2017.51002

Jabbar, M. A., & Grace, D. (2012). Regulations for safety of animal source foods in selected Sub-Saharan African countries: Current status and their implications. In *Prepared for The Safe Food, Fair Food Project. International Livestock Research Institute, Nairobi, Kenya*. Nairobi, Kenya.

James, C., Daramola, B., Reyers, F., Purnell, G., Turner, R., & James, S. J. (2014). *Qualitative Risk Assessment to support a policy decision on partially - eviscerated (effilé) poultry production*.

Jansen, W., Woudstra, S., Müller, A., Grabowski, N., Schoo, G., Gerulat, B., … Kehrenberg, C. (2018). The safety and quality of pork and poultry meat imports for the common European market received at border inspection post Hamburg Harbour between 2014 and 2015. *PLoS ONE*, *13*(2), 1–13. https://doi.org/10.1371/journal.pone.0192550

Jay, J. M., Loessner, M. J., & Golden, D. A. (2005). *Modern Food Microbiology 7th*. New York, USA: Springer Science + Business media, Inc.

Jeong, J., Lee, J., Lee, H., Lee, S., Kim, S., Ha, J., … Yoon, Y. (2017). Quantitative microbial risk assessment for Campylobacter foodborne illness in raw Bbef offal consumption in South Korea. *Journal of Food Protection*, *80*(4), 609–618. https://doi.org/10.4315/0362-028x.jfp-16-159

Jeong, S. H., Kang, D., Lim, M. W., Kang, C. S., & Sung, H. J. (2013). Risk assessment of growth hormones and antimicrobial residues in meat. *Toxicological Research*, *26*(4), 301–313. https://doi.org/10.5487/TR.2010.26.4.301

Josefsen, M. H., Löfström, C., Hansen, T. B., Christensen, L. S., Olsen, J. E., & Hoorfar, J. (2010). Rapid quantification of viable Campylobacter bacteria on chicken carcasses, using real-time pcr and propidium monoazide treatment, as a tool for quantitative risk assessment. *Applied and Environmental Microbiology*, *76*(15), 5097–5104. https://doi.org/10.1128/AEM.00411-10

Jun, W., Chang, G. Y., & Ning, L. (2013). Prevalence and risk assessment of Campylobacter jejuni in chicken in China. *Biomed Environ, 26*(4), 243–248. https://doi.org/10.3967/0895-3988.2013.04.002

Kaakoush, N. O., Castaño-Rodríguez, N., Mitchell, H. M., & Man, S. M. (2015). Global epidemiology of campylobacter infection. *Clinical Microbiology Reviews*, *28*(3), 687–720. https://doi.org/10.1128/CMR.00006-15

Kaptan, G., Fischer, A. R. H., & Frewer, L. J. (2017). Extrapolating understanding of food risk perceptions to emerging food safety cases. *Journal of Risk Research*, *9877*, 1–23. https://doi.org/10.1080/13669877.2017.1281330

Kariuki, E. N. (2018). *Bacteriological safety ofsStreet foods and factors associated with food contamination among street food vendors in Githurai and Gikomba Markets*. Jomo Kenyatta University of Science and Technology.

Karoki, W. H., Karanja, D. N., Bebora, L. C., & Njagi, L. W. (2018). Isolation, characterization, and quantification of bacteria from African sausages sold in Nairobi County, Kenya. *International Journal of Food Science*, *2018*, 1–9. https://doi.org/10.1155/2018/3861265

Keeton, J. T., & Dikeman, M. E. (2017). 'Red' and 'white' meats—terms that lead to confusion. *Animal Frontiers*, *7*(4), 29–33. https://doi.org/10.2527/af.2017.0440

Kelly, L. A., Hartnett, E., Gettinby, G., FAZIL, A., Snary, E., & Wooldridge, M. (2003). Microbiological safety of poultry meat: risk assessment as a way forward. *World's Poultry Science Journal*, *59*(4), 495–508. https://doi.org/Doi 10.1079/Wps20030031

Khairuzzaman, M., Chowdhury, F. M., Zaman, S., Al Mamun, A., & Bari, M. L. (2014). Food safety challenges towards safe, healthy, and nutritious street foods in Bangladesh. *International Journal of Food Science*, *2014*. https://doi.org/10.1155/2014/483519

Kharel, N., Palni, U., & Prakash, J. (2016). Microbiological assessment of ethnic street foods of the Himalayas. *Journal of Ethnic Foods*, *3*(3), 235–241. https://doi.org/10.1016/j.jef.2016.01.001

Kiilholma, J. (2010). Food-safety concerns in the poultry sector of developing countries. In *Poultry in the 21st Century*. Rome, Italy.

Kumar, M., Agarwal, D., Ghosh, M., & Ganguli, A. (2006). Microbiological safety of street vended fruit chats in Patiala city. *Indian Journal of Medical Microbiology*, *24*(1), 75–76.

Kwiri, R., Winini, C., Tongonya, J., Gwala, W., Mpofu, E., Mujuru, F., … Muredzi, P. (2014). Microbiological safety of cooked vended foods in an urban informal market : A case study of Mbare Msika ,. *International Journal of Nutrition and Food Sciences*, *3*(3), 216–221. https://doi.org/10.11648/j.ijnfs.20140303.24

Lammerding, A. M., & Fazil, A. (2000). Hazard identification and exposure assessment for microbial food safety risk assessment. *International Journal of Food Microbiology*, *58*(3), 147–157. https://doi.org/10.1016/S0168-1605(00)00269-5

Larsson, S. C., & Orsini, N. (2014). Red meat and processed meat consumption and all-cause mortality: A meta-analysis. *American Journal of Epidemiology*, *179*(3), 282–289. https://doi.org/10.1093/aje/kwt261

Lee, J., Ha, J., Kim, S., Lee, H., Lee, S., & Yoon, Y. (2015). Quantitative microbial risk assessment for Staphylococcus aureus in natural and processed cheese in Korea. *Korean J. Food Sci. An. Vol.*, *35*(5), 674–682. https://doi.org/10.3168/jds.2015-9611

Liu, Z., Zhang, G., & Zhang, X. (2014). Urban street foods in Shijiazhuang city, China : Current status, safety practices and risk mitigating strategies. *Food Control*, *41*, 212–218. https://doi.org/10.1016/j.foodcont.2014.01.027

Lues, J. F. R., Rasephei, M. R., Venter, P., & Theron, M. M. (2006). Assessing food safety and associated food handling practices in street food vending. *International Journal of Environmental Health Research* ·, *16*(5), 319–328. https://doi.org/10.1080/09603120600869141

Mafune, T. S., Takalani, T. K., Anyasi, T. A., & Shonisani, E. (2016). Microbial Safety of Street Vended Foods Sold in Thohoyandou , South Africa Microbial Safety of Street Vended Foods Sold in Thohoyandou , South Africa. *Journal of Human Ecology ISSN:*, *53*(3), 205–212. https://doi.org/10.1080/09709274.2016.11906973

Mageto, L., Ombui, J. N., & Mutua, F. K. (2018). Prevalence and risk factors for Campylobacter infection of chicken in peri-urban areas of Nairobi, Kenya. *Journal of Dairy, Veterinary & Animal Research*, *7*(1), 22–27. https://doi.org/10.15406/jdvar.2018.07.00184

Makelele, L. K., Kazadi, Z. A., Oleko, R. W., Foma, R., Mpalang, R. K. a, NgboLua, K. N., & Gedeon, B. N. (2015). Microbiological quality of food sold by street vendors in Kisangani, Democratic Republic of Congo. *African Journal of Food Science*, *9*(5), 285–290.

https://doi.org/10.5897/AJFS2015.1263

Manguiat, L. S., & Fang, T. J. (2013). Microbiological quality of chicken- and pork-based street-vended foods from Taichung, Taiwan, and Laguna, Philippines. *Food Microbiology*, *36*(1), 57–62. https://doi.org/10.1016/j.fm.2013.04.005

Maroko, R. A. (2016). *Dyanmics of Cooked Food Vending in Kayole Location, Nairobi County, Kenya* (Kenyatta University).

Marotta, F., Garofolo, G., Donato, G. Di, Aprea, G., Platone, I., Cianciavicchia, S., Giannatale, E. Di. (2015). Population diversity of campylobacter jejuni in poultry and its dynamic of contamination in chicken meat. *BioMed Research International*, *2015*, 1–10. https://doi.org/10.1155/2015/859845

Mcintyre, L., Vallaster, L., Wilcott, L., Henderson, S. B., & Kosatsky, T. (2013). Evaluation of food safety knowledge , attitudes and self-reported hand washing practices in FOODSAFE trained and untrained food handlers in British Columbia , Canada. *Food Control*, *30*(1), 150–156. https://doi.org/10.1016/j.foodcont.2012.06.034

Mensah, P., Mwamakamba, L., Kariuki, S., Fonkoua, M. C., & Aidara-Kane, A. (2012). Strengthening foodborne diseases surveillance in the WHO African Region: an essential need for disease control and food safety assurance. *Special Issue: Policy Responses to Food Insecurity in Africa.*, *12*(4), 6336–6353. Retrieved from http://www.ajfand.net/Volume12/No4/AJFAND-WHO-7.pdf

Mjoka, J., & Selepe, P. M. (2017). Food hygiene practices and attitudes of the street food vendors at KwaDlangezwa , Northern KwaZulu Natal. *African Journal of Hospitality,*

Tourism and Leisure, *6*(3), 1–12.

Monney, I., Agyei, D., Ewoenam, B. S., Priscilla, C., & Nyaw, S. (2014). Food hygiene and Safety Practices among Street Food Vendors : An Assessment of Compliance , Institutional and Legislative Framework in Ghana. *Food and Public Health*, *4*(6), 306–315. https://doi.org/10.5923/j.fph.20140406.08

Mughal, M. H. (2019). Campylobacteriosis: A Global Threat. *Biomedical Journal of Scientific & Technical Research*, *11*(5), 1–5. https://doi.org/10.26717/bjstr.2018.11.002165

Muhonja, F., & Kimathi, G. K. (2014). Assessment of hygienic and food handling practices among street food vendors in Nakuru Town in Kenya. *Science Journal of Public Health*, *2*(6), 554–559. https://doi.org/10.11648/j.sjph.20140206.19

Muinde, O., & Kuria, E. (2005a). Hygienic and sanitary practices of vendors of street foods. *African Journal of Food Agriculture Nutrition and Development*, *5*(7), 1–15.

Muinde, O., & Kuria, E. (2005b). Hygienic and sanitary practices of vendors of street foods. *African Journal of Food Agriculture Nutrition and Development*, *5*(7), 1–15.

Mukherjee, S., Mondal, T. K., De, A., Misra, R., & Pal, A. (2018). Knowledge, attitude and practice of food hygiene among street food vendors near a tertiary care hospital in Kolkata, India. *International Journal Of Community Medicine And Public Health*, *5*(3), 1206. https://doi.org/10.18203/2394-6040.ijcmph20180786

Muth, M. K., Beach, R. H., Karns, S. A., Taylor, J. L., & Viator, C. L. (2006). *Poultry slaughter and processing sector facility-level model*. Retrieved from https://www.rti.org/sites/default/files/resources/poultry_slaughter.pdf

Mutisya, E., & Yarime, M. (2011). Understanding the grassroots dynamics of slums in Nairobi: The dilemma of Kibera informal settlements. *International Transaction Journal of Engineering, Management, and Applied Sciences and Technologies*, *2*(2), 197–213.

Muyanja, C., Nayiga, L., Brenda, N., & Nasinyama, G. (2011). Practices, knowledge and risk factors of street food vendors in Uganda. *Food Control*, *22*(10), 1551–1558. https://doi.org/10.1016/j.foodcont.2011.01.016

Ng, Y., Wong, S., Cheng, H., Yu, P. H., & Chan, S. (2013). The microbiological quality of ready-to-eat food in Siu Mei and Lo Mei shops in Hong Kong. *Food Control*, *34*(2), 547–553. https://doi.org/10.1016/j.foodcont.2013.05.018

Nguyen, T. N. M., Hotzel, H., Njeru, J., Mwituria, J., El-Adawy, H., Tomaso, H., Hafez, H. M. (2016). Antimicrobial resistance of Campylobacter isolates from small scale and backyard chicken in Kenya. *Gut Pathogens*, *8*(1), 1–9. https://doi.org/10.1186/s13099-016-0121-5

Niyonzima, E., Bora, D., & Ongol, M. P. (2013). Assessment of beef meat microbial contamination during skinning , dressing , transportation and marketing at a commercial abattoir in Kigali city , Rwanda. *Pakistan Journal of Food Science*, *23*(3), 133–138.

Nkere, C. K., Ibe, N. I., & Iroegbu, C. U. (2011). Bacteriological quality of foods and water sold by vendors and in restaurants in Nsukka, Enugu state, Nigeria: A comparative study of three microbiological methods. *Journal of Health, Population and Nutrition*, *29*(6), 560–566. https://doi.org/10.3329/jhpn.v29i6.9892

Nobili, G., Franconieri, I., Bella, G. La, Basanisi, M. G., & Salandra, G. La. (2017). Prevalence of verocytotoxigenic Escherichia coli strains isolated from raw beef in southern Italy. *International Journal of Food Microbiology*, *257*(February), 201–205. https://doi.org/10.1016/j.ijfoodmicro.2017.06.022

Nonga, H. E., Ngowi, H. A., Mdegela, R. H., Mutakyawa, E., Nyahinga, G. B., William, R., & Mwadini, M. M. (2015). Survey of physicochemical characteristics and microbial contamination in selected food locally vended in Morogoro Municipality , Tanzania. *BMC Research Notes*, 1–10. https://doi.org/10.1186/s13104-015-1716-5

Nurudeen, A. A., Lawal, A. O., & Ajayi, S. A. (2013). A survey of hygiene and sanitary practices of street food vendors in the Central State of Northern Nigeria. *International Journal of Medicine and Medical Sciences*, *6*(5), 11–17. https://doi.org/10.5897/JPHE2013.0607

Odhiambo, W. A., Kebira, A. N., & Nyerere, A. (2017). Prevalence of Campylobacter jejuni and other bacterial pathogens in selected foods and drinks served in fast food kiosks in Ngara and Burma markets in Nairobi. *International Academic Journal of Health, Medicine and Nursing*, *1*(1), 32–57.

Odwar, J. A., Kikuvi, G., Kariuki, J. N., & Kariuki, S. (2014). A cross-sectional study on the microbiological quality and safety of raw chicken meats sold in Nairobi , Kenya. *BMC Research Notes*, *7*(627), 1–8.

Oguttu, J. W. (2015). *Participatory risk analysis of street vended chicken meat sold in the informal market of Pretoria , South Africa By*. (April), 1–254.

Oguttu, J. W., McCrindle, C. M. E., Makita, K., & Grace, D. (2014). Investigation of the food value chain of ready-to-eat chicken and the associated risk for staphylococcal food poisoning in Tshwane Metropole, South Africa. *Food Control*, *45*, 87–94. https://doi.org/10.1016/j.foodcont.2014.04.026

Okojie, P. W., & Isah, E. C. (2014). Sanitary conditions of food vending sites and food handling practices of street food vendors in Benin city, Nigeria: Implication for food hygiene and safety. *Journal of Environmental and Public Health*, *2014*. https://doi.org/10.1155/2014/701316

Olaoye, O. A. (2011). Meat: An overview of its composition, biochemical changes and associated microbial agents. *International Food Research Journal*, *18*(3), 877–885.

Ologhobo, A. D., Omojola, A. B., Ofongo, S. T., Moiforay, S., & Jibir, M. (2010). Safety of street vended meat products - chicken and beef suya. *African Journal of Biotechnology*, *9*(26), 4091–4095.

Oloo, J. (2010). Food safety and quality management in Kenya: An overview of the roles played by various stakeholders. *AJFAND*, *10*(11), 4379–4397.

Omemu, A. M., & Aderoju, S. T. (2008). Food safety knowledge and practices of street food vendors in the city of Abeokuta, Nigeria. *Food Control*, *19*(4), 396–402. https://doi.org/10.1016/j.foodcont.2007.04.021

Patel, D., Stansell, J., Jaimes, M., Ferris, K., & Webb, G. (2017). A Survey of Microbial Contamination on Restaurant Nonfood-Contact Surfaces. *Journal of Food Safety*, *37*(1), 2–7. https://doi.org/10.1111/jfs.12287

Pavesi, A. A.-B., Manuela, M., Feltes, C., & Block, J. M. (2017). Food quality and safety progress in the Brazilian food and beverage industry: chemical hazards. *Food Quality and Safety*, *1*(2), 117–129. https://doi.org/10.1093/fqs/fyx009

Petrović, Z., Milićević, D., Nastasijević, I., Dordević, V., Trbović, D., & Velebit, B. (2017). The role of food quality assurance and product certification systems on marketing aspects. *IOP Conference Series: Earth and Environmental Science*, *85*(1). https://doi.org/10.1088/1755-1315/85/1/012011

Pouokam, G. B., Foudjo, B. U. S., Samuel, C., Yamgai, P. F., Silapeux, A. K., Sando, J. T., Frazzoli, C. (2017). Contaminants in Foods of Animal Origin in Cameroon: A One Health Vision for Risk Management "from Farm to Fork." *Frontiers in Public Health*, *5*(September). https://doi.org/10.3389/fpubh.2017.00197

Pradhan, A. K., Ivanek, R., Grohn, Y. T., Bukoswki, R., Geornaras, I., Sofos, J. N., & Wiedmann, M. (2010). Quantitative risk assessment of listeriosis-associated deaths due to Listeria monocytogenes contamination of deli meats originating from manufacture and retail. *Journal of Food Protection*, *73*(4), 620–630. https://doi.org/10.4315/0362-028X-73.4.620

Quetz, da J. S., Lima, I. F. N., Havt, A., Prata, M. M. G., Cavalcante, P. A., Medeiros, P. H. Q. S., Lima, A. A. M. (2012). Campylobacter jejuni infection and virulence-associated genes in children with moderate to severe diarrhoea admitted to emergency rooms in northeastern Brazil. *Journal of Medical Microbiology*, *61*(4), 507–513. https://doi.org/10.1099/jmm.0.040600-0

Rahman, M., Arif, M. T., Bakar, K., & Tambi, Z. (2012). Food safety knowledge, attitude and hygiene practices among the street food vendors in Nothern Kuching City Sarawak. *Borneo Science*, *31*(September), 95–103.

Rahmat, S., Cheong, C. B., & Hamid, M. S. R. B. A. (2016). Challenges of developing countries in complying quality and enhancing standards in food industries. *Procedia - Social and Behavioral Sciences*, *224*(August 2015), 445–451. https://doi.org/10.1016/j.sbspro.2016.05.418

Rane, S. (2011). Street Vended Food in Developing World: Hazard Analyses. *Indian Journal of Microbiology*, *51*(1), 100–106. https://doi.org/10.1007/s12088-011-0154-x

Rani, Z. T., Hugo, A., Hugo, C. J., Vimiso, P., & Muchenje, V. (2017). Effect of post-slaughter handling during distribution on microbiological quality and safety of meat in the formal and informal sectors of South Africa: A review. *South African Journal of Animal Science*, *47*(3), 255–267. https://doi.org/10.4314/sajas.v47i3.2

Roever, S., & Skinner, C. (2016). Street vendors and cities. *Environment and Urbanization*, *28*(2), 359–374. https://doi.org/10.1177/0956247816653898

Rosnani, H. A., Radu, S., Othman, M., Toh, P. S., & Chai, L. C. (2014). *Assessment of Knowledge , Attitude and Practices Concerning Food Safety among Restaurant Workers in Putrajaya , Malaysia*. *32*(September 2013), 20–28.

Salam, A. A., Hiremath, S. R. R., & Iram, M. (2016). The Third Sustainable Development Goal: End Epidemics and other Communicable Diseases; Indian Perspective. *Indian Journal of Pharmacy Practice*, *9*(2), 73–76. https://doi.org/10.5530/ijopp.9.2.3

Samapundo, S., Cam Thanh, T. N., Xhaferi, R., & Devlieghere, F. (2016). Food safety knowledge, attitudes and practices of street food vendors and consumers in Ho Chi Minh city, Vietnam. *Food Control*, *70*(November), 79–89. https://doi. org/10. 1016/j.food cont. 2016.05.037

Samapundo, S., Climat, R., Xhaferi, R., & Devlieghere, F. (2015). Food safety knowledge, attitudes and practices of street food vendors and consumers in Port-au-Prince, Haiti. *Food Control*, *50*, 457–466. https://doi.org/10.1016/j.foodcont.2014.09.010

Sandel, M. K., & Mckillip, J. L. (2004). Virulence and recovery of Staphylococcus aureus relevant to the food industry using improvements on traditional approaches. *Food Control*, *15*, 5–10. https://doi.org/10.1016/S0956-7135(02)00150-0

Sani, N. A., & Siow, O. N. (2014). Knowledge , attitudes and practices of food handlers on food safety in food service operations at the Universiti Kebangsaan Malaysia. *Food Control*, *37*, 210–217. https://doi.org/10.1016/j.foodcont.2013.09.036

Sariffuddin, S., Wahyono, H., & Brotosunaryo, B. (2017). Street vendors hypergrowth: Consequence of uncontrolled urbanization in Semarang City. *Komunitas: International Journal of Indonesian Society and Culture*, *9*(1), 81. https://doi.org/10.15294/komunitas.v9i1.8497

Sezgin, A. C., & Şanlıer, N. (2016). Street food consumption in terms of the food safety and health. *Journal of Human Sciences*, *13*(3), 4072. https://doi.org/10.14687/jhs.v13i3.3925

Shehbaz, M. (2016). Evaluation of Current Food Safety Practices at Various Food Establishments in Lahore. *Journal of Food Processing & Technology*, *07*(03), 1–8. https://doi.org/10.4172/2157-7110.1000559

Smith, B. A., Fazil, A., & Lammerding, A. M. (2013). A risk assessment model for Escherichia coli O157:H7 in ground beef and beef cuts in Canada: Evaluating the effects of interventions. *Food Control*, *29*(2), 364–381. https://doi.org/10.1016/j.foodcont.2012.03.003

Smith, G. S. (1985). Fatalities Associated With Campylobacter jejuni Infections. *JAMA: The Journal of the American Medical Association*, *253*(19), 2873. https://doi.org/10.1001/jama.1985.03350430085033

Snary, E. L., Ramnial, V., Breed, A. C., Stephenson, B., Field, H. E., & Fooks, A. R. (2012). Qualitative release assessment to estimate the likelihood of Henipavirus entering the United Kingdom. *PLoS ONE*, *7*(2). https://doi.org/10.1371/journal.pone.0027918

Soares, L. S., Almeida, R. C. C., Cerqueira, E. S., Carvalho, J. S., & Nunes, I. L. (2012). Knowledge , attitudes and practices in food safety and the presence of coagulase- positive staphylococci on hands of food handlers in the schools of Camaçari , Brazil. *Food Control*, *27*(1), 206–213. https://doi.org/10.1016/j.foodcont.2012.03.016

Steyn, N. P., McHiza, Z., Hill, J., Davids, Y. D., Venter, I., Hinrichsen, E., … Jacobs, P. (2014). Nutritional contribution of street foods to the diet of people in developing countries: A systematic review. *Public Health Nutrition*, *17*(6), 1363–1374. https://doi.org/10.1017/S1368980013001158

Subratty, A. H., Beeharry, P., & Sun, M. C. (2004). A survey of hygiene practices among food vendors in rural areas in Mauritius. *Nutrition & Food Scienc*, *34*(5), 203–205. https://doi.org/10.1108/00346650410560361

Syne, S.-M., Ramsubhag, A., & Adesiyun, A. a. (2013). Microbiological hazard analysis of ready-to-eat meats processed at a food plant in Trinidad, West Indies. *Infection Ecology & Epidemiology*, *3*, 1–12. https://doi.org/10.3402/iee.v3i0.20450

Riet, H. van. (2002). The role of street foods in the diet of low-income urban residents, the case of Nairobi. In *The role of street foods in the diet of low income urban residents, the case of Nairobi* (Vol. 120).

Tafesse, F., Desse, G., Bacha, K., & Alemayehu, H. (2014). Microbiological quality and safety of street vended raw meat in Jijiga town of Ssoutheast Ethiopia. *African Journal of Microbiology Research*, *8*(4), 3867–3874. https://doi.org/10.5897/AJMR2014.7136

Tambekar, D. H., Jaiswal, V. J., Dhanorkar, D. V, Gulhane, P. B., & Dudhane, M. N. (2008). Identification of microbiological hazards and safety of ready-to-eat food vended in streets of Amravati City , India. *Journal of Applied Biosciences*, *7*, 195–201.

Tassew, H., Abdissa, A., Beyene, G., & Gebre-Selassie, S. (2010). Microbial flora and food borne pathogens on minced meat and their susceptibility to antimicrobial agents. *Ethiop J Health Sci.*, *20*(3), 137–143.

Tesfaye, W., Bereda, T. W., Emerie, Y. M., Reta, M. A., & Asfaw, H. S. (2016). Microbiological quality and safety of street vended raw meat in Jijiga town of Somali Regional State, southeast Ethiopia. *African Journal of Microbiology Research*, *4*(2), 3867–

3874.

Thornton, P. K. (2010). Livestock production: Recent trends, future prospects. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1554), 2853–2867. https://doi.org/10.1098/rstb.2010.0134

Toh, P. S., & Birchenough, A. (2000). Food safety knowledge and attitudes : culture and environment impact on hawkers in Malaysia . Knowledge and attitudes are key attributes of concern in hawker foodhandling practices and outbreaks of food poisoning and their prevention. *Food Control*, *11*, 447–452.

Tuyet-Hanh, T. T., Sinh, D. X., Phuc, P. D., Ngan, T. T., Van Tuat, C., Grace, D., Nguyen-Viet, H. (2017). Exposure assessment of chemical hazards in pork meat, liver, and kidney, and health impact implication in Hung Yen and Nghe An provinces, Vietnam. *International Journal of Public Health*, *62*(Oecd), 75–82. https://doi.org/10.1007/s00038-016-0912-y

Tyokumbur, E. T. (2016). Evaluation of cadmium (Cd) in domestic chicken meat and offal and associated health risk assessment in Ibadan. *International Journal of Pure and Applied Zoology Volume*, *4*(2), 203–209.

Umar, A., Mande, A., & Umar, J. (2018). The effect of food hygiene training among street food vendors in Sabon Gari Local Government Area of Kaduna State, Nigeria. *Sub-Saharan African Journal of Medicine*, *5*(1), 20. https://doi.org/10.4103/ssajm.ssajm_30_17

Wahidin, D., & Purnhagen, K. (2018). Improving the level of food safety and market access in developing countries. *Heliyon*, *4*(7), e00683. https://doi.org/10.1016/j.heliyon.2018.e00683

Wahyuni, H. C., Vanany, I., & Ciptomulyono, U. (2018). Identifying risk event in Indonesian fresh meat supply chain. *IOP Conference Series: Materials Science and Engineering*, *337*(1). https://doi.org/10.1088/1757-899X/337/1/012031

Walls, I. (2006). Role of quantitative risk assessment and food safety objectives in managing Listeria monocytogenes on ready-to-eat meats. *Meat Science*, *74*(1), 66–75. https://doi.org/10.1016/j.meatsci.2006.04.029

Wang, J., Guo, Y. C., & Li, N. (2013). Prevalence and risk assessment of Campylobacter jejuni in chicken in China. *Biomedical and Environmental Sciences : BES*, *26*(4), 243–248. https://doi.org/10.3967/0895-3988.2013.04.002

WHO/FAO. (2009). Risk assessment of Campylobacter in broiler chickens: Technical report. In *Microbial Risk Assessment Series*.

WHO. (1996). Essential safety requirements for street -vended foods. *World Health Organization*, *WHO/FNU/FO*, 1–41.

WHO. (2014). *WHO estimates of the global burden of diseases* (Vol. 46). https://doi.org/10.1016/j.fm.2014.07.009

WHO. (2018). Campylobacter. Retrieved May 30, 2019, from https://www.who.int/news-room/fact-sheets/detail/campylobacter

WHO, & FAO. (2011). *FAO/WHO guide for application of risk analysis principles and procedures during food safety emergencies*. Rome, Italy: FAO and WHO.

WHO, OIE, FAO, & Universiteit Utretcht. (2013). *The global view of campylobacteriosis: report of an expert consultation, Utrecht, Netherlands, 9-11 July 2012*. https://doi.org/ISBN 978 92 4 156460 1

Williamson, K., Allen, G., & Bolton, F. J. (2006). Microbiological examination of salad served with takeaway meals.

Yeboah-Manu, D., Kpeli, G., Akye, M., & Bimi, L. (2010). Bacteriological Quality of Ready-to-Eat food Sold on and Around University of Ghana Campuses. *Research Journal of Microbiology, 5*(2), 130–136.

Zaitseva, N., Shur, P. Z., Kiryanov, D., & Kamaltdinov, M. (2014). Health risk assessment of exposure to ractopamina through consumption of meat products. *International Journal of Advanced Research, 2*(9), 538–545.

Zeru, K., & Kumie, A. (2007). Sanitary conditions of food establishments in Mekelle town. *Ethiopian Journal of Health Development, 21*(1), 3–11.

APPENDICES

APPENDIX 1: VENDORS' CONSENT FORM

University of Nairobi Department of Food Science, Nutrition and Technology, Food Safety and Quality Assurance Programme

Beatrice Birgen Jeruto is a student from the University of Nairobi studying MSc. in Food safety and Quality Assurance. She is conducting a study on the food safety practices in street vended products in specific places in Nairobi County. In order to get this information, I am pleased to have you take part in this study.

The study involves answering of a few questions with the responses you give being filled in a questionnaire and a checklist to be filled regarding your business. The information you will provide will help in instituting measures in the prevention of food borne illnesses resulting from intake of street vended foods.

The information you will provide is confidential and in as much as a report of the same will be made, no names will be included. There is no way any information will be directly associated with you. I encourage you to participate in the study and your cooperation is highly appreciated.

Please sign below if you accept to be part of the study

Name of Interviewer……..

Signature of interviewer……

Date……..

In case of any problem,
Contact
Beatrice Birgen
0796368670

APPENDIX 2: CONSUMERS' CONSENT FORM

University of Nairobi Department of Food Science, Nutrition and Technology, Food Safety and Quality Assurance Programme

Beatrice Birgen Jeruto is a student from the University of Nairobi studying MSc. in Food safety and Quality Assurance. She is conducting a study on the food safety practices in street vended products in specific places in Nairobi County. In order to get this information, I am pleased to have you take part in this study.

The study involves answering of a few questions with the responses you give being filled in a questionnaire. The information you will provide will help in instituting measures in the prevention of food borne illnesses resulting from intake of street vended foods.

The information you will provide is confidential and in as much as a report of the same will be made, no names will be included. There is no way any information will be directly associated with you. I encourage you to participate in the study and your cooperation is highly appreciated.

Please sign below if you accept to be part of the study

Name of Interviewer……..

Signature of interviewer……

Date……..

In case of any problem,

Contact

Beatrice Birgen

0796368670

APPENDIX 3: VENDORS QUESTIONNAIRE

UNIVERSITY OF NAIROBI

DEPARTMENT OF FOOD SCIENCE, NUTRITION AND DIETETICS

Questionnaire Number ___/2017

IDENTIFICATION

Name of Interviewer ……

Date of Interview ……. /…../ 2017

Location: _____

SECTION A: SOCIO-DEMOGRAPHIC AND ECONOMIC INFORMATION

RESPONDENT'S Details

Residence	**Sex** **1=Male** **2=Female**	**Age** **Yrs.**	**Marital Status** **(codes)**	**Education** **(codes)**	**Income status**	**Religion** **(codes)**

Marital status	**Education**	**Occupation**	**Religion**
1=Married 2=Separated 3=Widowed	1=College/University 2=Completed Secondary 3=Completed primary	1=Salaried employee 2=Farmer 3=Self employment	1=Christian 2=Muslim 3=Traditionist

4=Single 5=Divorced 6=N/A	4=Dropped from primary 5=In primary 6=In secondary 7=Literate e.g. Adult Education 8=Illiterate 9=Pre-primary 10= Others (specify)	4=Casual labourer 5=Student 6=Housewife 7=Unemployed 8=Others (specify) 9=N/A	4=Others(specify)

Do you have any orientation in food safety?

1=Yes [ ] 2=No [ ]

SECTION B: ASSESSMENT OF FOOD SAFETY KNOWLEDGE

Please tick [√] whether the under listed questions are true using the scale (1=Yes, 2=No and 3=Do not know).

Questions	**1=YES**	**2=NO**	**3= DO NOT KNOW**
1. Poultry meat do not spoil easily even without refrigeration.			
2. Salmonella can't be found in food but only in water.			
3. I do not need a medical clearance to be a food vendor if I'm not feeling sick.			
4. Cooking eliminates all the bacteria in vended poultry.			
5. During sickness I need to take leave from work.			
6. Food borne illnesses are not that serious to cause death.			
7. Bad odor in food is a sign of food spoilage,			

8. Knives and utensils can result into cross contamination of foods.
9. Hand washing reduces chances of contamination of food.
10. All food-borne illnesses and AIDS have the same symptoms.
11. Food contact surfaces should not be cleaned everyday but only when they are dirty.
12. Foods from the supermarket are very clean and can be taken without washing.
13. Water used in food preparation can be an agent of food contamination.
14. Using sterile gloves can help prevent food contamination.
15. All people can be affected by food-borne illnesses.

SECTION C: HYGIENE PRACTICES

16. Are you the owner of the business?

1=Yes [ ] 2=No [ ]

17. Did you get a permit to run the business?

1=Yes [ ] 2=No [ ]

18. What kind of poultry products do you sell? (**Please list them)**

_____

_____

—

19. Do you deal in any other product apart from poultry products?

1=Yes [ ] 2=No [ ]

a. If YES, please specify

_____

b. How do you handle both of them at the same time?

_____

_____

_____

20. What is your daily customer base?

_____

21. In what form do your customers prefer their product given to them?

1=packaged 2=Unpackaged

22. Has any of your customers' ever complained of any illness after taking your food?

1=Yes [ ] 2=No [ ]

a. How did you handle it?

_____

_____

23. Did you go for any medical checks before starting the business?

1=Yes [ ] 2=No [ ]

24. How often do you clean this place?

1=Daily [ ] 2=Not Daily [ ]

25. Do you wash your hand every time before handling the food?

1=Yes [ ] 2=No [ ]

26. What do you use to clean the utensils you use in preparing the poultry?

1=Hot water and detergent [ ] 2= Cold water and detergent [ ] 3= Only cold water [ ]

27. Where do you get your water from?

1=Tap water [ ] 2=Borehole [ ] 3= Rainfall [ ] 4=Any other, specify

28. Do you have any specific clothing you wear while doing this business?

1=Yes [ ] 2=No [ ]

29. Do you have a specific supplier(s) you get your poultry from?

1=Yes [ ] 2=No [ ]

a. If YES, are there any specific hygiene related specifications you chose them for? **Please state them.**

_____
_____
_____

30. How do you store the chicken awaiting to be sold?

_____
_____
_____

31. In case of any poultry products remain how do you keep them?

_____
_____
_____

THANK YOU FOR PARTICIPATING

APPENDIX 4: CONSUMERS' QUESTIONNAIRE

UNIVERSITY OF NAIROBI

DEPARTMENT OF FOOD SCIENCE, NUTRITION AND DIETETICS

Questionnaire Number ___/2017

IDENTIFICATION

Name of Interviewer ……

Date of Interview ……. /…../ 2017

Sex …..1=Male 2=Female

Location: _____

SECTION A: SOCIO-DEMOGRAPHIC AND ECONOMIC INFORMATION

RESPONDENT'S Details

Residence	**Sex** **1=Male** **2=Female**	**Age** **Yrs.**	**Marital** **Status** **(codes)**	**Education** **(codes)**	**Occupation** **(codes)**	**Religion** **(codes)**

Marital status	**Education**	**Occupation**	**Religion**
1=Married 2=Separated 3=Widowed 4=Single 5=Divorced 6=N/A	1=College/University 2=Completed Secondary 3=Completed primary 4=Dropped from primary 5=In primary 6=In secondary 7=Literate e.g. Adult Education 8=Illiterate 9=Pre-primary 10= Others (specify)	1=Salaried employee 2=Farmer 3=Self employment 4=Casual labourer 5=Student 6=Housewife 7=Unemployed 8=Others (specify) 9=N/A	1=Christian 2=Muslim 3=Traditionist 4=Others(specify)

SECTION B: ASSESSMENT OF FOOD SAFETY KNOWLEDGE

Please tick [√] whether the under listed questions are true using the scale (1=Yes, 2=No and 3=Do not know).

Questions	1=YES	2=NO	3= DO NOT KNOW
1. Germs found in food can cause illnesses.			
2. Both the children and adults can suffer from food borne illnesses.			
3. Diarrhea and abdominal pains can be symptoms of food borne illness.			
4. Bacteria in food are the causes of rising cancer cases.			
5. Food in the refrigerator can never have bacteria.			
6. Spoilt food, if reheated is safe to eat.			
7. Proper washing of utensils prevent food contamination.			
8. Dust has germs that can contain germs that can contaminate food.			
9. Foods with nice smell and that are looking nice have no bacteria.			
10. Indigenous or traditional chicken cannot be contaminated with germs.			
11. Food should be left open to prevent it from spoilage by germs.			
12. Only the Europeans can suffer from food-borne illnesses as they have a low immunity.			

SECTION C: HYGIENE PRACTICES

13. How frequent do you consume street vended poultry?

1= More than twice a week [ ] 2= Once a week [ ] 3=Rarely in a month [ ]

14. From which places do you buy your street vended poultry. **Kindly describe the place.**

---

15. Have you ever suffered from any food borne illness?

1=Yes [ ] 2=No [ ]

a. If YES, what did you do about it?

---

16. Have you ever purchased some vended poultry and found out it later it is spoilt?

If YES,

a. What did you do?

---

b. How many times has this happened?

1= Once [ ] 2=More than Once [ ]

c. Do you still buy from the same vendors?

1=Yes [ ] 2=No [ ]

17. How do you decide on where to buy your street vended poultry from?

---

18. Do you buy the poultry too for children?

1=Yes [ ] 2=No [ ]

19. How would you know that the street vended poultry is safe for consumption?

---

20. Are the street vended poultry that you buy packaged?

1=Yes [ ] 2=No [ ]

21. Where do you consume the vended food you buy?

1=At the site 2=At home

a. If at home, do you prepare the street vended poultry further before consumption?

1=Yes [ ] 2=No [ ] 3=NA

22. Do you wash your hand before eating vended poultry?

1=Yes [ ] 2=No [ ]

23. Do you wash your hand after visiting the toilet?

1=Yes [ ] 2=No [ ]

24. Do you check the hygiene status of the place you buy vended poultry from?

1=Yes [ ] 2=No [ ]

25. How would you know if a street vended poultry is contaminated?

_____

_____

26. The vendors you buy from, do they have the food covered or displayed?

1=Yes [ ] 2=No [ ]

27. How do you handle the poultry product in places you are to select the poultry product on your own?

_____

_____

28. Do you mind about the hygienic handling of the product you buy?

1=Yes [ ] 2=No [ ]

THANK YOU FOR PARTICIPATING

APPENDIX 5: FOOD SAFETY CHECK LIST

Vendor's Name: _____

Location: _____

1. **Facilities**

Is the vending place sheltered? YES [ ] NO [ ]

Is the food prepared on-site or at home? YES [ ]NO [ ]

Are pests and animals such as flies evident around the vending stall? YES [ ] NO [ ]

Is the vending place clean? YES [ ] NO [ ]

Is there a hand washing facility such as troughs? YES [ ] NO [ ]

Are there proper waste disposal facilities? YES [ ] NO [ ]

If a bin, is it always closed (foot operated) bin? YES [ ] NO [ ]

2. **Environment around the stall**

Is the environment littered with waste and rubbish? YES [ ] NO [ ]

3. **Personal hygiene**

Does the vendor wash hands while preparing and handling food? YES [ ] NO [ ]

Does the vendor have appropriate clothing for vending such as apron? YES [ ] NO [ ]

Is the clothing of the vendor clean? YES [ ] NO [ ]

Are the nails of the vendor kept short? YES [ ] NO [ ]

Does the vendor handle food with their hand? YES [ ] NO [ ]

4. **Food storage**

Is the food awaiting sale covered? YES [ ] NO [ ]

5. **Utensils**

Are the utensils clean? YES [ ] NO [ ]

Are the utensils covered? YES [ ] NO [ ]

THANK YOU FOR PARTICIPATING

APPENDIX 6: ENUMERATORS TRAINING MANUAL

SESSION	DAY ONE	DAY TWO
MORNING	Introduction	Introduction
	Research Ethics	Research Ethics
BREAK		
MID-MORNING	Objectives of Vendor study	Objectives on Consumer study
	Question and answer	Question and answer
LUNCH BREAK		
AFTERNOON	Filling of questionnaire	Filling of questionnaire
	Question and answer	Question and answer
EVENING	Departure	End of training