

Sudan University of Science and Technology
College of Graduate Studies

**Assessment of Food-Safety Status of Street-Vended Foods in Khartoum
State - Sudan**

تقويم مدي سلامة الأغذية المباعة في الشوارع بولاية الخرطوم - السودان

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Dedication

I dedicate my thesis to my mother mainly and to my family. I also dedicate this to someone who is my source of strength and inspiration.

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Above all, praise is to my almighty Allah for giving me a good health, wisdom, ability, and strength to carry out this work and for all other graces.

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Abstract

This study was conducted to evaluate food safety in street-vended foods in Khartoum city: any assessment of bacteriological profile and the factors that contribute to food contamination, using standardized survey tool containing 41 questions to test food safety knowledge and the practices about 30 street vendors in the study.

The analysis of demographic characteristics revealed that the all participants were females and the majority of age group of 31- 40 years (53.3%) most of the vendors were with illiterate education (46.7%) and most of them were unmarried (60.0%). Concerning health and personal hygiene knowledge, these people agree that one of the most important responsibilities of the food handlers is washing hands to food safety measures (56.7%). Most of respondents failed to identified terms of food-borne disease.

Seventy five (75) swap samples of different site were taken from hands of workers, knives, dishes, foods and surfaces of food preparation and taken in sterile containers. Bacterial total viable count (TVCs) was carried out. The result of the TVCs revealed statistical significance difference of all samples site ($p > 0.05$). Isolation and identification of bacteria in different sample site were *Salmonella* spp, *Staphylococcus* spp, *Echerichia coli* and *Streptococcus* spp. The saving of food hygiene is very difficult to practice on street in setting where resources are scarce and surroundings are of low environmental and sanitary standards.

ملخص البحث

اجريت هذه الدراسة لتقييم مدى معرفة وممارسات الباعة المتجولون بسلامة الاغذية وكذلك لتقييم مستوى التلوث الجرثومي والعوامل المرتبطة به في مدينة الخرطوم, بالسودان وذلك بأستخدام استبيان يحتوى على عدد واحداً واربعين سؤالاً لاختبار معرفتهم وممارساتهم الصحية المرتبطة بالاغذية, حيث كان عدد المشتركين في الدراسة ثلاثون من الباعة المتجولون. وقد اظهرت نتائج الدراسة ان جميع المشتركين في الدراسة هم من الاناث وان غالبيتهم (53.3%) تتراوح اعمارهم ما بين (31-40) سنة حيث تمثل نسبة غير المتزوجين منهم (60.0%) وتقدر نسبة الحاصلين منهم على تعليم اولي بـ(46.7%) فيما يتعلق بمعرفتهم بالصحة والنظافة الشخصية من ضمن كل المشاركين في الدراسة (56.7%) منهم يدرك ان غسل اليدين مهم للغاية بالنسبة للذين يتعاملون مع الاغذية, معظم المشاركين فشلوا في معرفة مصطلحات التلوث الغذائي والامراض المنقولة بواسطة الغذاء الا ان بعض منهم اظهر مقدرة في التعرف علي مصطلحات التلوث الغذائي والامراض المنقولة بواسطة الغذاء.

ايضا اشتملت الدراسة على تقييم مستوي التلوث الجرثومي للغذاء حيث تم اجراء تحليل معلمي لعدد 75 عينة اخذت من اماكن مختلفة شملت ايدي العمال, السكاكين, الصحون التي يقدم فيها الطعام, الطعام المعد والجاهز للاكل والاسطح التي يتم فيها اعداد الطعام وذلك بأخذ مسحة من كل مكان ووضعها في حاوية معقمة تمهيداً لنقلها الي المختبر لاجراء اختبارات لعزل البكتريا والتعرف علي انواعها وعد الخلايا الحية في العينات, حيث اظهرت نتائج عد البكتريا احصائياً عن وجود اختلاف معنوي في العينات حسب المكان الذي جمعت منه كما ان انواع البكتريا التي تم عزلها والتعرف عليها في كل العينات هي البكتريا العنقودية(استافيلوكوكس) والبكتريا القولونية العنقودية(اي كولاي) والبكتريا السبحية(استربتوكوكس) وبكتريا السالمونيلا.

عليه فانه من الصعوبة بمكان الحفاظ على صحة الغذاء وممارسة الاشتراطات الصحية على مستوى الشارع وذلك نسبة إلى فقر الخدمات الاساسية في محيط بيئي نو مستوى صحي منخفض.

Introduction

The growing street food sector in low-income countries offers easy access to inexpensive food as well as new job opportunities for urban residents. While this development is positive in many ways, it also presents new public health challenges for the urban population. Street food is defined as, "Ready-to eat foods and beverages prepared and/or sold by vendors and hawkers especially in street and other similar public places (FAO, 1997), this is being adapted by other authors according to local culture (Tinker, 1997; Toh and Birchenough, 2000). It can be found wherever there is heavy flow of people, since their marketing success depends exclusively on location and word-of-mouth promotion (Winarno and Allain, 1991).

Safe food hygiene is difficult new to practice at street level, and outbreaks of diarrheal diseases have been linked to street food. Food-borne illness is a major international health problem and an important cause of reduced economic growth (WHO, 1998). In developing countries, drink, meals and snacks sold by street food vendors are widely consumed by millions of people. These street foods provide an affordable source of nutrients to many sectors of population. The occurrence of food contamination has always been through water, soil, raw materials, place of preparation, cooking utensils, equipments and importantly food handlers (Huq *et al.*,2006; Rane, 2011). According to WHO (1998) food handling personnel play an important role in ensuring food safety throughout the chain of food production, processing, storage and preparation. Mishandling and disregard of hygienic measures on the part of food vendors may enable pathogens to come in to contact with food and in some cases to survive and multiply in sufficient numbers to cause illness in the consumer. In most cases, running water is not available at vending sites, hands and dish washing are usually done in one or more buckets, and sometimes without soap. Waste waters and garbage are discarded nearby, providing nutrients for insects and rodents. Some of the foods are not efficiently protected against flies which may carry food borne pathogens. Safe food storage temperatures are rarely applied to street foods. In addition, there is potential health risks

associated with initial contamination of foods by pathogenic bacteria as well as subsequent contamination by vendors during preparation and through post-cooking handling and cross contamination. Outbreaks of food borne diseases are caused by foods that are contaminated intrinsically or that become contaminated during harvesting, processing or preparation (Torok *et al.*, 1997). In most countries, the most common food-borne illness is Staphylococcus food intoxication (Talaro *et al.*, 1996). Enterotoxigenic Staphylococcus strains and *E. coli* strains have been isolated from food implicated in illnesses (Adeyiwu, 1995, Firstenberg and Sullivan, 1997; Cencil *et al.*, 2003). *E. coli* and *S. aureus* are normal flora in human handling and animals, their presence in foods are indications of excessive human handling (Adamolekun and Adamolekun, 1992). *S. aureus* is a gram positive coccus, resistant to heat, drying and radiation. Its strains can be pathogenic and relatively non pathogenic. They produce disease when the bacteria contaminate food. They produce some enzymes which are implicated with staphylococcal invasiveness and many extracellular substances some of which are heat stable enterotoxins that render the food dangerous even though it appears normal (Prescott *et al.*, 2005). Once the bacteria have produced toxin, the food can be extensively and properly cooked, killing the bacteria without destroying the toxin. Many of their toxins are gene-based that is carried on plasmids. The intensity of the signs and symptoms may vary with the amount of contaminated food ingested and susceptibility of the individuals to the toxin.

Today, street food has become one of the major concerns of public health] and a focus for governments and scientists to raise public awareness. Hence, taking these factors into account this study was undertaken to assess the bacteriological profile and the factors that contribute to contamination of various street- vended foods consumed lavishly at street sides in Khartoum city.

General Objective

The purpose of this study was to assess the different parameter's associated with the hygiene and safety of the food prepared and sold in the streets of Khartoum.

Specific Objectives

The present study was being carried out:-

1. To identify the critical points of food contamination during preparation.
2. To determine bacterial number (total viable counts) and evaluate microbial contamination in street food.
3. To isolate and identify bacteria at different check points.
4. To investigate some practices that contributes to food contamination.

Chapter One
Literature Review

1.1. Street food

Food and green groceries are available on the street for a fraction of the cost in a restaurant or a supermarket (FAO, 2007). This food is termed as ‘street food’ and the consumption is common among those in the low socio-economic bracket (Mensah *et al.*, 2002). Street food is obtainable from a street side vendor, often from a makeshift or portable stall (FAO, 2007). Some street foods are regional, while others have spread beyond their region of origin (FAO, 2007). The food and green groceries sold in farmers' markets may also fall into this category, including the food exhibited and sold in fairs such as agricultural show and state fair (FAO, 2007). Most street foods are both finger and fast food.

Finger food is food eaten directly using the hands, in contrast to food eaten with a knife and fork, chopsticks, or other utensils (Kay, 1999). Fast food is food that can be quickly prepared and served (Jakle, 1999).

1.2. Importance of Street Food in Urban Areas

In developing countries, a large proportion of ready to eat foods are sold on the street (Mensah *et al.*, 2002). According to the Food and Agriculture Organization, 2.5 billion people worldwide eat street food every day (FAO, 2007). Increased reliance of street food has been identified as one of the characteristics of urban food distribution systems driven by changes in the urban way of life and poverty in developing countries (FAO, 1998). Street foods have already become a common feature of urban life (Hilda, 2002). The increasing poverty and time constraints to survive in developing countries indicate that the street food phenomenon will only increase (Hilda, 2002). With the increasing pace of globalization and tourism, the safety of street food has become one of the major concerns of public health, and a focus for governments and feeds millions of people daily with cheap and easily accessible food (Latham, 1997). Increased reliance on street food has been identified as one of the characteristics of urban food distribution

systems, driven by changes in the urban way of life and poverty in developing countries (FAO, 1998).

1.3. Nutritional Benefits of Street Food

The street food industry plays an important role in developing countries in meeting the food demands of the urban dwellers (Latham, 1997). Street foods play significant nutritional role for consumers, particularly for middle and low-income sectors of the population, who depend on street foods for their main food intake (Mensah *et al.*, 2002; Dardano, 2003). FAO reports that street foods provide nutritionally balanced diets, sufficient in quantity and presenting options for variety and choice for consumers, particularly from middle and low-income sectors of the population, who depend heavily on them (FAO, 1997).

The contribution to the daily food intake of poor urban dwellers is scarcely quantified in energy and nutrients (Hilda, 2002). The foods have been shown to contribute a substantial proportion of the daily requirement of energy and protein (25%-50%) for adolescents attending schools (Oguntona and Kanye, 1995) and urban market women (Oguntona and Tella, 1999) in Nigeria. They are reported to play a considerable role in the daily diet of low-income male urban workers in Hyderabad (Sujatha *et al.*, 1997), urban construction workers in Nairobi (Korir *et al.*, 1998) and Calcutta street traders (Chakravarty and Canet, 1996). Their nutritional value however depends on the ingredients used and how they are prepared, stored and sold.

1.4. Economic Benefits of Street Food

The street food industry offers a significant amount of employment, often to persons with little education and training (Latham, 1997). Street food in Nairobi provides a substantial amount of income for most vendors, with most of them earning an income above the official minimum wage while some of them earn twice or more of this amount (Mwangi, 2002). Street food operations sometimes involve the entire family in the procurement of raw materials, preparation and cooking of the meals (Mensah *et al.*, 2002). The role of women in the sector is significant, as

they control a large share of market activity and commodity trading (Mensah *et al.*, 2002). Street food vendors benefit from a positive cash flow, often evade taxation, and can determine their own working hours (Mensah *et al.*, 2002). In selling snacks, complete meals, and refreshments at relatively low prices, they provide an essential service to workers, shoppers, travelers, and people on low incomes. However, the people who depend on such food are often more interested in its convenience than in questions of its safety, quality and hygiene (Mensah *et al.*, 2002; Muinde and Kuria, 2005).

1.5. Preparation of Street Food

Street food is prepared by the vendors at home or at the road side stalls (Muinde and Kuria, 2005). Vendor's sites are mostly within five to metres radius of dusty roads and foot paths (Mwadime, 2001). The vending sites are self-allocated and not varnished with sanitary amenities (Mwangi, 2002). Foods are held in different ways before selling; fish are placed openly on the stalls and chips are held in cup boards next to the stalls while fruit salads are held in open bowls (Muinde and Kuria, 2005). After the food is prepared, it is not reheated to high temperatures before serving (Muinde and Kuria, 2005). The stalls are poorly constructed and increase the exposure to contamination by dust and smoke on the road side (Muinde and Kuria, 2005). Street vendors use tap water supplied from the municipal council or buy from water kiosks (Mwangi, 2002; Mwadime, 2001). In other instances water is ferried from home of the food vendors because there is no portable water available in their area of operation. This water is not enough for dish washing and food preparation and vendors do not wash fresh foods properly (Muinde and Kuria, 2005). Mensah (1999) noted that without formal education, the street food vendors lack knowledge on proper food handling and may play a role in transmission of food borne pathogens.

1.6. Knowledge, Attitudes and Practices (KAP)

The relationship between knowledge, attitudes and behavior is often explained through the (KAP). Knowledge accumulates through learning processes

and these may be formal or in formal instruction, personal experience and experiential sharing. It has been traditionally assumed that knowledge is automatically translated into behavior (Glanz *et al.*, 2002). However behavior change theorists and experiences in the HIV field have indicated that knowledge alone does not appropriate behavior modification.

Knowledge however is not insignificant and it is found to be vital in the cognitive processing of information in the attitude-behavior relationship.

Attitude involves evaluative concepts associated with the way people think, feel and behave.

It comprises a cognitive, emotional and a behavioral component implying what you know, how you feel and what you do (Keller, 1998). It has also been postulated that attitudes may influence one's intention to perform a given behavior or practice (Rutter and Quine, 2002). They are thus correlated with behavior, for instance if a personal has a positive attitude towards appropriate hand washing, they are more likely to wash their hands.

However, some social scientists have argued that KAP surveys are not necessarily adequate or sufficient to provide information especially for programmatic planning. It is argued that critical elements relating to a variable may not be captured in the use of a questionnaire and that in depth information gathering using qualitative methods may be additionally beneficial in eliciting information, as surveys fail to explain the logic behavior (Launiala, A. 2009). Another concern is that there is an assumption that there is direct relationship between knowledge and behavior.

In health related studies, however, it has been found that knowledge is not the only factor that influences treatment seeking practice and in order to change behavior, health programs need to address a number of issues including socio-cultural, environmental, economical and structural factors.

Behaviorists further add that a number of factors can influence one or more of the KAP variables such as self esteem, self efficacy and misconception. A few

studies have looked at this aspect of behavior change, including behavioral models in food handler training.

1.6.1. KAP on Food Safety and Foodborne Diseases

Contaminated food and water have been known to be sources of illness in human societies since antiquity. Foodborne diseases are still among the most widespread health problems in the contemporary world. In rich and poor countries alike, they pose substantial health burdens, ranging in severity from mild indisposition to fatal illnesses. However, the burden of foodborne disease is not well defined globally, regionally or at country level (Jayasuriya, 2003).

Estimates of the burden of food-borne disease are complicated by the fact that very few illnesses can be definitively linked to food. Often these links are only made during outbreak situations. The extent of the problem is however unknown as food-borne diseases often go undetected or underreported. The current estimates of 1.8 million deaths, only represent the tip of the iceberg (WHO, 2007).

Studies determining the burden of acute gastroenteritis provide the basis for estimating the burdens due to food and specific pathogens commonly transmitted by food (Tomlins, 2002).

Although acute gastrointestinal diseases are not all food-borne diseases do not always result in acute gastroenteritis, food does represent an important vehicle for pathogen causing acute gastroenteritis. Obtaining global estimates is further complicated in that when data obtained from various countries are pooled to derive regional or global estimates, the influence of the study design and existing surveillance systems on those estimates have to be considered (Maxwell, 2000).

In relation to study design it is evident that prospective and retrospective study designs yield different disease estimates. Prospective cohort studies have community and etiologic components, and retrospective study designs are cross-sectional surveys with or without supporting incidence rates that are pathogen specific. In cross sectional surveys, investigators ascertain the prevalence of self reported acute gastroenteritis among person in the community during a set period of

time. For example, in a retrospective study conducted in the United Kingdom, an incidence of 5.5 cases per person-year was calculated. However, a subsequent prospective study indicated a calculated incidence of almost 3 times that as calculated by the prospective study (Infectious Intestinal Diseases Study Team, 2000).

The retrospective estimate of foodborne diseases burden was similar to previous estimates from retrospective studies conducted in the United Kingdom, Australia, Canada, Ireland, and the United States (Feldman and Banatvala, 1949). Conversely, the prospective estimates from the English study are similar to prospective estimates from a study conducted in the Netherlands. Reasons for the differences between study designs have been attributed to recall bias or telescoping.

A more thorough examination of the effect of study design on disease estimates would be needed prior to a comparison of data from national studies. Inferences can be made regarding the enormity of the problem, when looking at estimates of the incidence of acute gastroenteritis during childhood, in that an important proportion of cases are caused by food-borne pathogens. The FAO estimates that as much as 70% of diarrheal diseases in developing countries are believed to be food-borne origin (FAO, 2006).

The World Health Organization (WHO) recognizes that food born diseases include a wide spectrum of illnesses which are a growing public health problem worldwide and are a major contributor to illness, compromised nutritional status, less resistance to disease and loss of productivity. The globalization of the food supply system has presented new challenges for food safety and has contributed to the international public health problem of food-borne disease. This is attributed to the growing industrialization and trade of food produce, rapid urbanization associated with increased food preparation and consumption outside the home and the emergence of new or antibiotic-resistant pathogens and food vehicles (WHO, 2003).

To initiate and sustain efforts aimed at preventing foodborne diseases at national and international levels, the magnitude of the problem need to be determined. In light of the data gaps relating to the true burden of foodborne diseases and its impact on development and trade, the WHO have embarked in 2010 on a global initiative to estimate the global burden of diseases in conjunction with multiple partners (WHO, 2010).

A study to assess knowledge, attitudes, and behavior concerning foodborne diseases and food safety issues amongst formal food handlers conducted in Italy found that the majority of food handlers who had attended a training course had knowledge and a positive attitude towards foodborne diseases control and preventive measures (Mensah, 2001).

The positive attitude was not supported when asked about self-reported behaviors and when observed during food preparation for practice of hygienic principles. This was on the basis that only 21% used gloves when touching raw, unwrapped food. Predictors of the use of gloves were educational level and attending courses. The authors suggested that emphasis should continue on improving knowledge and control of foodborne diseases amongst food handlers. In Malawi, a study on the KAP on food hygiene of caregivers also showed a poor relation between knowledge, behavioral and sanitary practices, as swabs from caregivers, hands and food tested positive for coli forms and *E. coli* (King, 2000).

Furthermore in study conducted in Mauritius on 50 street food vendors, it was reported that despite the efforts of health inspectors in promoting the risks of poor hygiene practices, and an awareness of hygienic conditions, the majority were not putting their knowledge into practice as they perceived their products to be of low risk. The authors attributed this to lack of knowledge and recommended a need to strengthen the educational program (Olsen, 2005).

Mukhola (1998) in assessing the factors influencing the safety and quality of street food in a rural area in Limpopo examined the knowledge, attitude and perceptions in both street food vendors and consumers. Her findings indicated that

the majority of street food vendors and consumers had little information regarding the proper preparation and storage of food as well as environmental conditions that may be detrimental to health. Furthermore 64.4% of consumers thought that street food is sold under unacceptable conditions and these needed improvement.

Based on the literature reviewed, many of the studies have been conducted on the formal sector; there is limited information on the effectiveness of training conducted on street food vendors. It is therefore very important to explore the KAP of street food vendors in order to allow for a better understanding of these variables in street food vendors in relation to food safety (Hansen, 2003).

1.6.2. Trade in Street Foods

Due to socioeconomic changes in many countries, the street food sector has experienced phenomenal growth in the past few decades. Urbanization and population growth are expected to continue and street-vended foods, which are largely but not exclusively an urban phenomenon, will expand accordingly (Atkinson, 1992). Street food trade has emerged as an economic activity and a source of income for the poor in many developing countries. Street foods are also considered essential for maintaining the nutritional status of the population.

In a longitudinal study conducted in Ghana, street food accounted for 19-27% of food expenses and provided 134-417 kcal per day per person (Bendeck, 2000). Street food vending assures food security for low-income urban populations and provides a livelihood for a large number of workers who would otherwise be unable to establish a business. The benefits of this trade extend throughout the local economy as often vendors buy their ingredients locally. Various projects have shown that street food trade generates a large volume of business, involving large amounts of money and provides a competitive source of employment and income to millions of people (FAO 1997, Garrett 2000).

The FAO estimates that there are approximately 100,000 vendors in Malaysia whose collective total annual sales amount to over \$2 billion. In a survey conducted in Accra, Ghana, the street food sector was shown to employ over 60,000 people

with an estimated turnover of US \$100 million. Street food is defined by the Food and Agricultural Organization (FAO) as ready-to-eat foods and beverages prepared and sold by vendors and hawkers in streets and other similar public places (FAO, 1997).

The central characteristic of street foods in this definition is their retail location, namely, that they are sold on the street and it is this that categorizes them as part of the informal sector (Frewer et al. 1996). To differentiate street food vendors from formal sector food establishments, such as restaurants, (Tinker 1997) adds a further qualification that street foods are sold on the street from “pushcarts or baskets or balance poles, or from stalls or shops having fewer than four permanent walls.

Thus those who manufacture and/or sell street foods are micro-entrepreneurs forming part of the so-called informal sector. In light of this, the informal sector is not enumerated by official data collecting agencies, and thus official statistics on the street food trade are virtually non-existent.

Street foods are a heterogeneous food category, encompassing meals, drinks, and snacks. They are mass consumer foods that are normally eaten without further processing or cooking. Street foods show variation in terms of ingredients, methods of processing, and consumption. Street food trade usually involves both retail and production activities, although the sale of street foods is the most visible part of the trade. Most street foods have been processed to some extent, much of which may have occurred unseen off-street. Because of this, the trade should be seen as part of the whole food system, rather than just as a service or retail activity (Rosen, 1993).

1.7. Street Food Vendors

A number of studies have examined the characteristics of vendors and have found that street food vendors do not form a homogenous group, but differ according to various socio-economic and demographic criteria. With regard to mode of selling, vendors can be broadly classified into stationary and ambulatory. It has been found that stationary vendors, who sold their wares from small stalls, kiosks,

and so forth, were the predominant type in most of the countries studied (Tanker, 1997).

Ambulatory vendors refer to those that push carts around selling their products. Most vendors operate from selected strategic locations, including bus and train stations, markets and shopping areas, commercial districts, outside schools and hospitals, residential suburbs, factories, and construction sites. In some places, it appears that vendors tend to concentrate in downtown commercial areas, but various country studies have shown this to be the exceptional in all locations except in Bangladesh and Thailand (Curtis, 1998). Nigeria, 23 percent of vendors were located in residential areas. It is also postulated that street-food vendors, owing to their lack of or no education as well as being poor, lack an appreciation for safe food handling. Consequently, this together with the surroundings that they are prepared and sold in, street food is perceived to be a major public health risk (Green, 1999).

1.7.1. Safety of Street Foods

The main health hazard associated with street foods is microbial contamination, although pesticide residues, transmission of parasites, the use of unpermitted chemical additives, environmental contamination and limited access to safe water have also been identified as possible hazards. The potential for the contamination of street foods with pathogenic micro-organisms has been well documented and several disease outbreaks have been traced to consumption of contaminated street foods (Azanza et al., 2000).

The risk of microbial contamination is dependent on the type of street food and how the food is prepared. Food risk is influenced by food type, pH, and method of preparation, water availability, handling, exposure temperature, and holding time. In general, cereal and bakery products with low moisture content, products that have been adequately sugared, salted, or acidulated, and some fermented products are less likely to support bacterial growth as opposed to dairy, egg, and meat products. Dishes containing raw ingredients or made with ice are also high risk items (Annor and Baiden, 2011).

Food that are cooked immediately prior to consumption are safer than those which have been cooked and stored at ambient temperature. Other factors implicated in causing microbial contamination include poor food preparation and handling practices, inadequate storage facilities, the personal hygiene of vendors, and a lack of adequate sanitation and refuse disposal facilities. In Ghana, in a study that investigated the microbial quality of street foods sold in Accra, *Shigella sonnei*, enteroaggregative *Escherichia coli* and *Salmonella arizonae* were the pathogens isolated from some food samples (P. Feglo and K. Sakyi, 2012).

In Ethiopia, a similar study isolated *Bacillus* spp. *Staphylococci* and *Micrococci* as the dominant groups in some foods. The health risk from street foods may be no greater than that posed by foods or dishes from other sources such as in restaurants (Shlim, 2005).

Two studies conducted in India found that the microbial quality of street foods was equivalent to, if not better, than that of foods bought from hotels and restaurants. In South Africa, a comparative study found no significant difference between 116 formal and informal food vendors regarding microbiological food quality. With regard to potential risk, formal vendors had more vending experience, used some precautions in food preparation and had better hygiene practices (Aycicek, 2004).

However, whilst food from the informal vendors was hot, food from formal food vendors tended to be cool and 73% stored leftovers for sale the next day, both of which are potential risk for microbiological contamination (Dorothy Yeboah-Manu, 2002).

1.7.2. Risk Factors associated with Street Foods

Street vended food has become a major public health issue worldwide and perceived to be major source of foodborne illness, due to lack of basic food safety knowledge and practices of the vendors. Rane, (2011) mentioned that the major sources contributing to microbial contamination are the place of preparation, utensils for cooking and serving, personal hygiene, raw materials, food preparation,

storage and reheating, time and temperature abuse of cooked foods, and waste disposal.

(a) Food handlers and personal hygiene

Personal hygiene is an important factor in food safety, maintaining a high standard of personal hygiene most importantly hand washing, would lead to protect food contamination and spread of microorganism (Aycicek *et al.*, 2004).

A number of diseases can be prevented by adopting good practices of personal hygiene. Performing correct personal hygiene practices could lower the risk of diseases and play important role in preventing the spread of them (Shlim, 2005).

However, handlers are consider as contributing risk factor in food contamination and transmission of food-borne disease to consumers. Research has indicated that most of foodborne illness outbreaks occurred in food service establishments is attributed to poor preparation practices and food handlers (Jones and Angulo, 2006; Brackett, 1999). Fawzi *et al.* (2009) reported inappropriate hygienic condition, only (3.4%) of the food handlers who practiced proper hygiene, most of the handlers did not practice proper hand washing technique and (93.1%) failed to avoid contamination from taps after hand washing. Poor personal hygiene would lead to food contamination with oral fecal parasites and spread of the diarrheal diseases. Idowu and Rowland (2006) assessed the level of personal hygiene among street food vendors and possibility of food contamination with eggs and cysts of parasites, they found that 97% of the vendors infected with parasites, only 3% free from parasites, toilet facilities represent 75%, only 25% had water and hand washing done without soap. Therefore, it is important to educate food handlers and encourage them to stop working when suffering from diarrhea, vomiting, jaundice, fever, sore throat, and discharges from ear, eye, or nose. Personal hygiene is principle of maintaining cleanliness and removal of dirt, soil, food residue and objectionable body odors. According to FAO, 1997) every food vendors the business should: 1) wear identification tag if issued by relevant authority, 2) dress

clean protective clothing such as apron, and clean all parts of the body, 3) refrain from unhygienic practices, such as smoking chewing gum, sneezing, coughing, touching body orifice during preparation or storages, 4) change apron when it becomes soiled, 5) avoid wearing jewelry, keep nail short so they are easy to clean, and regularly hand washing with soap and clean water.

(b) Hand washing

Hands are important vehicle to cross-contaminate foods from food contact surfaces, utensils and cooking equipment. Maintaining a high standard of personal hygiene is an important way to prevent such contamination (Sneed *et al.*, 2004). Organisms reside in gut can be transferred to food through hands after failing to apply correct hand washing. Effective hand washing with soap and water is most important to eliminate biological and chemical hazard and preventing the spread of pathogens (Miller *et al.*, 2009).

Correct hand washing with soap and water is a vital to reduce the spread of infection specially in high risk areas, and could be prevented a high proportion of cases during outbreaks (Hultin and Luby, 2003). Proper hand washing technique can reduce diseases spread through fecal-oral transmission, diseases spread through indirect contact with respiratory secretion, urine, saliva or any of the moist body substances, a study on 27 public school in Brazil to assess the hygienic practices of food handlers, found that all the handlers did not practice proper hand hygiene, 55.6% of them their hands contaminated with fecal coliform, and 51.9% were not subjected to medical examination (Campos *et al.*, 2009). It is necessary that food handlers practice hand washing with soap and clean water after engaging in activities which could introduce biological and chemical or physical hazards, hand should be washed when entering the food handling area after handling raw foods, visiting the toilet, holding garbage, touching animals, holding money and contact with toxic substances such as pesticides and disinfectants (WHO, 1996). According to WHO, (2009), hand washing technique with water and soap should: 1) takes 40-60 second, 2) first wet hands with soap rub together, 3) apply soap and rub hands

(palm to palm- right palm over left dorsum- palm to palm with fingers), 4) wash front and back, between fingers and under nails, 5)rinse hand with water, 6) dry hands with clean towel, and 7) turn of faucet with towel.

(c) Raw materials

Food can be contaminated at all stage of food chain from harvest or slaughter to final preparation and serving. Raw material is critical point and contributing factor to foodborne disease. Raw food materials like meat, poultry, sea food and their juices containing harmful microorganism that may transferred to food during preparation and storage and poses potential health risk. In most cases mean bacterial counts of raw materials were higher than cooked food (Mosupye and Holy, 2000), this attributed to the fact that raw foods may expose to pathogens or toxins at production sites, for instance meat can be contaminated in slaughtering stage, vegetables can be contaminated from irrigation water, soil and residues of fertilizers or pesticides in farms. In addition to that excessive delay during transport can increase time for microbial grow and natural process to occur, as well as physical damage during transport enable microorganism to access nutrient-rich underlying tissues, where they can grow rapidly (Adams and Nout, 2001). As stated by Islam et al, (2010), raw foods are ready contaminated by fecal materials, out of (213) raw food sample including raw meat, raw milk and fresh juices sample, were found positive for shiga toxin producing by *E. coli*. Deng *et al.* (2011) also found in their study a high concentration of Aluminum exceeded the standard upper limit of food in some raw food and food additives.

One of the most important principles in food safety is separation between raw and cooked foods, as well as use of separate equipments, knives, and cutting board, for handling raw foods during processing and storage to avoid recontamination (Reij, 2004). In section and hand sorting for raw food help to mitigate hazards, reducing contamination, and assuring that food would meet elements of quality and safety (Frank Devlieghere, 2013).

Raw materials should be stored in a way to protect them from contamination and deterioration of the food, in refrigerator food should be stored in small containers on the top shelf of the fridge to keep leaks from contaminating stored food (Henson and Traill, 1993).

(d) Water and Ice

Water is critical point in street food, and can be contaminated at the source in many ways or during storage. Such contaminated water poses threat to public health when it uses for drinking, cooking, processing of food, washing equipment and hand washing. Mutable researches stated that water is risk factor for endemic diseases and implicated in many outbreaks of human diseases, both in developed and developing countries (Baldursson and Karanis, 2011). Consequently use of safe water in vending operation is very important issue in food safety and can reduce the risk of waterborne diseases. In the street vending sites potable water must be used for drinking purpose and preparation of foods or beverages, running water must be available at close distance. On the other hand freezing does not remove chemical and biological hazard, contaminated ice can be a major contributor to transmission of waterborne disease, thus ice should be given from approved source, protected from cross contamination, moreover transported and stored in sanitary conditions (Adams and Nout, 2001).

(e) Preparation and processing

Preparation is set of methods aim to transform food or raw ingredient to food for human consumption, according to FAO (2004), food preparation and processing is defined as any change happened to food by heating, milling, grinding, smoking, mixing, coating, cutting, drying, to alter it is eating quality or shelf life. Proper preparation and processing techniques are essential to ensuring the safe of street vended-food. Preparation and processing operations should be adequate to eliminate or reduce hazards to an acceptable level, control of pathogen growth, and prevention of physical and chemical hazards (Simopoulos and Bhat, 2002). However, preparation and processing in unhygienic environment in a presence of infected food

handlers, are contributing factors to foodborne diseases and incidence of severe outbreaks like Cholera (Rabbani and Greenough, 1999). Furthermore, place of preparation, raw materials, utensils for cooking and serving, preparation of foods in advance of consumption, storage at ambient temperature, and time-temperature abuse in cooling or reheating are important issues and major sources for food contamination and foodborne diseases. Muyanja *et al.* (2011) shed light on risk factors associated with street vended food in Kampala by investigating a total of 225 street food vendors the results revealed that vendors failed to practice proper food handling in preparation of foods, running water was not available, improper management of waste disposal, food handled at ground level and exposed to flies. Physical methods of food preservation such as heating play important role in food safety. Various forms of heating such as boiling, frying, roasting, are an important methods for killing microorganism in food and ensuring that food is safe. Cooking food to temperature of 75°C for two minutes will kill all bacterial present and help to ensure that food is safe for consumption (WHO,1999). Separation between raw and prepared or cooked food in preparation and processing operation is essential principle to prevent contamination from raw food specially meat, poultry, and seafood to cooked food, such contamination may caused by direct contact or cross-contamination from equipments, utensils, cutting board, knives, surfaces and during storage (WHO, 2006). Washing with safe water for foods to be consumed raw is necessary to reduce contamination to acceptable level, moreover it is very useful for elimination of potential physical hazards. Improper practices regarding thawing frozen foods would lead to foodborne disease. Not only thawing foods in counter at room temperature is unsafe, but also thawing them at hot water may lead to foodborne disease, because of that bacteria have been found in foods before freezing can multiply to sufficient numbers to cause illness, therefore it is important and safe to thaw frozen foods in refrigerator in advance of cooking to ensure adequate cooking USDA (2011).

(f) Handling and storage of prepared food

Cooking and manipulating of food after cooking, storage, holding cooked food and reheating leftovers are critical control point associated with street food vendors Bryan *et al.* (1992). Holding foods after cooking at ambient temperature for several hours reported as risk factors contributing to the occurrence of foodborne illness. El-sherbeeney *et al.* (1985), tested a total of 114 food samples collected from street vendors, the laboratory results showed that 68% of samples had colony count exceeded the acceptable level, 37% was *Bacillus cereus*, 41% positive for *Staphylococcus aureus*, 97% at temperature range of 15-44 when collecting. Bryan *et al.* (1988) reported high colony count of bacteria including *Bacillus cereus* and *E. coli* from cooked food held at room or outdoor ambient temperature several hours during the day and from food held overnight. The most important equipment for keeping foods safe is a refrigerator. It was recommended to refrigerate perishable foods such as fruits, vegetable, meat, poultry, and fish below 5c within two hours after cooking, and place them in smaller quantities in shallow containers at the coldest section of the refrigerator. Proper food storage not only preserves food quality, but also prevents foodborne disease. Inadequate temperature control and ignoring regular cleaning would lead to survival of microorganism on refrigerator surfaces and causes cross-contamination to other foods (Abdalla *et al.*, 2008). The failure to adopt adequate food temperature control is involved in foodborne diseases and incidence of outbreaks. There is therefore a need to maintain good management practices to ensure food safety, the minimum holding temperature for foods to be served hot is not less than 63c, and that for food to be served cold is below 8c to halt or slow down microbial growth especially that foods are likely to support the growth of pathogenic microorganism (Food Standard Agency, 2006). Maintaining food safety and protecting food from contamination during transportation of food is a challenge to street food vendors. Vehicle used for transport food should be cleaned regularly and effectively to remove soil and food residues that may support the growth of pathogenic bacteria, and should not carry animals along with foods to minimize the possibility of contamination. Ackerley *et al.* (2010) reported that five

food safety hazards associated with transportation of food, lack of security for transportation unit or storage facilities, improper holding practices, improper temperature control, improper loading practices and sanitation of equipment, and cross-contamination.

(g) Vending unit, equipment and utensils

Vending unit, equipment, utensils, crockery and cutlery used in food preparation and serving can be source of contamination and causal factors of foodborne diseases when they are not thoroughly cleaned and sanitized (Maori and Nandita, 2010). The design and construction of cooking utensils and equipment is important to allow effective cleaning and sanitizing, they should be designed and constructed from appropriate materials without groove or sculpted surfaces, free from pockets or crevices, and do not release toxic materials or affected by sanitizing agents (WHO, 2002). However, there is potential health risk associated with utensils and cooking equipment when they are misused by street food vendors. Research stated that most vendors didn't renew water for washing and rinsing utensils. Barro *et al.* (2006) evaluated the hygienic status of dish washing water for microbiological assessment, it was found that unacceptable levels of different pathogenic bacteria such as Coliforms, *Staphylococcus aureus*, Salmonella and Shigella in food vending site. Zeru and Kumie (2007) mentioned in their study which conducted to evaluate the sanitary condition of food establishments, a high potential risk of infection in food establishment, 44.3% of the food utensils found with unsatisfactory level of bacterial colony count, 45.5% were found contaminated with coliform. Cleaning and sanitizing of food contact surfaces of equipments and utensils help to reduce contaminating safe food during processing, preparation, storage and serving. Proper manual cleaning process requires three washing bowls, the first bowl containing detergent and soap to remove greases, soil and bacterial film the second bowl for rinsing to remove food particles or washing compound, the third bowl for sanitizing by rinsing in hot water 80c (FAO, 2009).

(h) Point of sale

Following rules of environmental hygiene in the design of the work place, selecting appropriate premises and vending sites, provision of basic sanitary facilities and infrastructures are necessary factors to ensure food safety (Ismail and Abdallah, 2004). Stationary sales points should be designed and constructed in away make them easy to clean and disinfect, able to reduce food contamination and must have adequate supply of water as well as located in a place away from dust , sun, rubbish and sewerages, away from infestation by pets, and not used for purposes other than food. King *et al.* (1998) reported that, out of 160 sell points studied on food safety issues, only 1.8% of the premises met all the hygienic requirements. A study carried out to assess the hygienic conditions in pilgrim catering establishments in regard to location and surrounding environments of food premises in Makkah and Almadinah city Kindom Saudia Arabia, the study revealed that most of the establishments (78%) had violation notes, the surrounding environments were not good in 98% of them, unclean roofs observed in 39% of establishments, cracked and broken walls and flour in 52% of them, doors and windows neither clean nor pest proof in 48% of them, insect traps not enough in 63% of establishments, in adequate cleaning for food utensils and containers in 45% of the establishments and improper waste management in (57%) of the food premises (SFDA, 2006).

However deficiencies in basic hygiene standards and facilities in fast food premises could be a causative agent leading to sever illness and incidence of outbreaks (Giraudon *et al.*, 2009). Therefore, regular inspection and monitoring of food premises is necessary to ensure compliance with basic food hygiene standards.

(i) Waste management

Street food premises must be located away from food preparation, storage, handling and serving area to avoid contamination, as well as supplied by liquid and solid waste disposal system, approved and comply with authority with authority requirements, to ensure that the system able to carrying away the wastes. All solid waste should be removed from working area and disposed in to suitable containers. However failure to dispose wastes and ignoring routine inspection of disposal area

would cause health problems including contamination, bad odor and infestation by pests, flies, insects, rats, and wandering dogs. So the design and the construction of the waste containers should adequately contain the volume of accumulated solid waste and easy to handle for disposal (FAO, 1997).

1.8. Food Contamination

Pests, birds and insect can gain access to food and act as disease carriers or cause physical damage. Depending on nature of the food and storage environment foods are substrates for undesirable microbial growth which causes them to deteriorate and spoil. Spoilage microorganism found in or on food change palatability of foods while others lead to food poisoning if contaminated food is consumed in a sufficient quantity. In general foodborne disease can result from bacteria, moulds and yeasts, their presence depends on appropriate nutrient substrates, sufficient water, suitable temperature, ph, and presence or absence of oxygen. However contaminated foods are pathogenic to human and constitute hazard of food poisoning which include intoxication caused by ingestion of toxins and illness resulting from microbial infection via intestinal tract. The risk often depends on susceptibility of individual consumer, the pathogen and the sufficient dose (Schroder, 2003).

1.8.1. Microbial safety of foods

1.8.2. Food borne diseases

The global incidence of food borne disease is difficult to estimate, but it has been reported that in the year 2000 alone 2.1 million people died from diarrhea diseases (WHO, 2011). Unsafe food causes many acute and life-long diseases, ranging from diarrheal diseases to various forms of cancer (WHO, 2011). WHO estimates that food borne and waterborne diarrheal diseases taken together kill about 2.2 million people annually, 1.9 million of them children (WHO, 2011). The risk of serious food poisoning outbreaks linked to street foods remains a threat in many parts of the world, with microbiological contamination being one of the most significant problems (FAO, 1998). Food-borne pathogens are recognized as a major

health hazard associated with street foods, the risk being dependent primarily on the type of food and the method of preparation and conservation (FAO, 1998; FAO/WHO 2005). In Kenya, incidences of food borne disease outbreaks have been reported each year (MOH, 2003). Virulence coding genes present in the genomic regions known as pathogenicity islands (Hacker and Kaper, 2000). *Staphylococcus aureus* is one of the most prevalent pathogens causing several outbreaks (Veras et al. 2008). *Staphylococcus aureus* is a gram positive, catalase and coagulase positive microorganism (Veras *et al.*, 2008). Contamination of food with enterotoxigenic *Staphylococcus aureus* causes staphylococcal enterotoxins (SEs) intoxication hence the associated symptoms like vomiting and diarrhea. Major serological enterotoxins that have been characterized are: SEA, SEB, SEC, SED, and SEE (Robbins *et al.*, 1977) and recently SEG, SEH, SEI, SEJ, SEK, SEL, SEM, SEN, SEO, SEP, SEQ, and SEU (Letertre *et al.*, 2003; Yarwood *et al.*, 2002). SEA is the most common SE associated with foodborne outbreaks followed by SED. However, the type of SE is not relevant because SEs are very similar in structure and function (Balaban and Rasooly, 2000).

Shiga toxin-producing *Escherichia coli* are a group of bacteria strains capable of causing significant human disease (Richard, 1999). The pathogen is transmitted primarily by food (Richard, 1999). The subgroup enterohaemorrhagic *E. coli* includes the relatively important serotype O157:H7, and more than 100 other non-O157 strains (Richard, 1999). Infection is transmitted primarily by food and less commonly by direct contact or water (Richard, 1999). Shiga toxin is a family of toxins produced by a variety of organisms, including *Shigella dysenteriae* type I and Shiga toxin-producing *Escherichia coli*. These toxins have a cytotoxic effect on intestinal epithelial cells that probably causes the characteristic bloody diarrhea (Richard, 1999). Laboratory identification of *E. coli* O157:H7 is easily performed using specialized media but identification of non-O157 Shiga toxin-producing *Escherichia coli* strains requires detection of the Shiga toxin gene by polymerase chain reaction or DNA probe-for virulence genes *stx1*, *stx2* and *eae* (Richard, 1999).

In 2004, Enterococcusgenustook the place of fecal coliforms as the new federal standard for water quality and public beaches in Hawaii USA. It provides a higher correlation than faecal coliforms with many of the human pathogen often found in city sewage (Jin *et al.*, 2004). Enterococci however do not multiply in water especially in low organic matter. They are less numerous than Escherichia coli (James *et al.*, 2005).

1.8.3. Staphylococcus aureus

It is Gram positive Cocci-non sporing, motile and capsulated. It is formed circular, smooth, shiny surface and often pigmented (golden-yellow) in Ajar medium. It presents in the nose of 30% of healthy people and may be found on the skin. It has tow type of toxins: Enterotoxins type A-E, G.H.I.J. an ingestion of microgram amount of toxin can induce the symptoms of nausea, vomiting, and diarrhea and toxic shock syndrome toxin (TSST-1). Staphylococcus disseminated in pus and dried infected wound, burns, infected skin lesions, sputum and cough from lung of patients with bronchopneumonia. The body of human being and animals are the main reservoir. Acquisition of infection may be exogenous from external source or endogenous from patients own body. Hand washing is important in preventing the spread of the disease. (Greenwood *et al.*, 2007).

1.8.4. Bacillus cereus

It is positive *Bacillus*, motile and lacks the glutamic acid capsule, found on soil, water, and vegetation. It is formed large, grey and irregular colonies. It has been associated with food poisoning and found in raw foods such as rice. It has tow type of food poisoning, the first is vomiting form which occurring within six hours of ingestion. The second is diarrheal form of food poisoning which occurring within 8-24 hours after ingestion similar to enteritis caused by E.coli and salmonella. Proper cooling and good storage of foods would prevent food poisoning caused by Bacillus cereus (Greenwood *et al.*, 2007).

1.8.5. *Streptococcus* species

Streptococcus is a genus in the family *Streptococaceae*. Some species were reported to be associated with the upper respiratory tract of man and other animals causing scarlet fever and septic sore thorax (Mead, 1982). Others were in the intestinal tract of man and animals. They were described as Gram-positive, catalase-negative cocci producing small colonies within the mesophilic and psychrophilic (Mead, 1982).

1.8.6. *Campylobacter jejuni*

Campylobacter is widely spread in nature and is isolated from wild and domestic animals as well as from the environment. Poultry is a major reservoir of *Campylobacter jejuni*. Many commercial poultry flocks appear to be symptomless carriers of *C. jejuni*, with up to 107.g-1 of gut content being demonstrated in the ileum and caeca of infected poultry and similar levels in the feces (Genigeorgis *et al.*, 1986; Mead, 1989; Zottola and Smith, 1990). Some poultry flocks that are negative before slaughter will therefore become contaminated during processing. *Campylobacter* is micro aerophilic with a relative high minimum growth temperature (30°C) and there seems little likelihood of them multiplying in the processing plant or on the raw, processed product (Mead, 1982).

The main problem in processing is that of cross-contamination (Zottola and Smith, 1990; Smeltzer, 1981). *Campylobacter* species are more sensitive than many other organisms to the adverse effects of environmental conditions (drying, freezing and cold storage). For this reason, attention has been given to factors influencing the survival of *Campylobacters* in processing (Mead, 1982).

Although freezing is harmful to *Campylobacter*, it does not eliminate this organism from poultry. Nevertheless, the contamination rate tends to be higher in fresh than in frozen carcasses. *Campylobacter* spp. are also more sensitive to chlorine than *E. coli*, but are not eliminated from poultry carcasses by immersion chilling in chlorinated water. On the contrary, cooling-water seems to be an important reservoir of this organism: 100-3000 CFU.ml-1 were demonstrated and

survival over long periods at low temperatures is possible. *Campylobacter* was also isolated from air samples as well as equipment (Cunningham, 1987; Mead, 1989; Zottola and Smith, 1990).

1.8.7. Salmonellosis

It has been increased within the past 20 years on many continents. Investigations of salmonella outbreaks revealed that its emergence is attributed to contact with birds and eating different foods of animal origin particularly meat, pork, poultry, dairy product and eggs from hens whose ovaries are infected by the organism (Potte et al., 1997). Salmonella can also lead to reactive arthritis, serious infections and deaths. The largest outbreak occurred in the Chicago area in 1985, involving over 16,000 laboratory-confirmed cases out of 200,000 cases (Shays, 1996).

Enterobacteriaceae .1.8.8

Enterobacteriaceae are a large family of Gram-negative rods, grow under aerobic or anaerobic conditions and do not form spores. In addition to that they constitute part of the human and animal flora and colonize the lower gastrointestinal tract of humans and animals. *E. coli* are the most common species of this group followed by *Klebsella*, *Proteus* and *Enterobacter* species (Janda and Abbott, 2006).

(a) Escherichia

Escherichia is a genus of the family Enterobacteriaceae. It is described as a coliform of the intestinal tract of man and other animals from which it might be found in soil, water and many other places in nature. *E. coli* and *Aerobacter aerogenes* are known as Gram-negative, short rods, lactose fermenters. *E. coli* was reported as the most important entero-pathogenic coliform and differentiated from *A. aerogenes* by IMVIC reaction. This common lactose fermenting faecal genus is shown to have serotypes pathogenic for humans. They are frequently reported in the literature and are known as entero-pathogenic *E. coli* (EPEC). Certain serotypes of *E. coli* produce food-borne disease (Mead *et al.*, 1993; FAO, 1997).

(b) *Klebsiella*

Klebsiella is a genus of the family *Enterobacteriaceae*. This genus is Gram-negative rods, non-motile, capsulated, aerobic and facultatively anaerobic, catalase positive, oxidase negative and attacked sugars fermentative. This genus is among the infections due to miscellaneous micro-organisms. *Klebsiella* was the predominant flora in faecal samples from outbreak of poisoning involves 30 students (Riemann, 1969).

(c) *Proteus*

Proteus is a genus of the family *Enterobacteriaceae*. This species is found in the intestinal tract of man and animals. They are Gram-negative, motile, urease -positive. *P. vulgaris* and *P. morganii* produce hydrogen sulphide in abundant quantities, to liquefy gelatin and to swarm on moist agar. Outbreaks of food poisoning were ascribed to *Proteus* (Riemann, 1969; Mead *et al.*, 1993).

1.8.9. *Pseudomonas*

Pseudomonas is a genus of the family *Pseudomonadaceae*. The species is widely distributed in nature in soil and water, plants in the intestinal tract of man and other animal. These were found to be the most important bacteria in the low temperature spoilage of food such as meat and poultry. They were motile and non-motile Gram-negative rods producing water-soluble pigment causing metallic sheen. An epidemic involving 409 cases of acute enteritis were reviewed *P. aeruginosa* was isolated from many patients (Riemann, 1969).

1.8.10. *Listeria monocytogenes*

It is an aerobic Gram-positive bacterium, widely distributed found in raw and unprocessed food product such as meat, vegetables, dairy and appetizers that consume without further heating. Outbreaks often associated with the consumption of contaminated coleslaw, soft cheese, hot dogs, soil, food product both of animal and vegetable origin, water and sewage. In addition to that it can be carried by almost any animal species and asymptomatic humans cause acute gastroenteritis. The emergence of listeriosis is a result of complex interactions between various

factors that reflect changes in social patterns like the increased use of refrigerators for preserving foods and the increased in consumer demand for street foods. Unlike other foodborne pathogens listeria tend to multiply in refrigerated foods and it is associated with high case fatality rate (20-30%), therefore it ranks among the most frequent causes of foodborne death (Shabbir, 2007).

***Clostridium botulinum* .1.8.11**

Botulism is a rare and fatal disease caused by neurotoxins (BoNTs) produced by *Clostridium botulinum* which results from either ingestion of preformed BoNT in foods contaminated by bacteria or production of BoNT after colonization of bacteria in intestine. Outbreaks of botulism are often associated with home preservation practices such as canning, bottling, preservation in oil, and long shelf-life (Shabbir,2007).

1.8.12. *Corynebacterium*

Corynebacterium, a genus which is the *Coryneform* group. Members of the genus are found in the intestinal tract of man and animal and had been isolated from spoiling foods of various types. The described characteristics of the genus were Gram-positive rod showing granules and cloud-shaped swelling, non-spore formers, mesophilic and psychrophilic, non-motile and non-capsulated bacilli. The species *C. diphtheriae* is milk-borne (Mead, 1982).

1.9. Microbial Safety of Street Foods

A lack of knowledge among street food vendors about the causes of food-borne disease is a major risk factor (FAO, 1998). Poor hygiene, inadequate access to potable water supply and garbage disposal, and unsanitary environmental conditions such as proximity to sewers and garbage dumps further exacerbate the public health risks associated with street foods (FAO, 1998). Traditional processing methods that are used in preparation, inappropriate holding temperatures and poor personal hygiene of food handlers are some of the main causes of contamination of street-vended food (Mensah *et al.*, 2002; Barro *et al.*, 2006). Recent studies have indicated that ready to eat foods and food preparation surfaces may be reservoirs for microbial

contamination (Mankee *et al.*, 2005; Ghosh *et al.*, 2007; Christison *et al.*, 2008). Street foods in some African countries have been tested for various microorganisms of public health concern, including faecal coliforms, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* species and *Bacillus cereus* (FAO/WHO 2005). *Escherichia coli* and *Staphylococcus aureus* were recovered in a significant proportion of the food, water, hand and surface swabs tested in Harare, Zimbabwe (FAO/WHO, 2005). Street foods can also be sources of several groups of enteropathogens (Mensah *et al.*, 2002).

Epidemiological importance of microbial foodborne disease in street .1.9.1 foods

Despite the availability of food safety strategies for public health and economic development in many countries, food safety policies, plan of action and legislation have not been implemented especially in developing countries (Anonymous, 2001). In recent times, food safety issues have assumed a wider dimension because of the reliance on fast food whose preparation the consumer has no control over. In the busy way of life today, people eat more meals outside their homes. In developing countries a large portion of ready to eat is sold on the streets. If this food is not handled hygienically or not stored at the right temperature, food borne illnesses are bound to occur (Anonymous, 2001). All age groups consume street foods in Africa (FAO/WHO, 2005). However, there may be differences in the type of client depending on locality (Mensah *et al.*, 2002). While it is often thought that children under five years of age are fed at home, Mensah *et al.* (2002) observed that many mothers working at the markets in Accra also bought some food items from vendors to feed their babies. This has serious implications on the health of the children (FAO/WHO, 2005). Mahale *et al.* (2008) cited documented outbreaks of illnesses in humans associated with the consumption of street vended foods.

1.10. Prevention and control of foodborne diseases

Treatment is not available for many infections for foodborne diseases, thus prevention efforts may be more effective and required at all level of food chain.

Surveillance that combines sub typing methods, cluster identification, and collaborative epidemiologic investigation can halt the disperse of outbreaks. Furthermore, outbreak investigation and case-control studies of sporadic cases can identify sources of infection and guide to prevention strategies, as well as identifying animal reservoirs is critical to prevention of foodborne diseases (Tauxe,1997). Nicolas et al. (2007) shed a light on the role of food safety concept developed by WHO and FAO in helping governments to elaborate guidance for street food production, vending and consumption, producers and vendors, training about HACCP and global view on safe street-vended food production.

Control of foodborne diseases may be achieved through the application of the following: 1) cook food thoroughly at required temperature, 2) eat cooked foods immediately (within 30 minutes), 3) store cooked foods carefully (below 7c or above 63c, 4) reheat cooked foods thorough once to above 63c, 5) avoid contact between raw foods and cooked foods, 6) wash hands repeatedly e.g. after touching raw foods, contaminated surfaces, money and body, 7) keep all kitchen surfaces meticulously clean, 8) protect foods from insects, rodents and other animals, and 9) use safe water.

1.11. Common problems face street vended foods

Common problems face street vended foods include 1) no support from governments and lack of political will to regulate the sector, 2)improper food handling practices and poor sanitation in sites, 3) lack of knowledge on good manufacturing practices and vendors unwillingness to adopt proper sanitation techniques, 4) inadequate technologies to prepare, store and distribute food, 5) there is no training program and it is high cost to train personnel, 6) and different opinions regarding the safety, no standards among countries and limited skilled personnel (Caribbean Regional working group on street food vendors, 2002).

1.12. Developing and improving street vending sites

According to FAO (1997), knowledge forum developing strategies to assure safety of street-vended food, associated with awareness of the importance of this

informal sector and understanding the risk due to unhygienic practices. A set of strategies conducted by municipal and local authorities to enhance street food sector including:

Detailed study about the street vended-food, socio-economic profile of street vendors and consumers, survey of the street food vendors including observation of hygienic practices during food preparation and handling, analysis of food samples and evaluation of infrastructures (vending unit, adequate storage facilities for hot and cold foods, availability of potable water, latrines, garbage and sewage disposal, supportive services water-electricity). Training sessions for vendors and inspectors, education campaigns for consumers, reinforcement the exchange of experiences between countries, raising consumer awareness about food safety (WHO, 2000).

Before conducting the study a preliminary survey should be done to estimate the number of vendors and their locations. In addition to that vendors should be classified according to the type of food on sell, attention must be paid to the vendors who sell hazardous foods or who prepared foods at home and transporting foods to vending sites. However, conducting the system of hazard analysis and critical control point will improve the safety of street vended foods. Moreover, close supervision from relative authorities and annual medical examination for food vendors will enhance the quality of street foods (Sun and Ockerman, 2005; WHO, 2012).

1.12.1. Routine medical examinations

According to WHO,(1998) in many countries vendors are subjected to periodic screening test prior to working as food vendors. The examinations test may include: medical history can be done by short questionnaire focus on food safety issues, physical examination which focus on lesions on the exposed skin surface, and throat swabs for the presence of streptococci.

Neither blood tests nor x-ray for tuberculosis are required, because there is no evidence that any sexual disease and tuberculosis can be transmitted by foods (WHO, 2012).

1.12.2. Consumer training

It is very important to educate consumer to the fact that food safety has become a major issue of public concern. Consumer educations encourage them to concern about safety and hygiene and enable them to determine what to consume and from whom to purchase foods based on hygienic measures (Ekanem,1998). Multiple educational approaches including posters, media, seminars, and food safety messages in schools could be used by relevant authorities to educate consumer about food safety issues such as association between contaminated food and foodborne diseases, proper food handling practices and time temperature control. As stated by Sanlier (2009) in his study which carried out in Ankara, Turkey to determine food safety practices of young and adult consumer, the results showed that children at risk of getting foodborne diseases, so more attention must be paid to this group by health personal to raise awareness among children in relation to food safety.

1.12.3. Training of food handles

Basic training on food safety and food hygiene for street food workers was perceived to be so important particularly before licensing. At all events very few vendors gained their knowledge of food handling by formal training (Omemu andAderouju,2008). The training courses often conducted by governments or recognized institutions, and it needs for collaboration among health authorities, municipalities and community. The selection of trainees should based on their interests, ability and education, the course should be designed to suit the education. Training materials should be developed to provide information about food handling practices and hazards association with street foods in specific society to make vendors aware of their responsibilities to consumers, able to judge potential hazards and able to take corrective action. Furthermore, training will enhance knowledge about the value of disease surveillance and epidemiological information in food safety program. However, information gathered from conducting HACCP such as

identifying critical practices, critical points, and corrective action could be included in training programs (FAO,1997).

Chapter Two

Materials and Methods

2.1. Study Area and Population

Khartoum state is the capital of Sudan, which is located in north Eastern part of centre of Sudan. The state is located between 21^o , 25-24^o , 45^o East and 15^o , 9-16^o , 45^o North. The state cover 20,73 KM distance. Khartoum state is divided in to three administration governate Khartoum, Omdurman, And Khartoum North. The governate bounders by north kordofan in the west and in the north by Nile River state and in the North West by the northern state and by the White Nile State in South and Gazera State in the East. The climate is semi-desert, dry and hot in summer (maximum temperature of 47C^o and minimum temperature of 22.7C^o). the range of rain fall is 150 per year. The population of people in Khartoum about more than 7 million of people (WHO, 2000).

A cross-sectional study was conducted for a period of six months, from June to December/2013, in the food prepared and sold in the streets of Khartoum. Thirty food vendors were randomly selected. One swab samples was collected from each selected vending site.

The population of this study consisted of street vendors who operating their businesses in the major streets, public places, sidewalk, and markets.

2.2. Questionnaire design and data collection

The questionnaire issued consisted of 41 questions, and it is a modified version of a questionnaire from US Food and Drug Administration (FDA, 2003). The questionnaire was developed and the final version of survey tool consisted of 41 questions to test food safety knowledge and practices of thirty street food vendors. The questionnaire based on principles of food safety and pathogen control factors. The first part of the questionnaire consisted of demographic characteristics of the participants and their socio-economic information, the next questions were about food items sold by vendors, followed by questions about health and personal hygiene knowledge, practices and preventing cross-contamination. In addition there were questions concerning the parameters that considered in food handling practices. Finally, some questions were precisely designed to address the knowledge

of food contamination and foodborne illnesses including types of food contaminants, symptoms of foodborne illness and types of foodborne illnesses. The questionnaire was reviewed and pretested to verify its validity on 30 randomly selected street food vendors, the results of the pretest were used in the revision of the initial survey tool. The respondents were notified that survey was confidential and their contribution on the study was voluntary. After that data were obtained by interviewing vendors and asking them series of questions.

2.3. Samples collection

A total of 75 swab samples taken from 5 site including knives, hand of workers, food ready-to-eat, dishes and surface of food preparation were obtained from different locations. The swab collected in sterile container, appropriately labeled and sent aseptically on ice soon after collection to laboratory for bacterial identification and total viable count.

2.4. Methodology of Viable Bacterial Cell Count

Serial dilutions were used, plating and counting of live bacteria to determine the number of bacteria in a given population was used. Serial dilutions of a solution containing an unknown number of bacteria were made.

The total number of bacteria in the original solution was determined by counting the number of colony forming units and comparing them to the dilution factor. Each colony forming unit represented a bacterium that was present in the diluted sample. The numbers of colony forming units (CFU's) were divided by the product of the dilution factor and the volume of the plated diluted suspension to determine the number of bacteria per mL that were present in the original solution.

2.4.1. Serial Dilution

Five small, sterile test tubes were prepared labeled 1 through 5 and then 4.5 ml of M9 salts was added to each test tube. M9 salts are a physiological buffered minimal medium that contains inorganic salts but no carbon source. Bacteria do not grow in this media but remain in a state of stasis until the diluted cells are plated on media containing a carbon source. 0.5 ml of the original solution was pipetted into

test tube 1. Bacterial suspension was mixed thoroughly (using the vortexes on each bench) before proceeding to the next step. 0.5 ml of the diluted bacterial suspension was drawn using from the first test tube a clean pipette and pipetted that into the second test tube. Continual in this fashion until serial dilution of original bacterial suspension into test tube 5 was Five small, sterile test tubes were prepared labeled 1 through 10 and then 4.5 ml of M9 salts was added to each test tube1. Continual in this fashion until serial dilution of original bacterial suspension into test tube 5 was suspension was added to yield a total volume of 5.0 mL

$$\frac{0.5 \text{ mL}}{\text{mL} + 0.5 \text{ mL}} \xrightarrow{4.5} \frac{0.5 \text{ mL}}{5.0 \text{ mL}} \times \frac{1}{10} \xrightarrow{10} \frac{1}{10^2} \xrightarrow{\times 10} \frac{1}{10^2} \xrightarrow{\text{dilution}} 1:100$$

2.4.2. Plating the Serially Diluted Cells

The following dilutions were made: 1×10^{-1} , 1×10^{-2} , 1×10^{-3} , 1×10^{-4} , 1×10^{-5} . There were cultured in TSA plates. After sterilizing the stick, the hockey stick was used to spread the bacterial suspension evenly over the entire surface of the plate. The plate was allowed to dry. This process was done with the remainder of the bacterial dilutions. All the plates were taped together and incubated, upside down, at 37°C for 24 hours.

2.4.3. Counting colony forming units

For each dilution, the number of colony forming units on the plates was counted. Typically numbers between 30 and 300 are considered to be in the range where one's data is statistically accurate. Alternatively, if the numbers are evenly distributed on the surface of the plate. If the number of CFUs on the plate is below 10, the number of CFUs has to be recorded but was not used in the calculations.

T=Trials

Table 1. Calculation of Average bacteria/mL Total viable counts (log₁₀ CFU cm⁻²):

Dilution Factor	Number of bacterial colonies (CFUs)					AAvg # CFU	Avg # bacteria/ml
	T1	T2	T3	T4	T5		
1:10-1							
1:10-2							
1:10-3							
1:10-4							
1:10-5							

To calculate the number of bacteria per mL of diluted sample one should use the following equation:

$$\frac{\text{Number of CFU}}{\text{Volume plated (mL) x total dilution used}} \longrightarrow \frac{\text{Number of CFU}}{\text{mL}}$$

For cell suspension and counted 200 bacteria, then the calculation would be:

$$200/0.1 \text{ mL} \times 10^{-5} \text{ or } 200/10^{-4} \text{ or } 2.0 \times 10^{11} \text{ bacteria per ml}$$

2.5. Bacterial isolation and identification

Isolates of test organisms were obtained from the 5 sites of street food vendors using prepared nutrient agar, nutrient broth, Mac Conkey agar (MCA) and Blood Agar. The plates were incubated at 37c° for 24hrs. Well isolated colonies obtained from agar medium and different broth cultures of Gram-negative and Gram-positive bacteria were constantly sub cultured into agar slants from time to time, incubated at 37c° for 24 hrs and stored at 4c°. Identification was based mainly on the followings; i/ Indole production (ii) Presence of catalase (iii) Haemolysis on blood agar (iv) Acid and gas production (v) Microscopic and macroscopic examination of morphology (vi) Gram stain. The methods TVC and Identification of the different strains that used were as described by Harrigan and MacCance, (1966) Barrow and Feltham, (1993).

2.5.1. Liquid Cultural Media

a. Peptone Water

Peptone water was prepared according to Cruikshnk *et al.* (1975). Ten gram peptone and five grams NaCl were dissolved by heating in 1000 ml distilled water. The pH was adjusted to 7.2 and the medium was distributed in five amounts in the test tubes and sterilized by autoclaving at 115c° for 15 minutes under pressure 15 lb per square inch. The stock was preserved in the refrigerator.

b. Nutrient Broth

Nutrient broth (Oxoid*) contained lab-lemco powder one gram yeast extract two grams peptone five grams and sodium chloride five gram. The pH was adjusted to 7.4 approximately. An amount of 13 grams of the dehydrated medium was added to one liter of distilled water. The reconstituted medium was mixed well and distributed in five ml amounts and sterilized by autoclaving at 121°C for 15 minutes under pressure 15 lb per inch.

2.5.2 Solid Cultural Media

a. Nutrient Agar

Nutrient agar was obtained in a dehydrated form (Oxoid*) the medium contained, Lab-lemco powder one gram, yeast extract two grams, peptone five grams, NaCl five grams, and agar 15 grams per 1000 ml. pH was adjusted to 7.4 approximately. The medium was prepared by adding 28 grams of dehydrated medium to 1000 ml distilled water and dissolved by boiling and distributed in final containers and sterilized by autoclaving at 115 °C for 15 minutes under pressure 15 lb per square inch.

b. Blood Agar

Blood agar was prepared according to Barrow and feltham, (1993). Ten ml sterile defibrinated sheep blood was added to 90 ml nutrient agar which was melted and cooled to 50 °C. The blood agar after mixed well was distributed (15-20 ml) under flame into sterile petridishes and allowed to solidify at room temperature. The prepared plates were kept in the refrigerator.

c. MacConkeys Agar

MacConkeys agar of (Oxoid*) contained peptone 20 grams, lactose ten grams, bile salts five grams, neutral red 0.075 grams and agar 12 grams. pH was adjusted to 7.4 approximately. Forty grams of the dehydrated medium were suspended in one liter of distilled water dissolved by boiling, then sterilized by autoclaving at 121 °C for 15 minutes under pressure 15 lb per square inch. The medium was dispensed in sterile petri dishes in * Oxoid Laboratory Products, London.

d. Mannitol Salt Agar

Mannitol salt agar (Oxoid*) contained: lab-lemco powder one gram, peptone ten grams, mannitol ten grams, sodium chloride 75 grams, phenol red 0.025 grams, and agar 15 grams. An amount of 111 grams of the dehydrated medium was suspended in one liter of distilled water. The mixture was boiled to dissolve completely. Then sterilized by autoclaving at 121 °C for 15 minutes under pressure 15 lb per square inch, and distributed in sterile Petri dishes 15 ml each.

2.6. Biochemical tests

2.6.1 Entero pluri test

The test was used for identification of the *Enterobacteriaceae*: *Salmonella*, *Klebsiella*, *E. coli* and *Proteus* and other gram negative oxidase negative bacteria, the identification based on biochemical tests performed on culture media containing specific substrates. The combinations of negative and positive reactions allow building up a code number that permits to identify bacteria by using the codebook. The test was done as described by the producer company (LIOFILCHEM). An isolated colony from agar medium was picked up by needle of the Enteropluri-test system without penetrating in to the agar, next to that the needle was inoculated throughout the sectors of the system. After that the system was incubated at 37°C for 24 hours. Finally, the change in color in the different sectors was observed for positive reactions and the bacterium was identified by following instructions on codebook (Shabbir, 2007).

2.6.2. Indole test:

Kovac's reagent (3-4 drops) was added in the sector of Indole, the positive pink-red color has developed within 15 minutes for *E. coli* (Shabbir, 2007).

2.6.3. Catalase test:

This was done by mixing a dense culture with 2 drops of H₂O₂ and looking for bubbles. Presence of bubbles indicates positive test and the organisms considered to be *Staphylococcus* (Tanya parish, 2014).

2.7. Statistical Analyses

The data were analyzed with SPSS software (Statistical Package for the Social Sciences, version 11.5, SSPS Inc, and Chicago, IL, USA). Descriptive statistics were used to analyze the data, questions were coded, frequency and percentage were computed. In addition All TVCs bacteria were converted to log₁₀ CFU/cm⁻² for analysis and ANOVA was performed. Cross-tabulation and the X chi square test were used to examine the relationships among and between variables. Statistical significance was set at a P value of <0.05.

Table 2: questionnaire design for data collection in Khartoum city

Variables	Description
Demographic characteristics	Age- sex- educational level- marital status- acquisition of knowledge of food preparation- length of time vending-
Personal hygiene	Knowledge of (hand washing- preventing cross-contamination- body cleanness)
Personal hygiene practices	Effective hand washing, reasons and requirement
Foodborne illnesses	Familiarity- type- contaminants- symptoms

Chapter Three

Results

Demographic characteristics of the participant are shown in table (3). The characteristics that evaluated were: a gender, educational level, and marital

status. The analysis revealed that all vendors questioned were female. The majority of them (53.3%) were in the age group of 31-40 years, followed by age group of 21-30 years (30%) and only (10%) had age group less than 20 years. Most of the respondents (46.6%) had illiterate education, (40%) of them had primary school certificate, (13.3%) of them had secondary school certificate, no anyone of them had a diploma (0.0%). With regard to their marital status, it was found that (43.3%) of the vendors single, (30%) of them married, and (26%) of them separated.(80%) of the vendors operated their businesses from stationary establishments inside malls or from stalls along the streets, while (20%) of them were mobile. About (30%) of the vendors spent less than five years vending, but (60%) of them spent between 6-10 years, while (10%) of these respondents spent less than twenty years. In addition, the study indicated that most of the respondents (73.3%) acquired their knowledge of food preparation through observation, whereas (26.7%) of them taught by their parents, or self teaching and or formal training. Concerning whether questioned street vendors were practicing their work under legal recognition, it was found that (63.3%) of them had health certificate, while (36.7%) of them worked without health certificate.

Table (3): profile of street vendors studied in Khartoum state

Parameters	Frequency	Percentage (%)
Sex		
Male	0.0	0.00
Female	30	100
Age		
<20	3	10.0
21-30	9	30.0
31-40	16	53.3

>40	2	6.6
Education attainment		
Illiterate	14	46.7
Primary	12	40
Secondary school	4	13.3

Diploma	0.0	0.00
Marital status		
Married	9	30
Single	13	43.3
Separated	8	26.7
Type of vendors		
Mobile	6	20
Stationary	24	80
Health certificate		
With	19	63.3
Without	11	36.7
Long of time spent vending (year)		
>20	3	10
6-10	18	60
<5	9	30
Acquisition of knowledge of preparation		
Through observation	22	73.3
Others	8	26.7

Food safety and foodborne disease knowledge of street food vendors are presented in Table (4). Regarding knowledge by important of hands washing, hygiene and factors affecting in rate of risk of food contamination about 63.3% of them had true responses to statements (Washing hands before work reduces the risk of food contamination), 26.7% of respondents had false response and 10.0% of them didn't a know. Also 63.3% of them had true responses to statement (Using gloves during work reduces the risk of food contamination), 13.3% had false responses and 23.3% didn't a know. Majority of them about 80.0% had true responses to statement (Proper cleaning and handling of instruments reduces the risk of food contamination), 16.7% of them had false responses, 3.3% didn't a know. 13.3% of the respondent had true responses to statements (Eating and drinking in the work place increases the risk of food contamination), 46.7% of them had false responses, 40.0% didn't a know. Questioned respondents (All person including children, adults, pregnant women and Old-ages at equal risk of food poisoning) the majority of them about 53.3% didn't a know, 26.7% of them had true responses, 20.0% of them had false responses. Regarding foodborn disease transmission about 50.0% of

them had true responses to statement (Typhoid can be transmitted by food), 6.7% had false responses, 43.3% didn't a know. 56.7% of them had false responses to statement (Jaundice can be transmitted by food), 3.3% had true responses, 40.0% didn't a know. About 93.3% of them had true response to statement (Diarrhea can be transmitted by food) and 6.7% didn't a know. 40.0% of them had true responses to statement (AIDs can be transmitted by food) majority of them 60.0% had false responses. 33.3% had true responses to statement (Brucellosis can be transmitted by food), 30.0% of them had false responses, 36.7% didn't a know. 63.3% had true responses to statement (Bloody diarrhea can be transmitted by food), 10.0% of them had false responses, 26.7% of them didn't a know. About 66.7% of them had true responses to statement (Abortion in pregnant women may be induced by foodborne disease), 10.0% had false responses, 23.3% didn't a know. The majority of them about 90.0% didn't a know that Salmonella is among the foodborne pathogens, 3.3% of them are know that. 6.7% of respondants had true responses to statement (Hepatitis A virus is among the foodborne pathogens), 13.3% of them had false response, 80.0% didn't a know. 6.7% of them had true response to statement (Hepatitis B is among the foodborne pathogens), 10.0% of them had false responses, 83.3% of them didn't a know. 13.3% of them had true responses to statement (Staphylococcus is among foodborne pathogens), majority of them about 86.7 didn't a know. 3.3% of them had true responses to statement (Clostridium botulinum the foodborne pathogens), also 3.3% had false responses, most of them about 93.3% didn't a know. Regarding reaction to infectious diseases of eye and skin the respondents about 63.3% had true responses to statement (During infectious diseases of eye, it is necessary to take leave from work), 10.0% of them had false response, 26.7% didn't a know. Also 56.7% of respondent had true response to statement (During infectious diseases of skin, it is necessary to take leave from work) and 43.3% of them had false responses.

Table (4) food safety and foodborne diseases knowledge of street food vendors.

Statements	Responses, n (%)			Asymp. Significance	
	True	False	Do not a know	G negative	G positive
Washing hands before work reduces the risk of food contamination	63.3%	26.7%	10.0%	0.960	0.266
Using gloves during work reduces the risk of food contamination	63.3%	13.3%	23.3%	0.427	0.714
Proper cleaning and handling of instruments reduces the risk of food contamination	80.0%	16.7%	3.3%	0.098	0.312
Eating and drinking in the work place increases the risk of food contamination	13.3%	46.7%	40.0%	0.053	0.039
All person, including children, adults, pregnant women and old – ages are at equal risk of food poisoning	26.7%	20.0%	53.3%	0.667	0.195
Diarrhea can be transmitted by food	93.3%	0.0%	6.7%	0.440	0.054
Aids can be transmitted by food	40.0%	60.0%	0.0%	0.018	0.044
Brucellosis can be transmitted by food	33.3%	30.0%	36.7%	0.717	0.955
Bloody diarrhea can be transmitted by food	63.3%	10.0%	26.7%	0.456	0.309
Abortion in pregnant women may be induced by food borne disease	66.7%	10.0%	23.3%	0.220	0.436
Salmonella is among the food borne pathogens	3.3%	6.7%	90.0%	0.629	0.693
Hepatitis A virus is among the food	6.7%	13.3%	80.0%	0.352	0.149

borne pathogens					
Hepatitis B virus is among the food borne pathogens	6.7%	10.0%	83.3%	0.336	0.917
Staphylococcus is among the food borne pathogens	0.0%	13.3%	86.7%	0.019	0.005*
Clostridium botulinum the food borne pathogens	3.3%	3.3%	93.3%	0.677	0.538
During infectious disease of eye, it is necessary to take leave from work	63.3%	10.0%	26.7%	0.652	0.203
During infectious disease of skin, it is necessary to take leave from work	56.7%	43.3%	0.0%	0.697	0.346

Health and personal hygiene adoption of street food vendors showing in Table (5). About 56.7% of them agree that one of the most important responsibilities of the food handlers is washing hands to safety measures and about 43.3% of them had no idea. About 73.3% of respondents agree that using gloves is important in reducing risk of food contamination, 20.0% of them that disagree and 6.6% had no idea. Majority of them about 80.0% agreed using of apron is important in reducing risk of food contamination, 10.0% of them disagree and also 10.0% had no idea. 83.3% agree that using masks is important in reducing risk of food contamination, 3.3% of them disagree that and 13.3% had no idea. 46.7% of them agree that using caps is important in reducing risk of food contamination, 36.7 of respondents disagree that and 16.7% of them had no idea. 40.0% agreed that should not touch foods without gloves, 53.3% of them disagree that and 33.3% had no idea. 46.7% of them agree that raw and cooked foods should be stored separately to reduce risk of food contamination, 20.0% of them disagree and 33.3% had no idea. 56.7% of them agree that food hygiene training for workers is an important issue in reducing risk of food contamination and 43.3% of respondents had no idea. 80.0% of them agree that

health status of the workers should be evaluated before employment, just 10.0% of them disagree and also 10.0% of them had no idea. Majority of them about 93.3% agree that foodborne illnesses can have deleterious health and economic effect on the society and only 6.7% of them had no idea about that.

Table (5) health and personal hygiene adoption of street food vendors.

Statements	Responses, percentage n (%)			Asymp. Significance	
	Agree	Disagree	No idea	G negative	G positive
One of the most important responsibilities of the food handlers is washing hands to food safety measures	56.7%	43.3%	0.0%	0.697	0.346
Using gloves is important in reducing risk of food contamination	73.3%	20.0%	6.7%	0.648	0.659
Using apron is important in reducing risk of food contamination	80.0%	10.0%	10.0%	0.167	0.056
Should not touch foods without gloves	40.0%	53.3%	6.7%	0.316	0.214
Raw and cooked foods should be stored separately to reduce risk of food contamination	46.7%	20.0%	33.3%	0.123	0.406
Food hygiene training for workers is an important issue in reducing risk of food contamination	56.7%	0.0%	43.3%	0.222	0.558
Health status of the workers should be evaluated before employment	80.0%	10.0%	10.0%	0.918	0.982
Food borne illnesses can have deleterious health and economic effect on the society	93.3%	0.0%	6.7%	0.337	0.685

Food hygiene practices of street food vendors presented in Table (6). About 23.3% of the respondents never use of gloves during work, 13.3% of them rarely used gloves during work, also 13.3% sometimes use of gloves during work, majority of them about 30.0% often use gloves during work and 20.0% always use gloves during work. 33.3% also they never wash your hands before using gloves, 26.6% rarely wash your hands before using gloves, 20.0% of them sometimes wash your hands before using gloves, 13.3% often wash your hand before using gloves and 6.7% of them always wash your hands before using gloves. Regarding wear apron, mask and cap, 23.3% of them never wear apron during work, 20.0% rarely wear apron during work, 16.7% of them sometimes wear apron during work and the majority of them about 40.0% always wear apron during work. 66.7% of them never use mask during work, 10.0% rarely use mask during work, 16.7% sometimes use mask during work, 6.7% of them often use mask during work. The majority of respondents 86.7% always use cap during work, 3.3% rarely use cap during work, 10.0% sometimes use cap during work. About 10.0% never wash your hands before you touch raw meat, 56.7% of them always wash your hands before you touch raw meat, 20.0% rarely wash your hands before you touch raw meat, 3.3% sometimes wash your hands before you touch raw meat, 10.0% of them often wash your hands before you touch raw meat. Also 40.0% of them never wash your hands after you touch raw meat, 30.0% rarely wash your hands after you touch raw meat, 13.3% of them sometimes wash your hands after you touch raw meat, 6.7% often wash your hands after you touch raw meat, 10.0% of them always wash your hands after you touch raw meat. About 50.0% of respondents never wash your hands after rest time when you come back to work, 3.3% of them always wash your hands after rest time when you come back to work and 23.3% rarely wash your hands after rest time when you come back to work. 33.3% of them always eat or drink in your work place, 23.3% often eat or drink in your work place and 33.3% sometimes eat or drink in your work place. The majority of them about 83.3% never smoke in your work place, 10.0% rarely smoke in your work place and 6.7% of them sometimes

smoke in your work place. Questioned respondents (How often do you use the products of your working plant?), 6.7% of them never use the products of your working plant, 53.3% always use the product of your working plant and 23.3% of respondents rarely use the products of your working plant. Regarding to recommend the products of your working plant to other about 10.0% of them never recommend the products of your working plant to other, majority of them about 50.0% always recommend the products of your working plant to other, 26.7% often recommend the products of your working plant to other and 13.3% of them rarely recommend the product of your working plant to other.

Table (6) food hygiene practices of street food vendors.

Statements	Responses, percentages n (%)					Asymp. Significance	
	Never	Rarely	Sometimes	Often	Always	G negative	G positive
Do you use gloves during work?	23.3%	13.3%	13.3%	30.0%	20.0%	0.821	0.772
Do you wash your hands before using gloves?	33.3%	26.7%	20.0%	13.3%	6.7%	0.061	0.134
Do you wear apron during work?	23.3%	20.0%	16.7%	0.0%	40.0%	0.492	0.864
Do you use mask during work?	66.7%	10.0%	16.7%	6.7%	0.0%	0.796	0.731
Do you use cap during work?	0.0%	3.3%	10.0%	0.0%	86.7%	0.805	0.409
Do you wash your hands before you touch raw meat?	10.0%	20.0%	3.3%	10.0%	56.7%	0.129	0.328
Do you wash your hands after you touch	40.0%	30.0%	13.3%	6.7%	10.0%	0.733	0.326

raw meat?							
Do you wash your hands after rest time when you come back to work?	50.0%	23.3%	13.3%	10.0%	3.3%	0.427	0.186
Do you eat or drink in your work place?	0.0%	10.0%	33.3%	23.3%	33.3%	0.141	0.189
Do you smoke in your work place?	83.3%	10.0%	6.7%	0.0%	0.0%	0.195	0.313
How often do you use the products of your working plant?	6.7%	23.3%	6.7%	10.0%	53.3%	0.781	0.971
How do you recommend the products of your working plant to others?	10.0%	13.3%	0.0%	26.7%	50.0%	0.994	0.186

In Table (7) the total viable count in hands was 6.10, knives 6.12, dishes 6.08, foods 6.08 and surfaces of food preparation 6.14.

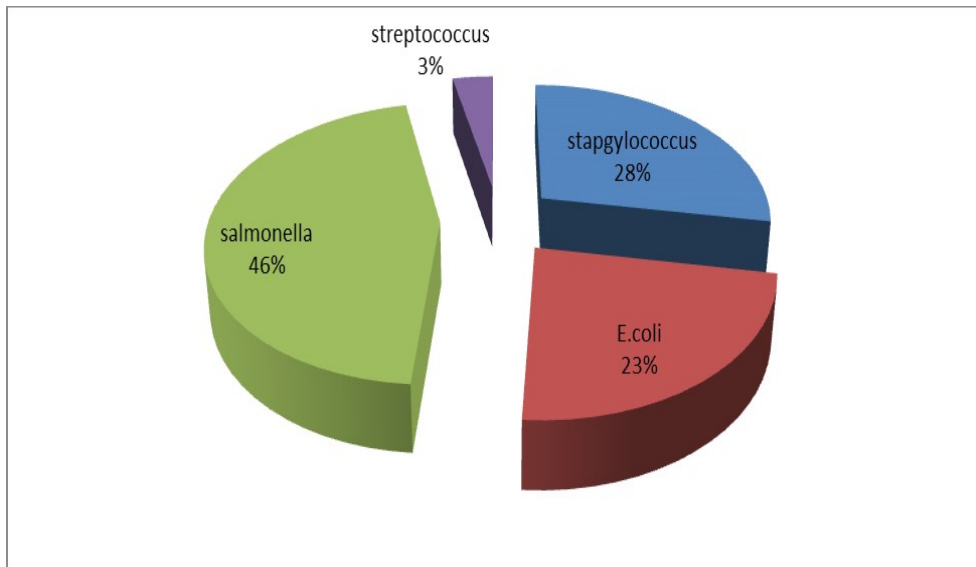
Table (7): Mean level of total viable count (TVC) of bacteria ($\log_{10}\text{g}_{(\text{ml})}$) in street food vended in Khartoum city.

Sites	Number of samples	Mean $\log_{10}\text{g}_{(\text{ml})}$	Significance
		TVC	
Hands	15	6.10	No significance
Knives	15	6.12	No significance
Dishes	15	6.08	No significance
Foods	15	6.08	No significance
surfaces	15	6.14	No significance

Bacteriological examination of vended food identified some Gram-negative and gram-positive bacteria. About 46% of samples isolated *Salmonella* spp, 28%

isolated *Staphylococcus* spp, 23% isolated *E.coli* and just 3% isolated *Streptococcus* spp. Figure (1) summarizes the results of general bacterial profile.

Figure (1) General bacterial isolated percentage.



In Table (8) presented the distribution of Salmonella in different site of samples taken. In hands it was found that positive to *Salmonella* spp as; 53.3% of samples taken from knives, 60.0% from dishes, 60.0% from foods positive infected salmonella just 33.3% of samples from surfaces of food preparation had positive result to salmonella.

Table (8) The association between salmonella and site of samples taken.

Sample site	Negative(-ve)	Positive(+ve)	Total
Hands	5 (33.3%)	10 (66.7%)	15 (100%)
Knives	7 (46.7%)	8 (53.3%)	15 (100%)
Dishes	6 (40.0%)	9 (60.0)	15 (100%)
Foods	6 (40.0%)	9 (60.0%)	15 (100%)
Surfaces	10 (66.7%)	5 (33.3%)	15 (100%)
Total	34 (45.3%)	41 (54.7%)	75 (100%)

Pearson chi-square (X^2) Asymp sig “p-value”= 0.409 no significance, there was no significance association between salmonella and sample site.

Table (9) percent's the distribution of *staphylococcus* spp in deference site of sample taken which positive are; 33.3% of samples of hands, 33.3% of samples of knives, 46.7% of samples of dishes, 33.3% of samples of surfaces.

Table (9) The association between staphylococcus and site of samples taken.

Sample site	Negative (-ve)	Positive (+ve)	Total
Hands	10 (66.7%)	5 (33.3%)	15 (100%)
Knives	10 (66.7%)	5 (33.3%)	15 (100%)
Dishes	8 (53.3%)	7 (46.7%)	15 (100%)
Foods	12 (80.0%)	3 (20.0%)	15 (100%)
Surfaces	10 (66.7%)	5 (33.3%)	15 (100%)
Total	50 (66.7%)	25 (33.3%)	75 (100%)

Pearson chi-square (χ^2) Asimp sig “p-value” = 0.663 no significance

There was no significance association between staphylococcus and sample site.

In Table (10) shows the distribution of *E.coli* in deference site of sample taken which positive are; 13.3% of samples of hands, in knives found 33.3%, 26.7% of sample of dishes, in foods found 26.7%, and 28% of samples of surfaces cut.

Table (10) The association between E.coli and site of sample taken.

Samples site	Negative (-ve)	Positive (+ve)	Total
Hands	13 (86.7%)	2 (13.3%)	15 (100%)
Knives	10 (66.7%)	5 (33.3%)	15 (100%)
Dishes	11 (73.3%)	4 (26.7%)	15 (100%)
Foods	11 (73.3%)	4 (26.7%)	15 (100%)
Surfaces	9 (60.0%)	6 (40.0%)	15 (100%)
Total	54 (72%)	21 (28%)	75 (100%)

Person chi-square (χ^2) A symp sig “p-value” = 0.573 no significance no significance there was association between the E.coli and sample site.

In table (11) shows the association between streptococcus and sample site that positive are;. 6.7% of sample of knives, 6.7% of samples of food, and 6.7% of samples of surfaces cut.

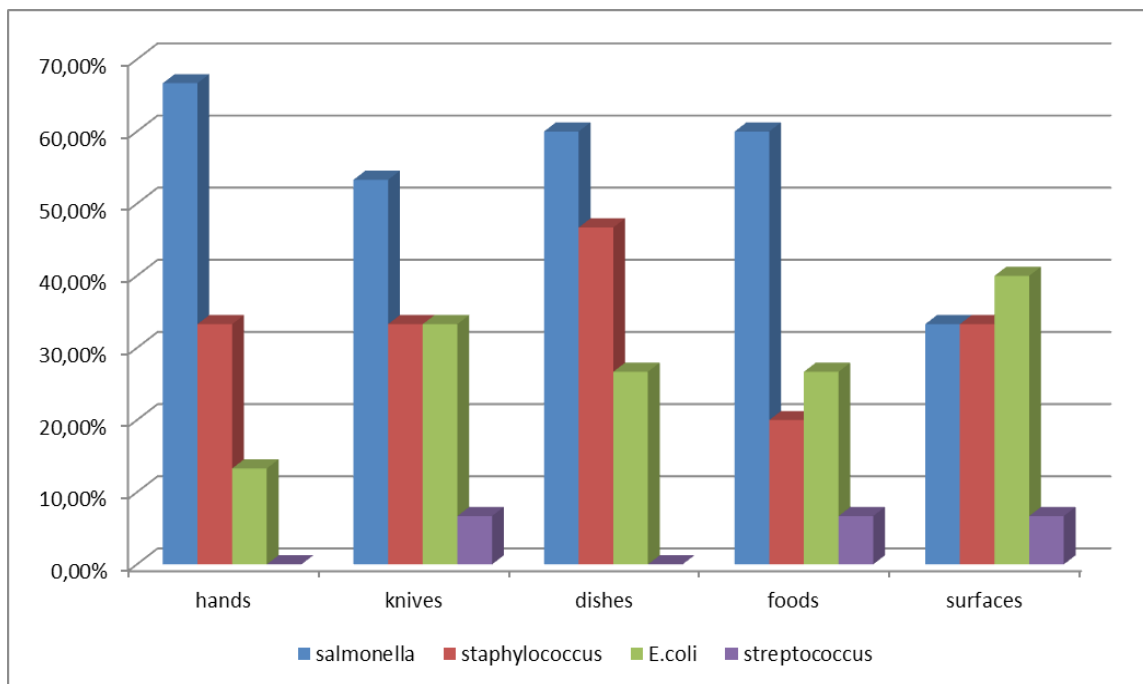
Table (11) The association between streptococcus and sample taken.

Sample site	Negative (-ve)	Positive (+ve)	Total
hands	15 (100%)	0 (0.0%)	15 (100%)
Knives	14 (93.3%)	1 (6.7%)	15 (100%)

Dishes	15 (100%)	0 (0.0%)	15 (100%)
Foods	14 (93.3%)	1 (6.7%)	15 (100%)
Surfaces	14 (93.3%)	1 (6.7%)	15 (100%)
Total	72 (96%)	3 (4.0%)	75 (100%)

Person chi-square (χ^2) A symp sig “p-value” = 0.72 no significant there is no significant association between streptococcus and sample site.

Figure (2): The percentage of bacterial distribution in hands, knives, dishes, foods and surfaces of food preparation.



Chapter Four
Discussion

The socio-economic and demographic data in this study revealed that all of the food vendors were women. And the majority of them (53.3%) fell at the age group of (31- 40), followed by age group of (21-30) about (30.0%). Furthermore, the study revealed the absence of formal training, however most vendors (73.3%) gained their knowledge of food handling and cooking skills through observation, whereas (26.7%) of them acquired knowledge through others including taught by their parents and self taught. This result is similar to the study in Gizan city, Saudi Arabia reported by Elhaj Moutz, (2012) who found that (74.0%) from respondents gained their knowledge of food handling and cooking skills through observation, whereas (26.0%) of them acquired knowledge through others including taught by their parents and self taught. In addition (80.0%) of them operated their business from stationary establishments while (20.0%) were mobile. These result are in contrast with finding reported by Chukuezi,(2010) who found that (95.2%)of the vendors operated from stalls along the streets while only (4.8%) of those were mobile . Educationally (46.7%) of the interviewers were illiterate, (40.0%) had primary school certificate, (13.3%) had secondary education and all respondents had not diploma. In addition (30.0%) of them were married, (43.3%) were unmarried while (26.7%) separated. About (60.0%) of them had been working for less than ten years, followed by (30.0%) who worked for less than five years, and just (10.0%) who worked for more than twenty years. these result are in contrast with finding reported by Abdalla *et al.* (2009) in their study in Atbra city, Sudan, reported that (42.0) of the vendors were illiterate,(48.0%) had primary education. In the same study they also reported that most of surveyed people (64.0%) were married, as well as (78.0%) of them had in food vending work for less than five years while only (2.0%) worked for more than twenty years. In general, the respondents answers were good to some extend in some areas of personal hygiene practices, but there were also poorly answered in areas of health and personal hygiene knowledge especially questions asked about risk factor of food contamination and diseases transmitted by food. Nevertheless, the study reported that almost of respondents

(63.3%) decided that washing hands before work reduces the risk of food contamination also (63.3%) decided that using gloves during work reduces the risk of food contamination and majority of them about (80.0%) said that proper cleaning and handling of instruments reduces the risk of food contamination this consider good knowledge according to (Luby *et al.*, 2005). The results showed that the majority of the vendors did not know that hepatitis A virus (93.3% of the respondents), hepatitis B virus (93.3%), Salmonella (96.7%) and Staphylococcus (100%) are pathogen that are responsible for foodborne diseases and more than half (73.3%) of the respondents vendors failed to discern the groups at risk of foodborne diseases. The same finding was reported by Wood burn and Raab (1997). (63.3%) knew that bloody diarrhea can be transmitted by food whilst (60.0%) recognized that AIDS can't be transmitted by food and (93.3%) knew that diarrhea can be transmitted by food. One the other hand, (56.7%) knew that it is necessary to take leave from work during case of infectious skin diseases and (63.3%) knew that it is necessary to take leave from work during case of infectious eye diseases. (33.3%) of vendors did not know that abortion could be induced by foodborne diseases. (86.7%) did not know that eating and drinking in the work place increase the risk of food contamination. In comparison to study in Haiti (Frak *et al.*, 2013) found that all vendors did not know that hepatitis A virus (96.3%) Salmoella (100%) and Staphylococcus (98.7%) were foodborne pathogens. In agreement with this finding, vendors from Iran and Brazil also failed to identify these foodborne pathogens (Ansari-Lari *et al.*, 2010; Soares *et al.*, 2012). However they found also (93.8%) of the vendors knew that bloody diarrhea can be transmitted through food. (68.7%) knew that AIDS could not be transmitted by food even through there is an on-going HIV prevention campaign in Haiti and also in Sudan. This means that more efforts should be done to reinforce the campaign in Khartoum. (88.8%) from respondents in Haiti also knew that it is necessary to take leave from work during infectious diseases of skin (42.5%) of vendors did not know that abortion could be induced by foodborne diseases. More than half (55.0%) of the vendors did not know that eating

and drinking while preparing food can lead to contamination. Although in other studies vendors were not able to identify the group at risk of foodborne diseases (Asari-Lari et al., 2010). (56.7%) of vendors agree that one of the most important responsibilities of the food handlers is washing hands to safety measures. However (73.3%) agree that using gloves is important in reducing risk of food contamination. (80.0%) agree by using apron is important in reducing risk of food contamination also (83.3%) agree that using mask and just (46.7%) agree that using caps is important in reducing risk of food contamination that may be due to increase of temperature in Khartoum make wearing of caps difficult to vendors. (40.0%) agree that should not touch foods without gloves. (46.7%) of them agree that raw and cooked foods should be stored separately to reduce risk of food contamination as in other studies conducted in Ghana and South Africa, a high percentage of street food vendors (84.4%) who participated in this study were aware of the importance of separating cooked and raw foods in order to prevent foodborne diseases (Donkor et al .,2009, Lues et al .,2006). Furthermore (56.7%) agree that food hygiene training for worker is an important issue in reducing risk of food contamination. Majority of respondents about (80.0%) agree that health status of the workers should be evaluated before employment and (93.3%) of them agree that foodborne illnesses can have deleterious health and economic effect on the society. (23.3%) of them never use gloves during work only (6.7%) of respondents always washed your hands before using gloves. Just (23.3%) of them never wear apron during work. No one always use mask during work this result acceptable due to the level of education, it was very low as (86.7%) of the participants had not attend secondary school, no one of them had gone to university and (63.3%) did not have any food safety training and had not health certificate. The same finding have been observed by Muyanja *et al.* (2011), Abdalla *et al.* (2009), Chukuezi (2010), and Muinde and Kuria (2005) in Uganda, Sudan, Nigeria and Kenya, respectively. But in the use of cap (86.7%) of the respondents always use cap during work this related to Sudanese culture women traditionally covered head the same finding in Haiti (Frank *et al.*, 2013). Regarding

hands washing more than half (56.7%) of respondents always washed your hands before you touch raw meat but (10.0%) only always washed your hands after touch raw meat and only (3.3%) of them always washed your hands after rest time when you come back to work. Other studies have also observed that low percentage of vendors use aprons and gloves while handling, preparing and serving food as well as poor care with hands washing (Chukuezi, 2010; Subratty *et al.*, 2004; Lues *et al.*, 2006; Muinde and Kuria, 2005). In our study (33.3%) of questioned respondents always ate and drank at their work place and about (83.3%) never smoked in their work place of course, all of them were women and women rarely smoked in developing countries (WHO 1999). Half of them (50.0%) always recommend all the others. The overall mean of total bacterial viable count (TVC) ranged from (6.08 – 6.14) log₁₀/g(ml) the analysis revealed that surfaces of food preparation had mean score count minor significantly higher than other site, this attributed to improper cleaning to the surfaces. Regarding microbial assessment of samples were *Salmonella* spp , *Staphylococcus* spp , *E.coli* and *Streptococcus* spp, this finding is similar to previous report by Edema and Omemo, (2004). The most prevalent bacteria was *Salmonella* about (46.0%) it was detected in samples of hands, knives, dishes, surfaces and food followed by *Staphylococcus* about (28.0%), *E. coli* (23.0%) and just (3.0%) of samples prevalent *Streptococcus* distribution only in knives, foods and surfaces. The higher level of *Salmonella* contaminated was (66.7%) found in hands this resulting to poor hands cleaning and can't found significance association between *Salmonella* and sample site (p=0.4). the higher level of contamination by *Staphylococcus* found in dishes about (46.7%) of samples prevalent by *Staphylococcus* this due to cross-contamination and improper washing and the temperature in dishes stable to *Staphylococcus* and normal *Staphylococcus* survive found in hands of human. No significance association between *Staphylococcus* and sample site (p=0.6). higher level of prevalent *E.coli* found in the surfaces of food preparation (40.0%) *E. coli* normal survive in GIT of human and normal found in feces the present of *E. coli* in surfaces of food preparation that

detected to fecal contamination and cross-contamination and also no significance association between *E. coli* and sample site ($p=0.5$). in foods samples found all the type of bacteria detected in study Salmonella present in food samples at higher level of bacteria about (60.0%) followed by *E. coli* about (26.7%) this also due to cross-contamination and inadequate cooking, uneven heating and the level of bacterial in ready to eat foods in this study was high (6.08- 6.14) \log_{10}/g (ml) comparing with acceptable level $< 5 \log_{10}/g$ (ml) according to (NSW food authority, 2009), and the food detected in this study considered at the risk level and critical to human health.

Conclusion

The research has demonstrated that most street vendors in this study do not have adequate food safety knowledge on topics of health and personal hygiene such as hands washing and preventing cross-contamination. In addition to that they have also inadequate knowledge on microbial hazards and disease transmission. This lack of knowledge leads them to improper hygienic practices which place consumers at increase risk of contracting food-borne diseases. The organism isolated from food samples include *Salmonella* spp, *Staphylococcus* spp, *Streptococcus* spp, *E. coli*, the presence of these pathogenic bacteria reflect the poor hygienic quality of food product sold in streets, and indicated that foods do not meet the recommended hygienic standards. In conclusion street food vendors must have better knowledge of food safety concepts and need to receive more information about food handling practices to enable them to translate knowledge in to practice.

Recommendations

It's recommended that:

- 1- Governmental policies and protocols regarding food vendors subsequent enforcement (including the provision of resources) need to be addressed as a matter of urgency through localities
- 2- Training in food hygiene is essential for food vendors because of the health and financial risk associated with poor food hygiene
- 3- Adequate training strategies should be established, implemented and maintained to improve the knowledge and resulting attitude and practices of food vendors and food consumers
- 4- Close supervision of street foods in food safety and hygiene including sampling assessment and conducting HACCP must be done by relative authorities, as well as enhancing sanitation and basic infrastructure in vending sites.

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Appendix

Parameters	Frequency	Percentage (%)
Sex		
Male		
Female		
Age		
<20		
21-30		
31-40		
>40		
Education attainment		
Illiterate		
Primary		
Secondary school		
Diploma		
Marital status		
Married		
Single		
Separated		
Type of vendors		
Mobile		
Stationary		
Health certificate		
With		
Without		
Long of time spent vending (year)		
>20		
6-10		
<5		
Acquisition of knowledge of preparation		
Through observation		
Others		

Statements	Responses, n (%)		
	True	False	Do not a know
Washing hands before work			

reduces the risk of food contamination			
Using gloves during work reduces the risk of food contamination			
Proper cleaning and handling of instruments reduces the risk of food contamination			
Eating and drinking in the work place increases the risk of food contamination			
All person, including children, adults, pregnant women and old – ages are at equal risk of food poisoning			
Typhoid can be transmitted by food			
Jaundice can be transmitted by food			
Diarrhea can be transmitted by food			
Aids can be transmitted by food			
Brucellosis can be transmitted by food			
Bloody diarrhea can be transmitted by food			
Abortion in pregnant women may be induced by food borne disease			
Salmonella is among the food borne pathogens			
Hepatitis A virus is among the food borne pathogens			
Hepatitis B virus is among the food borne pathogens			

Staphylococcus is among the food borne pathogens			
Clostridium botulinum the food borne pathogens			
During infectious disease of eye, it is necessary to take leave from work			
During infectious disease of skin, it is necessary to take leave from work			

Statements	Responses, percentage n (%)		
	Agree	Disagree	No idea
One of the most important responsibilities of the food handlers is washing hands to food safety measures			
Using gloves is important in reducing risk of food contamination			
Using apron is important in reducing risk of food contamination			
Using masks is important in reducing risk of food contamination			
Using caps is important in reducing risk of food contamination			
Should not touch foods without gloves			
Raw and cooked foods should be stored separately to reduce risk of food contamination			
Food hygiene training for workers is an			

important issue in reducing risk of food contamination			
Health status of the workers should be evaluated before employment			
Food borne illnesses can have deleterious health and economic effect on the society			

Statements	Responses, percentages n (%)				
	Never	Rarely	Sometimes	Often	Always
Do you use gloves during work?					
Do you wash your hands before using gloves?					
Do you wear apron during work?					
Do you use mask during work?					
Do you use cap during work?					
Do you wash your hands before you touch raw meat?					
Do you wash your hands after you touch raw meat?					
Do you wash your hands after rest time when you come back to work?					
Do you eat or drink in your work place?					
Do you smoke in your work place?					
How often do you use the products of your working plant?					
How do you recommend the products of your working plant to others?					

