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Food Safety in Sub-Sahara Africa, An insight into Ghana and Nigeria

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ABSTRACT: Food safety is a global concern in today's world, and harnessing food safety in Sub-Saharan Africa, especially Nigeria and Ghana are momentous. This review presents an insight into the situation of food safety in Nigeria and Ghana. Using a desktop review technique, research papers were evaluated to find major sources of food safety concerns. It was revealed that many studies reported on food contamination at the consumption level whereas few reported on the healthiness of the production chain. Improper handling of food at the local markets, vending sites hygiene practices of food vendors, and bad transportation and packing systems have all been implicated. Inadequate education is a major cause of food contamination, especially at the consumption level. Again, etiologic agents responsible for food-borne illness in Ghana and Nigeria range from viruses, fungi, parasites, and protozoans to bacteria. They include rotavirus, hepatitis A virus, Lassa fever (LHF), human noroviruses (HNoV), *Aspergillus parasiticus*, *Aspergillus flavus*, *Aspergillus niger*, *Taenia solium*, *Ascaris spp.*, *Toxoplasma gondii*, *Cryptosporidium spp.*, *Enterobacter spp.*, *Pseudomonas spp.*, *Campylobacter spp.*, *Escherichia coli*, *Staphylococcus spp.*, *Salmonella spp.*, *Vibrio cholerae* and *Listeria monocytogenes*. Their toxins are responsible for numerous food contaminants. Some foods are contaminated with chemicals including pesticide residues, lead, mercury, etc. Laws of food safety are not well enforced leading to complications in the food production chain. Rigorous monitoring and evaluation coupled with surveillance and education to harness the situation and detect issues that compromise the right process is a necessity. Finally, intentional enforcement of regulations by regulatory agencies will go a long way to curb food contamination and food-borne illnesses within the region.

KEYWORDS: Food safety, contamination, toxins, diseases, chemicals, and pathogens

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Introduction

Internationally, there has been a recognition of food safety as one of the major hindrances to development in both developed and underdeveloped nations.¹ The United States, for instance, has been estimated by the WHO to lose over 5 billion dollars as a result of food safety issues, especially, foodborne diseases.² Food safety with regards to diseases is said to be competing with other major killer diseases such as tuberculosis, HIV/AIDS, malaria, etc.³ WHO, stated that about 98% of the food safety burden comes from underdeveloped nations. Moreover, Africa, in general, is said to report more deaths and hospitalizations concerning food safety issues.⁴

The food safety testing market in the world is estimated at a value of 5.1 billion United States dollars for Europe in 2019, and projections are that, by the year 2025, this value is expected to rise to 7.2 billion dollars. The other testing values for other regions from 2017 to 2025 are represented in Figure 1 for 8 years. North America in 2017, 2018, 2019, and 2025 was the highest in these values, followed by Europe, Asia-Pacific, and the Rest of the world combined, yet with the lowest values.⁵ The variation between regions was found to be highly significant ($P \leq .0058$) and that of years ($P \leq .007$) as well.

Ghana and Nigeria have food regulatory bodies, yet the application of food standards in the food industries seems to be problematic. Right from the selection of seeds to sowing in line with the appropriate cultural practices until harvesting and marketing cannot be guaranteed. This alone stands as an agent for microbial, chemical, and fecal contamination, heavy metals poisoning, pest infestation, parasitic infection, and other physical and chemical contamination.⁶ The necessity of conducting reviews to reveal the current challenges in the food industry to elucidate the issues of food safety is a necessity. Local markets with little or no attention to food regulations receive few or no research publications in these 2 countries. Though it has been documented that, the local markets are the larger sources of foods in Ghana and Nigeria, there is not much attention to their application of food safety standards by food regulatory bodies such as the FDA.⁷ There is, therefore, the need to verify by way of a review to unveil the truths and clarify the challenges, with key facts to find solutions to the identified complications.

Methodology

To establish the challenges confronting food safety and possible solutions in sub-Saharan Africa especially Ghana and



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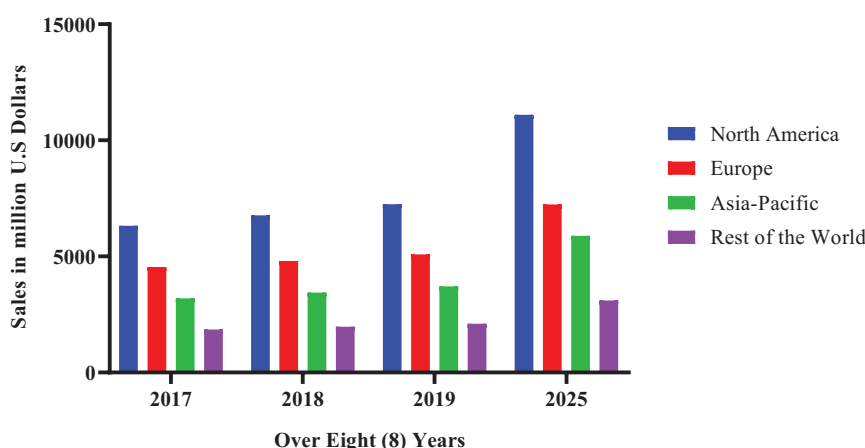


Figure 1. Projected worldwide food safety testing market trends (2017-2025), variations between regions were highly significant ($P \leq .0058$) at an alpha level of $P < .05$, and variations between years were also significant ($P \leq .007$).

Nigeria, a systematic review of the literature was conducted. A literature search plan was designed and executed. First of all, search sites including university repositories, google scholar, PubMed, Science Direct, Nature publications, Sage, Statista, and other reputable sources of publications were established and used for the study. Search styles were basically by the adaption of the Boolean operators such as “AND” “OR” and “NOT” were used. The search terms include “food contamination,” “food poisoning,” “Parasitic contamination of food,” “Pesticides traces in food,” “Weedicides traces in food,” “heavy metals in food,” and “Biological and Physical agents of food contamination,” “Outbreaks of foodborne disease in Ghana,” “Outbreaks of foodborne disease in Nigeria,” and others.

The inclusion criteria are reports on food safety issues published in reputable journals and are current in Ghana or Nigeria. The study employed 5 different searches. Search 1 was conducted, 2 months before search 2, and search 3 was conducted 1 month after search 2. Searches 1, 2, and 3 were all done in 2019 while searches 4 and 5 were done in 2020. Search 4 was done in the first month of 2020 while search 5 was done in March 2020. In all, 2631 documents were found. Out of this, some were research articles, review papers, case studies, news reports, book chapters, etc. Elimination techniques were established and employed in choosing the documents for the research. Out of the total of 2643, about 1621 were found to be duplicates, ordinary surveys (questionnaires/descriptive surveys), and others were found to contain invalid references (these references could not be traced or are non-existent). And an additional elimination was done after going through the abstract and the titles of the documents. While the exclusion criteria were papers published in Ghana and Nigeria and merely on surveys were excluded. After all these rigorous processes, a total of 115 papers were finally found to be eligible for the review but are too many hence a random selection of 69 papers was then done after the final selection of all included papers. Concerning the desktop review technique, all documents finally chosen were then printed,

stapled, and coded. The records are included in Figure 1 and Tables 1 to 3.

Food Safety in SSA

The region is well known for its stagnation in economic growth due to its inability to utilize technology in its mineral processing and agriculture.⁸ For agriculture, the region has all it takes to grow. However, due to other obstacles, the agricultural sector has been faced with numerous challenges including rainfall, fertilizers, skilled labor, adequate input supplies, and others.⁶³ The SSA specifically wastes a lot of food at farms and also in the entire production chain leading to numerous complications including food contamination.⁹ Food contamination is a leading cause of food insecurity in the SSA, however little or no attention has been paid to this issue in many West African countries including Ghana and Nigeria.¹¹ To be self-sufficient in food, one needs fertile land and good labor, fortunately, SSA has all these, yet suffers from food insufficiency. The paucity of farm inputs such as fertilizers and the right quantity of water for crops to grow is said to be a hindrance.¹² The SSA is largely dependent on rainwater for most agricultural activities but most areas in these regions lack adequate rains falls. They also suffer from fertilizer prices where many local farmers are unable to afford the fertilizer quantity required by their crops.¹³ All these leads to forfeiture of yield and the few produce are now for the survival of the fittest.

Sub-Saharan Africa with all its fertile lands and labor is not able to produce food to match the population growth.¹⁴ The population of SSA as of 1960 was over 220 million and with a GDP of over 29 billion. Meanwhile, the population of SSA in 2018 was beyond 1 billion and its GDP is over 1.6 trillion.⁶⁴ The production section is unable to meet the growing population as a result of its inability to solve the problem of food safety. Many countries in this region such as Ghana have less attention to food contamination and foodborne illness which is a major contributing factor to food insecurity.¹⁵ Table 1 below presents studies on food trends in SSA.

Table 1. Food safety trends in SSA.

AUTHORS	MAIN ISSUES	FINDINGS	IMPLICATIONS
Bicaba et al ⁸	Eradication of poverty in Sub-Saharan African	Under plausible assumptions, extreme poverty will not be eradicated in SSA by 2030, but there are possibilities of reduction from higher levels to lower levels.	SSA needs more time than 2030 to eradicate poverty. However, high growth and income redistribution toward the poor segments of society should be encouraged. Policies toward structural transformation and industrialization should be enacted.
Lokpobiri ⁹	Agriculture Promotion Policy	"Agriculture Promotion Policy ¹⁰ provides a new paradigm in approach and processes toward attaining food security and foreign exchange earnings in Nigeria's agricultural production in the short, medium and long terms."	"For the APP to endure for stable and consistent implementation of its long-term solutions to Nigeria's agricultural challenges, it should be presented to the National Assembly for enactment as a piece of legislation."
Udomkun et al ¹¹	Mycotoxins in Sub-Saharan Africa	"Mycotoxins have been found frequently in foods in SSA, they are the reason for low competitiveness of agricultural commodities in SSA region. They negatively affect both humans and livestock, household security, livelihood, productivity, and income leading to severe economic loss. There is also limited awareness of mycotoxins along the food production chain."	Mycotoxins are associated with food produced from SSA and are one reason for low exportation. The region can improve upon this situation by upholding new techniques for detection and enacting holistic policies to monitor the entire food production chain effectively.
Adeyeye ¹²	Food processing, storage, and its impact on food safety	Challenges of food security: "Under nutrition and overconsumption, rising food prices, population growth, rapid diet transitions, and threats to agricultural production, inefficient production practices and supply chains and declining investment in food system research."	Food in Africa is not secured and hence the need for harnessing food in Africa.
Druilhe ¹³	Fertilizer in sub-Saharan Africa	In low input/low output agricultural systems, fertilizer subsidies can play a role in raising fertilizer use and agricultural productivity. This can lead to kick-start market development with an increase in input demand at a large scale.	Fertilizer subsidies do not guarantee its full utilization or certainty for productivity. Hence does not has any control over its usage and lacks long-term sustainability.
van Ittersum et al ¹⁴	Can sub-Saharan Africa feed itself?	The population growth and consumption of cereal crops in SSA have increased than average crop yield in the region.	For SSA to be self-sufficient in food, there is a need for a larger production. The production rate should surpass the consumption rate and population growth rate.
Akuu et al ¹⁵	Poor food safety acquiescence among street food vendors	There is a generally higher awareness of food hygiene practices. However, most food handlers do not practice good hygienic practices about food.	The people in these regions are sound in knowledge yet do not maintain good hygienic practices due to pressure, laziness, and other unknown reasons.

Determinants of Food Safety

Figure 2, points out various factors that alter the quality and safety of Foods. These factors have been explored in detail in this review.

Food Safety in Ghana

Ghana has been experiencing beyond 626 000 food poisoning prevalence throughout the country yearly, about 298 100 cases of hospitalization yearly,¹⁸ accounting for over 48% of all food poisoning issues reported.⁴¹ Mortality with regards to food poisoning has been over 90 000 individuals yearly contributing to about 14% of all hospitalizations in Ghana.¹⁸

The government of Ghana has suffered a loss of over 70 million united state dollars yearly in its quest to reduce the foodborne disease menace.⁶⁵ Numerous homes have also

incurred injuries in physical bodies and also financially. Some homes were completely taken away by the outbreak of diseases such as cholera and typhoid fever in Accra.⁶⁶ On the Cape Coast and some other major cities in Ghana, cholera and typhoid outbreaks occur annually.^{67,68} This has been a great deterrent to the country though their food production has been quite good as is always, somewhat above their rate of population growth.

There are numerous points of contamination of food in Ghana but the common ones include cooking food in unhygienic environments and using unhygienic methods of cooking, using wrong or improper storage systems for most foods.¹⁶ As for drinks, some even use inappropriate sweetness, coloring agents, syrups, and preservatives.¹⁸ Also, the addition of sexual provoking agents to gain customers, and the addition of

Table 2. Studies on Ghanaian situation of food-borne illness.

AUTHOR	TYPE OF STUDY	MAIN ISSUE	FINDINGS	IMPLICATIONS/RECOMMENDATIONS
Points of contamination				
Akabanda et al ¹⁶	Research article	Food safety	Most food handlers had sufficient knowledge about food hygiene and hence food safety. However, most of them did not know about specific pathogens responsible for causing typhoid fever and diarrhea, <i>Salmonella typhi</i> , and Hepatitis A. Despite this, the majority of them know that typhoid fever and diarrhea are food-borne diseases.	Since the study shows that most people involved in selling food do not have much knowledge of the etiological agents responsible for the food-borne disease. Avoiding them will be difficult without sufficient knowledge about them. Hence the need for education; workshops and training to equip them to avoid food-borne diseases.
Balali et al ¹⁷	Review	Microbial contamination	Etiological agents ranging from viruses, bacteria, parasites, and fungi are found to be responsible for microbial contamination in recent times.	Indication of low hygienic conditions during food preparation and after preparation before consumption.
Ababio and Lovatt ¹⁸	Review	Food safety and food hygiene in Ghana	Most studies on food safety were done in cities and also on commercial street foods. Microbiological safety was the main target with limited information on institutional catering and other categories of hazards. The media is the main source of reporting.	Much need to be done concerning food safety regulations. The use of workshops and training has been recommended.
Quansah et al ¹⁹	Research article	Microbial quality of vegetables	"Vegetable source and type had a significant influence on the microbial counts." "Sampled leafy green vegetables had poor microbial quality"	"Consumption of fresh leafy green vegetables without sanitizing or heat treatment should be discouraged"
Alemu ²⁰	Review	Microbial contamination of notes currency	The currency notes in circulation contain pathogens that are resistant to antibiotics and therefore a public health concern.	Everyone needs to be vigilant and conscious of pathogenic microbes on the currency and therefore employ personal hygiene methods to be safer.
Food poisoning in Ghana				
Addis and Sisay ²¹	Research article	"Heavy Metals and Potential Health Risk Assessment of Honey"	The study showed that concentrations of lead, nickel, copper, and manganese were higher in honey quite above the recommended levels of WHO/FAO.	This means that honey produced and sold in the study area is not completely safe for eating and hence there is a need to monitor and control heavy metals contamination of honey.
Magna et al ²²	Research article	"Exposures and risks associated with the ingestion of lead in the diets"	The study found out that there was a higher risk of lead exposure and hence the risk of cancer development in consumers	The chances of lead consumers are higher and subsequently cancer development hence a public health concern.
Owusu-Kwarteng et al ²³	Thesis report	Microbial contamination of beef	Some microbes isolated include <i>E. coli</i> and <i>Staphylococcus</i> spp. <i>Salmonella</i> spp.	The presence of these pathogens shows that the beef sold is of low microbial quality. The species of <i>E. coli</i> showed that there are possibilities of <i>Shiga toxins</i> contamination.

(Continued)

Table 2. (Continued)

AUTHOR	TYPE OF STUDY	MAIN ISSUE	FINDINGS	IMPLICATIONS/RECOMMENDATIONS
Duedu et al ²⁴	Research article	Microbial quality of pre-cut vegetable salads sold at Tamale	The study found higher loads of <i>Escherichia coli</i> , <i>Bacillus cereus</i> , <i>Salmonella spp.</i> , and <i>Shigella spp.</i> in a decreasing order respectively.	The food safety of vegetables sold at Tamale has been compromised and hence the need for urgent intervention. <i>Shiga</i> -producing toxins pathogens were found and hence possible of this occurs after consumption.
Chemicals in Ghanaian foods				
Tortoe et al ²⁵	Research article	Management and control of food safety among street food and informal market in Ghana.	The study found out that most foods such as Waakye and Kenkey were intrinsically safe while <i>fufu</i> was implicated with pathogenic microbes.	This implies that, to some extent, food sold in Ghana for consumption is somewhat free from pathogenic microbes, and also few of them especially <i>fufu</i> are usually contaminated.
Futagbi et al ²⁶	Research article	Microbial contamination of mangoes in Accra Ghana.	About 25% of mango samples show no presence of pathogenic <i>E. coli</i> , microbial count for both internal and surfaces mangoes	"The study shows that mangoes sold in markets in Accra can pose a health risk to consumers, particularly very ripe ones and those full of scars or punctures"
Toxins in Ghanaian foods				
Blankson and Mill-Robertson ²⁷	Research article	Aflatoxins contamination of cereals.	The study shows that most cereals were contaminated with aflatoxins.	This implies that measures should be put in place to prevent contamination and also harness cereal production chains to enhance food safety standards and save consumers' lives.
Darko ²⁸	Thesis	Microbial safety of food in industries in Ghana.	Found that there were food safety issues in the food industries in Ghana. especially most of them were contaminated with microbes	There is a need to improve practices of food safety standards in the food industries and Ghana. This is to prevent microbial contamination.
Adinortey ²⁹	Thesis report	Antibiotic resistance	The study showed that <i>E. coli</i> isolated in cape coast Ghana was resistant to many antibiotics.	<i>E. coli</i> which was food in foods was also found to be highly resistant to many antibiotics and hence a public health concern.
Saba ³⁰	Research article	"Identification and molecular characterization of bacteria isolated from human, animal, and food origins"	The study found out that, there is "high fecal contamination of street food (Waakye, Jollof, and Macaroni)"	This means that street food sold in the study area is mostly contaminated and hence the need to control measures.
Kunadu et al ³¹	Research article	Antimicrobial resistance of <i>Salmonella</i> in Ghana.	The study revealed that <i>Salmonella</i> was resistant to over ten different antibiotics in Ghana.	This means that consumers of raw milk should be careful not to be infected with this dangerous pathogen. It also calls for a pragmatic control system in the dairy industry in Ghana.

(Continued)

Table 2. (Continued)

AUTHOR	TYPE OF STUDY	MAIN ISSUE	FINDINGS	IMPLICATIONS/RECOMMENDATIONS
Level of education, attitude, and knowledge of food vendors and handlers in Ghana				
Acheampong ³²	Thesis report	Food hygiene practices among food vendors.	"It was also observed that 84.0% of food vendors used the same hands to serve and collect money, 30.3% had not been given a certificate to sell and 89% used their bare hands to serve or dish out food."	Due to significantly low knowledge of cross-contamination issues, most food vendors cross-contaminate food by using the same hand in serving food and also in collecting cash without washing. There is a need for education and training to control the situation.
Ababio et al ³³	Research article	Food safety issues in senior high schools.	The study found that staffs are much more aware of food safety and hence no contamination might call for public health concerns.	Most workers at the senior high school level had much knowledge of food safety and also practised food safety standards significantly.
Malik ³⁴	Thesis report	"Food safety knowledge of food handlers in Ghana"	The study showed that most of the food handlers had sufficient knowledge of food safety issues. However, their attitude still needs some modifications as it scores lower percentages and hence leading to microbial contamination	Though food handlers are quite aware of safety issues, there is a need for education and training to make them know the detrimental effects associated with food contamination. This hopes to modify their attitude.
Malik ³⁴	Research article	"Food Hygiene Awareness, Processing and Practice among Street Food Vendors"	The results reveal that most food handlers had sufficient knowledge of food safety and adhere to the safety standards practices.	This explains the reason why the study did not find most of the foods being contaminated and those few contaminations were a result of hand cross-contamination.
Microbial contamination cases in Ghana				
Mensah et al ³⁵	Research article	"Microbial quality of foods sold on streets of Accra"	Most foods were found to be associated with pathogenic microbes such as enteropathogens pathogens	"Street foods can be sources of enteropathogens. Vendors should therefore receive education in food hygiene"
Annan-Prah et al ³⁶	Research article	Food safety on Street foods in Cape Coast Ghana	The study revealed that <i>Escherichia coli</i> and some fungi were very higher in food samples.	"Stakeholder education, legislation, verifiable microbiological standards, inspections, and environmental sanitation improvement are necessary"
Yeboah-Man et al ³⁷	Research article	"Bacteriological quality of ready-to-eat foods"	The study documented that many ready-to-eat foods in Accra are contaminated with " <i>E. coli</i> , <i>Klebsiella pneumoniae</i> , <i>Streptococcus</i> sp., <i>Enterobacter cloacae</i> , <i>Bacillus</i> sp., <i>Pseudomonas aeruginosa</i> , <i>Staphylococcus aureus</i> , <i>Proteus</i> sp., <i>Streptococcus agalactiae</i> and <i>Enterococcus faecalis</i> ."	"Consequently, current results call for a more rigorous supervision by the public health department of the university to protect the university community from the future occurrence of food poisoning"
Feglo and Sakyi ³⁸	Research article	Bacterial contamination of food	The study found the following pathogens to be associated with street foods. " <i>Staphylococci</i> , <i>Bacillus species</i> , <i>Klebsiella pneumoniae</i> , <i>Aeromonas pneumophila</i> , <i>Enterobacter cloacae</i> , <i>Staphylococcus aureus</i> , <i>Escherichia coli</i> , and <i>Pseudomonas aeruginosa</i> ."	This means that street foods are not completely safe and hence there is a need for control measures taken to ensure the complete safety of consumers.

(Continued)

Table 2. (Continued)

AUTHOR	TYPE OF STUDY	MAIN ISSUE	FINDINGS	IMPLICATIONS/RECOMMENDATIONS
Atter et al ³⁹	Research article	"Safety of a street vended traditional maize beverage, ice-kenkey, in Ghana"	The study revealed that there were no coliform bacteria found in <i>Kenkey</i> sold in Ghana, a traditional beverage.	<i>Kenkey</i> in Ghana is somewhat safe for drinking. However, it sometimes contains aflatoxins and hence the need for safety concerns.
Pesewu et al ⁴⁰	Research article	Bacterial quality of "Quality of Raw-mixed Vegetable Salads"	" <i>Escherichia coli</i> (35%), <i>Staphylococcus aureus</i> (33%), <i>Klebsiella</i> sp. (17%), and <i>Bacillus</i> sp. (15%)"	"Ghana had high bacterial contamination and their persistence and proliferation is a reflection of poor hygienic practices by the street food vendors."
Yeleliere et al ⁴¹	Review article	"Review of microbial food contamination and food hygiene in selected capital cities of Ghana"	"Based on the review, the most predominant bacteria isolated in Ghanaian foods were <i>Enterobacter</i> spp., <i>Escherichia</i> spp., <i>Staphylococcus</i> spp. and <i>Pseudomonas</i> spp."	The paper stated that the most abundant pathogens isolated recently from foods in Ghana are " <i>Enterobacter</i> spp., <i>Escherichia</i> spp., <i>Staphylococcus</i> spp. and <i>Pseudomonas</i> spp."

Table 3. Food safety issues in Nigeria.

AUTHOR	TYPE OF STUDY	MAIN ISSUE	FINDINGS	IMPLICATIONS/RECOMMENDATIONS
Food sanitation concerns and contamination in Nigeria				
Sonaiya ⁴²	Research article	15 year of family poultry research and development at Obafemi Awolowo University, Nigeria	It was investigated that vaccination plus supplementation enlarged flock size, reduced death, and the number of chicks produced per hen per year also increased.	The study implies that a combination of vaccination, feeding, housing, breeding, and farmer training has been industrialized into a smallholder family poultry model for food security and poverty alleviation for rural people.
Ogundele et al ⁴³	Research article	Wastes dispersal	The study reported evidence of improper waste disposal and inhabitants of such areas have suffered numerous health effects.	"all levels should adopt an integrated waste management system with appropriate policy agenda, public programs and strategic action plans that will enhance environmental governance and end indiscriminate waste disposal"
Food poisoning in Nigeria				
Adeyemi et al ⁴⁴	Research article	"effects of calcium carbide as a fruit ripening agent"	The study shows that "even though calcium carbide may have significant fruit ripening ability, it also causes a significant reduction in the fruit nutrients for the Kaduna populace"	This implies that calcium carbide is not sufficiently recommended for fruit ripening.
Cases of food safety in Nigeria				
Biological cases with regards to the microbial origin				
Odeyemi ⁴⁵	Review	Antimicrobial resistance of <i>Aeromonas hydrophila</i> isolated from different food sources	The study shows <i>A. hydrophila</i> has been isolated from meat and, milk, meat products, and vegetables.	This implies that the presence of antimicrobial-resistant <i>A. hydrophila</i> in food poses dangers to the public and aquatic animal health.

(Continued)

Table 3. (Continued)

AUTHOR	TYPE OF STUDY	MAIN ISSUE	FINDINGS	IMPLICATIONS/RECOMMENDATIONS
Iwu et al ⁴⁶	Research article	"Knowledge, Attitude and Practices of Food Hygiene among Food Vendors in Owerri, Imo State, Nigeria"	"The study revealed that there were statistically significant relationships between knowledge, formal training on food hygiene, attitude and the level of food hygienic practices."	"It is therefore recommended that public health management involve the development of strategies that will equip them with the necessary knowledge and skills to provide vending services hygienically and safely."
Ezirigwe ⁴⁷	Review	"Much ado about food safety regulation in Nigeria"	"The results reveal that regulators, enforcement officers, lawmakers, food handlers and even the consuming public do not pay attention to food safety very seriously"	This demonstrates that if the definition of "food" in the food laws is extended, in line with best practices and recent realities, to allow for comprehensive directives and coordination of the food chain system then there will be a decrease in food poisoning.
Onyeneho and Hedberg ⁴⁸	Research article	An Assessment of Food Safety Needs of Restaurants in Owerri, Imo State, Nigeria	The study shows that all respondents said that they washed their hands after handling raw meat, chicken, or fish.	This suggests that the lack of present knowledge of food safety among restaurant staff highlights increased risk associated with fast foods.
Nnebue et al ⁴⁹	Research article	Assessment of the food hygiene practices of food handlers in the Federal Capital Territory of Nigeria	The results reveal that One hundred and fifty (89.3%) of them wash their hands after the use of toilets, while only 44 (26.7%) change their hand gloves at work.	It is therefore recommended that there should be education regularly on basic personal, self-care, hygienic techniques, and good housekeeping practices.
Faremi et al ⁵⁰	Research article	Food Safety and Hygiene Practices among Food Vendors in a Tertiary Educational Institution in South Western Nigeria	The study shows that "Knowledge of food safety among respondents showed that 76 (31.9%) of respondents had adequate knowledge on transmission of foodborne diseases while 160 (67.2%) had inadequate knowledge."	This implies that vendors need education on safe hygiene practices knowing that knowledge without practice is bitty and useless.
Idoga et al ⁵¹	Research article	Analysis of Factors Contributing to the Spread of Cholera in Developing Countries	It was identified that floods and lack of environmental hygiene and improper sewage disposal were the core causes of the spread of cholera in Benue State.	The research highlights the reasons aiding the spread of cholera in Nigeria by directing government donor agencies to channel their focus and prepare ahead because of an emergency.
Dan-Nwafor et al ⁵²	Research article	"A cluster of nosocomial Lassa fever cases in a tertiary health facility in Nigeria: Description and lessons learned, 2018"	The study says HCW interviews identified a low index of suspicion for <i>Lassa fever</i> leading to inadequate infection prevention and practices as possible contributing factors to nosocomial transmission.	This means there is a need to train and sensitize HCWs on strict adherence to hygiene while providing care, irrespective of a patient's provisional diagnosis.
Metals and chemical poisoning of food, the Nigerian cases				
Orisakwe et al ⁵³	Review	"Heavy metals in miscarriages and stillbirths in developing nations"	The research discloses that miscarriages and stillbirths were observed from exposure to five heavy metals namely; mercury, chromium, lead, arsenic, and cadmium.	This suggests that medical practitioners involved in women's health in sub-Saharan Africa should consider if these heavy metals can become extra biomarkers in the analysis of miscarriages and stillbirths.

(Continued)

Table 3. (Continued)

AUTHOR	TYPE OF STUDY	MAIN ISSUE	FINDINGS	IMPLICATIONS/RECOMMENDATIONS
Adeleke ⁵⁴	Case report	Food poisoning	The study revealed the use of lethal preservatives in yam floor processing might be responsible for the case of food poisoning.	Proper processing of yam floor should be ensured to prevent public health implications
Tirima ⁵⁵	Research article	“Unknown risk: co-exposure to lead and other heavy metals among children living in small-scale mining communities in Zamfara State, Nigeria”	The study reveals that environmental pollution in Bagega village, examined by X-ray fluorescence of soils, includes mercury, lead, cadmium, manganese, and arsenic.	This means Zamfara state presents an extreme picture of both lead and multiple heavy metal morbidity and mortality, but related situations have become increasingly prevalent worldwide.
Okiei et al ⁵⁶	Review	Determination of Copper and Lead in Water Samples from Zamfara State, Nigeria by Linear Sweep Anodic Stripping Voltammetry	The results indicate that in addition to lead poisoning, copper poisoning may have contributed to the mass mortality in the areas.	This suggests that there will be more mortality rate among the inhabitants.
Nwosu et al ⁵⁷	Short communication	“Arsenic Exposure from Bean Seeds Consumed in Owerri Municipal, Imo State, Nigeria”	“The pooled mean total arsenic was 0.47 µg/g while the estimated daily mean dietary intake of total arsenic was 32.9 µg/g for a typical adult in the place. This value is below the permissible limit of 18-480 µg/day for an adult at the average weight of 60 kg established by the European Food Safety Authority”	“This suggests that bean seeds, sold and consumed in Owerri Municipal, do not have inherent and acquired arsenic-associated health risks”
Knowledge and personal hygiene of food handlers in Nigeria				
Iwu et al ⁴⁶	Review	Knowledge, Attitude, and Practices of Food Hygiene among Food Vendors in Owerri, Imo State, Nigeria	“It was also showed that there were statistically substantial relationships between attitude, formal training on food hygiene and the level of food hygienic practices.”	“The public health management of food vending services should be equipped with the necessary skills and knowledge to provide vending services hygienically and safely.”
Pepple ⁵⁸	Research article	Food poisoning	The water source is of the open market “40% had knowledge of Hepatitis A as a food-borne pathogen, 20%, had knowledge of <i>Salmonella</i> , 21%, <i>E. coli</i> , and 12% <i>Listeria</i> and 7% had knowledge of <i>Vibrio</i> as pathogens.”	“Lack of knowledge on safety and hygiene practices among food vendors (owners and staff) indicates the increased risks of food poisoning associated with the food vendors and restaurants.”
Oludare et al ⁵⁹	Research article	Knowledge and food handling practices	The study posits that most respondents had good knowledge of food and personal hygiene practices and most of them do practice this during working hours.	The level of education has a tremendous impact on food handling and practices.
Umar et al ⁶⁰	Research article	“Personal and food hygiene practices among food vendors”	All food vendors do not have any formal training or education on food and personal hygiene. Also, about half of the vendors do not practice personal and food hygiene. However, most of them had a good environment where their food is sold.	Lack of education has been a problem among food vendors in Nigeria, it has contributed to too many vendors contaminating their food before consumption. There is there for a need for conscious education of food vendors in Nigeria.

(Continued)

Table 3. (Continued)

AUTHOR	TYPE OF STUDY	MAIN ISSUE	FINDINGS	IMPLICATIONS/RECOMMENDATIONS
Nwanta et al ⁶¹	Review	Abattoir operations and waste management in Nigeria: A review of challenges and prospects	This paper shows the present state of the Nations abattoir operations and waste management and also discussed the problems and prospects of the industry concerning environmental quality and public health.	The paper determines that Local governments should be encouraged to build and manage abattoirs, slabs, and slaughterhouses nationwide for more effective management.
Obidiegwu et al ⁶²	Review and field activity report	"Public Health Challenges in Somachi Main Abattoir Owerri"	The study recommended that the abattoir should be upgraded to a modern standard with all facilities to meet food hygiene and safety standards. It is also recommended that all workers get educated and updated on new ways of hygiene practice at the abattoir.	It is evident that many places where the meat is processed are turned to pollute the environment but good policies and functional facilities, regulation education and training of workers and updates on new ways of work will impact the meat industries.



Figure 2. Factors that determine the safety of foods.

caffeine to most drinks or caffeine substances to boost alertness in consumers.⁶⁹ Some food handlers also have very poor personal hygiene, poor environmental sanitation, and prepare food in contaminated environments, shocked gutters, and other

places prone to higher amounts of most etiological agents responsible for causing foodborne illnesses¹⁶ (Figure 3).

Food poisoning occurs when chemical agents from microbes such as toxins, for example, *Shiga* toxins are present in food and can cause illness to consumers either animals or humans.²¹ Numerous studies in Ghana have revealed the incidence of chemical poisons such as lead, arsenic, and others.^{22,70} In the year 2013, a study revealed the occurrence of lead in street food sold in Ghana.²⁵ Other studies revealed the existence of numerous other chemical substances which are at a dose of even harming humans and animals instantaneously.¹⁸ Chemicals contaminations come from the water and pesticides used in the production of crops, especially fruits and vegetables.¹⁸ Notwithstanding, studies on fresh produce also recorded the incidence of pesticides and other chemicals in salad and other vegetables and fruits.⁷¹⁻⁷⁴ Fertilizers and other manures such as fecal matter from both animals and humans used for farming without treatment also serve as a source of contamination.¹⁹ Similarly, some other studies have also confirmed the occurrence of microbial toxins in foods such as those of *Staphylococcus aureus*, *Escherichia coli*, *Campylobacter*, *Listeria*, and others.^{23,75,76} Also, markets and handling matters revealed the highest levels of potential contaminations sources.²⁰ Farming practices are the major main sources of physical and chemical contamination.⁷⁷

Level of Education, Attitude, and Knowledge of Food Vendors and Handlers in Ghana

Studies on sanitation concerning food vendors, and other catering services documented low standards of food hygiene practices among them.^{18,32,33,78} Low education has also been of great deterrent in the Ghanaian government to mitigate foodborne illness.³³ Some of the workers responsible for handling food in the food preparation process have little or no knowledge about food poisoning, contamination, and even

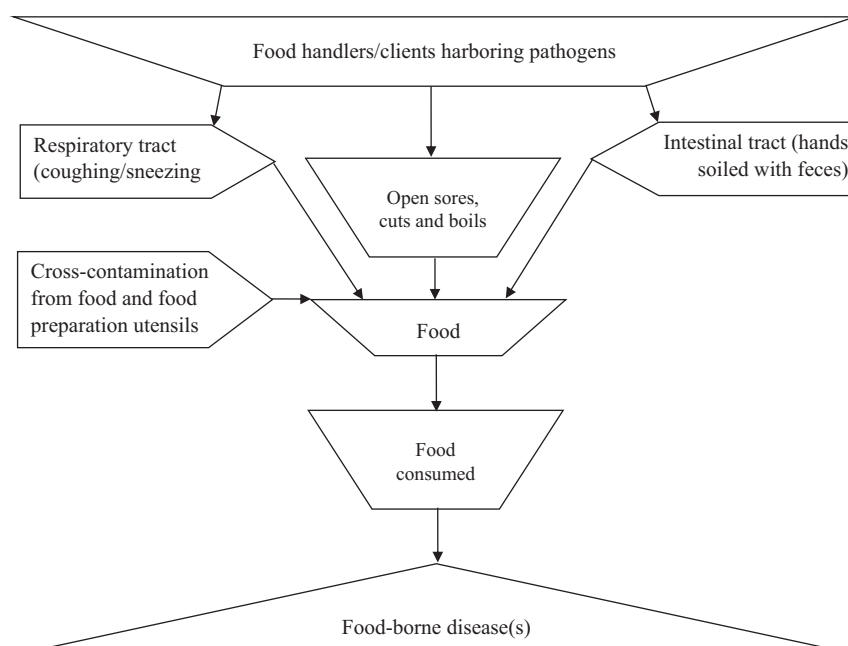


Figure 3. Schematic diagram for the origin of foodborne illness.

hygiene as a whole.^{78,79} A study conducted directly on the education level of food vendors in Ghana provided beyond doubt results that significantly show that most food vendors have little or no education at all on food hygiene, appropriate food handling, appropriate food processing coupled with the right techniques, and others.³⁴

Moreover, 2 studies documented that most food vendors do not practice the basic hygiene required of them and per the standards of the food regulations in the country.^{66,78} The study shows that pressure on food vendors leads to many of them not being concerned about the safety of the food, especially at most fast-food joints. Vegetables and other fresh produce,^{24,26,80} local and exotic chickens,⁸¹ kebabs joints, and chemical contamination.⁸² It can be concluded here that many food vendors and handlers are yet to accept and practice to capacity the basic hygiene principles about food in Ghana.

Studies have documented numerous etiological agents isolated from the Ghanaian currency, which is the Ghana cedi⁸³ other studies such as^{18,32} also show that over 80% of food handlers and vendors receive cash and use the same hands without washing to serve food (bare hands 89%) to customers.^{32,35,84} The worst is that over 29% of the food vendors are illegal.³² They are not having any certificate concerning operational certification. Still,³² a microbiological study on such foods documented that most of the foods contain fecal coliforms over 58% of them, dangerous *Salmonella typhi* was found to represent 12% although *Staphylococcus aureus* had 62%, *Escherichia coli* was 41.7%. Acheampong concluded that the levels of these pathogens were quite above acceptable levels.³² Food hygiene practices have been a challenging issue when it comes to food vendors due to lack of education and most unwillingness to adhere to such rules,⁸⁵ however, for the safety of Ghanaians, and also for economic growth and development,

all efforts must be put in place to ensure that they are educated and practice what they have learned.

Microbial Contamination of Food Cases in Ghana

Numerous bacteria cause contamination of food and lead to poor quality of food and sometimes food poisoning. There has been the isolation of numerous bacterial pathogens in both Ghana and Nigeria. Studies conducted on the microbial quality of salad in Kumasi Ghana revealed the presence of *Enterobacteria*, *Salmonella*, *Shigella*, *E. coli*, *Campylobacter*, *Listeria*, and other pathogens which are not even of bacterial origin.^{17,41,86} Parasites have also been found to be associated with food in the Ashanti region of Ghana, especially Kumasi. A study at Pankrono Kumasi revealed the presence of numerous parasites in local and exotic chickens sold at marketplaces.^{17,81}

Numerous studies in Ghana showed the presence of pathogenic agents responsible for causing several foodborne diseases. Notable is a study³⁵ conducted in the capital city of Ghana found that mesophilic bacteria was about 69%, but *Staphylococcus aureus* was 31%, *Bacillus cereus* was 5.5% and *Enterobacteriaceae* was 33%. The study also shows that entero-aggregative *Escherichia coli* and *Shigella sonnei* were found to be associated with macroni, tomato set, and rice and light soup containing *Salmonella arizonae*.

Similarly, reports from Cape Coast Indicated bacterial contamination of meat pie, fried fish, banku with stew, khebab, and others.³⁶ These bacteria included dangerous *Escherichia coli* from human fecal matter and some fungi were also found in the food said to be "*Aspergillus flavus*, *Aspergillus candidus*, *Aspergillus niger*, *Cladosporium herbarum*, *Penicillium citrinum*, *Necrospora crassa*, *Rhizopus*, *Mucor* and *Fusarium* species". In the year 2010, *Shigella* spp., *Escherichia coli*, *Salmonella* spp., and *Enterobacteriaceae* have also been found in most foods sold in

Ghana especially in Accra with a contamination rate of 52%. These values were quite above the acceptable levels recommended by the WHO.³⁷

Most ready-to-eat foods including vegetables, fruits, ice-kenkey, “fufu,” macroni, salad, and others were highly contaminated with enteric bacteria which are capable of producing Shiga toxins for poisoning the food.³⁸

Also, the existence of coliform bacteria such as *Staphylococcus aureus*, *Escherichia coli*, yeast, and aerobic mesophilic, moulds in some foods sold in Tema and Accra especially ice-kenkey were confirmed.³⁹ Another study in 2014 revealed that some vegetable products such as salad sold in Kumasi Ghana demonstrated higher levels of pathogens such as rotavirus.⁸⁷ Similar studies were conducted in Accra which also revealed contamination levels of *Escherichia coli* to be 35%, *Staphylococcus aureus* to be 33%, *Klebsiella* spp. to be 17%, and finally, *Bacillus* spp. 15%.⁴⁰

Numerous pathogens have been found in foods in Ghana and have been isolated. A review heightened that, these isolates have a strong link with food-borne illness in the country and hence the need for food safety actions.¹⁷

In recent times, a study established the existence of dangerous mycotoxins and pesticides in food sold in Ghana.²⁷ In 2017, Darko did a similar study in Accra, and mycotoxins were still found in foods indicating that food vendors had done nothing or little has been done to control the contamination of food with mycotoxins.²⁸ The presence of Shiga toxins producing *Escherichia coli* and *Shigella* spp in foods in Ghana indicates that such foods should be contaminated with the toxins.^{29,88} Also, heat-stable toxin-producing *Staphylococcus aureus* is associated with several foods sold on the streets of Ghana and in restaurants.³⁰ The reports on the outbreak of Listeriosis in South Africa cautioned the Ghanaians and the government to put measures in place to prevent the outbreak of that disease in Ghana. The etiological agent of Listeriosis is *Listeria monocytogenes* a bacteria capable of producing extremely poisonous toxins that are highly fatal.^{23,89} A study also found *Salmonella* to be associated with fresh milk in Ghana.³¹ This pathogen has been isolated in Ghanaian foods and therefore a cause for alarm.

This review shows that most foodborne cases have been associated with *Enterobacter* spp., *E. coli*, *Staphylococcus* spp., *Pseudomonas* spp., and some fungi and viruses in decreasing order of occurrence. Some reviews had similar trends including⁴¹ however⁸⁹ found the opposite except for fungi and viruses. However, most reviews accepted *Enterobacter* spp to be the most isolated organism from most foods sold in Ghana.

Food Safety in Nigeria

In Nigeria, despite numerous and diverse techniques to solve the problem of food safety, there are still many challenges with this topic in the minds of the people. For food to be secured, then every individual, at any material moment, must

have economic access to enough, nutritious but safe food to correspond to their nutritive needs for a good and healthy life.⁹⁰ It is general knowledge that the nutritional quality of a country is determined by food producers (farmers) and management by food processors. In Nigeria health sector reports that over 50% of deaths among children are a result of food safety in Nigeria.⁹¹ Malnutrition alone contributes to over 50% of all deaths among children death in Nigeria.^{92,93} Meanwhile, several studies from different other countries have proven that foodborne illness contributes to the highest part of food safety in a country.⁹⁴⁻⁹⁶ In Nigeria, Foodborne Diseases (FBDs) remain more deadly than Vector-Borne diseases. The government spends a projected amount of US\$3.6 billion per annum as the cost for FBDs.⁹⁷ This makes it the leading strain on the healthcare system in Nigeria. Diarrhea alone accounted for “US\$854 million” annually as of 2011.⁴⁷

The government of Nigeria has in the past employed tremendous efforts to curtail the problem of food safety. Many organizations have been set up by the government, yet this problem is getting out of hand. It is surely impossible to estimate correctly the levels of foodborne damages to the country. Few cases are reported and analysis is usually based on that.⁹⁸ Unlike Ghana, where many cases are reported, production is far more than population growth, malnutrition is under control, and cholera, typhoid fever, and other disease are now somewhat calm in Ghana.

Food Regulations and Organizations in Nigeria

In the year 2000, the National Policy for Food System and Implementation Strategy (NPFSIS) Policy on Food Hygiene and Safety (FHS) was successfully launched in Nigeria as included in its National Health Policy officially. It has been reported that “Responsibilities for food safety and hygiene practice devolve on different tiers of government and their agencies—federal, state, and local.”⁹⁹ In Nigeria, enforcement of food safety laws and other regulations about the universal safety of food is done mostly at the local level.¹⁰⁰ At the local government, a section has been created to be responsible for carrying out the duties of enforcing laws concerning public health. These laws include all regulations concerning food handling, food hygiene, food safety, catering establishment, etc. Some circumstances warrant the enactment of by-laws at the local government council level to control the problem of food safety within food premises.

Some laws in Nigeria specifically for regulation and control of food include “Standards Organization of Nigeria Decree (1971), the Marketing of Breast Milk Substitute Decree number 41, (1990), the Food and Drugs Decree number 35 (1974), The public health Law/Ordinance Cap 164 (1917/1958), and the Animal Disease Control Decree number 10 (1988).” Others include “National Agency for Food and Drugs Administration and Control (NAFDAC) Decree, number 15 (1999), Consumer Protection Council Decree number 66

(1992), and the Counterfeit/Fake drugs/unwholesome processed Food Decree, number 15, 1999.”¹⁰¹ Following the literature, there is a need to revise the present legislation on food safety in Nigeria as most of them are not applying the current society and food trends in the realities of today’s world.

Cases of Food Safety in Nigeria

The ingestion of food or drinks contaminated with microbes or other chemical substances giving rise to illness or abnormal functioning of the body can be said to be a foodborne disease.¹⁰² Throughout the entire globe, FBDs have been a big problem with an estimated 47.8 million FBDs occurring in just a year.¹⁰² The United States accounts for about 2 million cases while Australia and the United Kingdom account for 5.4 million and 2 million cases each year respectively.¹⁰² With regards to Nigeria, most cases of foodborne illness and food safety are not been reported frequently but documents have it that over 90 000 cases are reported every year.⁴⁵ Australia as a developed country suffers from food safety issues with its population being about 1:7 of Nigeria, Australia records over 4.1 million cases of gastro and over 230 000 reports of *Campylobacter* and *Salmonella* accounting for over 55 000 reports.⁴⁵ With regards to the population ratio of Nigeria and Australia, it is obvious that many cases of food safety have not been reported, and could even be over 8 million cases unreported. Based on the high unreported incidences in Nigeria and other developing countries, it will be difficult to design a solution to foodborne illness to meet the situation of the country. Other issues such as the self-prescription of medication instead of going to the hospital and being treated by a medical professional are also other problems. FBDs comes with symptoms such as diarrhea, vomiting and fever which are usually seen as common illness and therefore handled by buying drugs from pharmacy shops and taking self-prescribe medication.⁴⁶

Though there are high levels of unreported cases of FBDs in Nigeria, a few have been reported. For instance, 20 deaths were recorded in Ibadan, Oyo State as a result of consumption of incorrectly preserved sandwiches said to have been contaminated with *Salmonella*. It has been documented that, food poisoning occurred in Ambrose Alli University and other surrounding environments as a result of *staphylococcal aureus* poisoning.⁴⁷ In another report, 3 people died and a total of 60 incidences were recorded as a result of eating food during a burial ceremony giving rise to gastrointestinal infections.⁴⁸ Furthermore, 62 people died in the year 2017 at a settlement where most of its inhabitants were Fulani herdsmen as a result of zoonotic bacterial infection responsible for gastroenteritis diarrhea disease.⁴⁷

Intestinal parasites were also isolated from some food handlers’ stools in Ibadan, and the Federal State Capital Territory,⁴⁹ Nigeria, where their loads were said to be extremely higher than expected.¹⁰³ The study concluded by suggesting that food

handlers should be screened and treated for all forms of FBDs and thought on the general food safety regulations and being supervised the practice of the regulations to the best of their capacities. Lack of standardized hygiene practices could be a source of infections of numerous intestinal helminths, entero-etiological bacteria, and some protozoans.

The use of unsafe water and other equipment in the food production chain contributes to the risk of contamination. International organizations such as WHO maintains that “one of the key principles of food safety is the use of safe water and raw materials for food preparation.”¹⁰² The research indicated that the higher prevalence of Lassa fever in Ekiti State specifically Are-Ekiti rural community was a result of bad practices of processing in the contaminated environment.⁵⁰ Such cases were all dominated by one method called “sundry” a method popularly used for food preservation in that community. For Nigeria, waste disposal alone is a threat to the consumption of food in the country. Most wastes are not properly disposed of providing a breeding site and habitat for most vectors of numerous diseases.^{104,105} Most etiological agents such as those responsible for causing disease and conditions such as infantile diarrhea, typhoid, and even almighty cholera in humans are encouraged to persist in such environments.¹⁰⁵

Cholera in Nigeria is said to be endemic and hence seasonal infection.⁵¹ Cholera is said to be higher prevalent during the rainy season in the country and higher again in places where there is very poor sanitation. The outbreaks of cholera in Nigeria can be traced way back to 1970 and 1990 with higher incidences occurring in “1992, 1995-1996, and 1997.”¹⁰⁶ Reports indicate that over 37 200 cases of cholera have been reported in the year 2010 with as many as 1434 deaths.¹⁰⁷ In the year 2011, a similar incidence occurred whereas many as over 22 700 cases were reported and over 720 mortalities with the case-fatality rate being 3.2%¹⁰⁷ in recent times meanwhile Ghana is almost eradicating cholera,¹⁰⁸ and Nigeria 2018 still records over 24 400 cases of cholera with about 830 deaths whilst the case-fatality rate is 1.95% with records from only 20 states out of the total of 36 states in the genesis of 2018 to around October.¹⁰⁹ Cholera cases in 2019 have also been reported recently in Nigeria.⁵²

The burden of diseases like diarrhea in Nigeria is something the government cannot conclude as it is being settled. As of 2014, diarrhea alone accounted for about 5% of the Nigerian general mortality rate among other numerous causes of death in the country.¹¹⁰ Documents have it that, the incidence of childhood diarrhea alone in Nigeria is about 18.8%.¹¹¹ For those children under 5, diarrhea has been responsible for more than 16% of deaths.¹¹² This has been estimated to be about 150 000 cases yearly.¹¹⁰ The higher prevalence of diarrhea in Nigeria has been attributed to the consumption of unsafe water and other issues such as the preparation of food under unhygienic conditions.

Metals and Chemical Poisoning of Food, the Nigerian Cases

Unlike Ghana, many food safety issues concerning food poisoning in Nigeria have been associated strongly with the abuse and sometimes misuse of chemicals used in the food production chain, especially agrichemicals. Lead poisoning has also been recorded in Nigeria.⁵⁵ In addition to heavy metals contamination, Zamfara State also recorded contamination of both lead and copper in water.⁵⁶ Nigeria, a country that has been recognized as among the leading countries with higher consumption of antibiotics, especially for veterinary services has been implicated.^{113,114} Remains of some antibiotics such as erythromycin, tetracycline, penicillin, and streptomycin in some livestock products and even poultry meat have been reported frequently.^{115,116} Some reports indicate that the values are quite higher than that of the recommended levels of the WHO.¹¹⁶ Not only antibiotics are used abysmally in Nigerian agriculture, but also pesticides. Though these chemical formulations are a necessity in today's agriculture, they have also been found to be a deterrent to human and other animals' lives. For instance, in Nigeria, it has been found that pesticides have been used for shielding livestock and crops from numerous infections and pests, and even in fishing.⁴⁷

Farmers in Nigeria also use pesticides to preserve harvested crops such as vegetables including cabbages, carrots and others, beans, and various grains to protect them from the infestation of insects.¹¹⁷ Despondently, the international market has rejected most of the products from Nigeria as a result of higher levels of pesticides remaining in such products. Storage chemicals in Nigeria have also been implicated directly as a reported food poisoning as a result of chemicals used during storage has been demonstrated in Owerri Municipal, some individuals were hospitalized as a result of consumption of pesticide preserved beans.⁵⁷ Still, some students in a second-cycle institution at the Gombe State fell ill after consumption of food said to be containing higher levels of pesticides.¹¹⁸ Some dangerous chemicals such as carbide and balms including other insecticides used in Nigeria for the ripening of fruits have been implicated as well.¹¹⁹

Knowledge and Personal Hygiene of food Handlers in Nigeria

In Nigeria, several reports have demonstrated the levels of knowledge of food handlers and their levels of personal hygiene, organizational hygiene, and environmental hygiene concerning food safety regulations practices indicating that there is a need for rigorous work in the food industry to ensure total food safety in the country.^{46,59,120} Research conducted in Owerri, specifically Imo State, revealed on "knowledge of food handlers on food safety protocols," under various types of food establishments demonstrated very poor knowledge of etiological agents and practices concerning food safety to prevent the association of etiological agents with food.⁴⁶ Many of the respondents did

not know that a sick person could also transfer the etiological agents to food (Figure 3). This is one of the major reasons for the invasion of numerous etiologic agents in food environments and probably food itself in Nigeria. Another research conducted in Garki, specifically at Abuja stated that many foods handlers lack the knowledge on "food safety and hygiene practices" after an assessment of their level of knowledge on various perimeters on food safety such as "knowledge of food safety in general," "contamination," "food poisoning," and "control measures." Respondents included both food vendors and owners of the vending company.⁵⁸ Additionally, a study was conducted on the knowledge of nurses who are also food handlers in a tertiary care health care setting and the results indicated that most of them had little knowledge yet does not even practice the knowledge they had.⁵⁹

Concerning various display methods exhibited by food markets including butchers, sellers, and others in Nigeria. Research conducted in the eastern part of Nigeria revealed abysmal and unsanitary conditions concerning the display of food. For instance, it was found that customers usually in their attempt to choose the biggest meat, use unwashed bare hands to touch the food which could probably contain microbes that could contaminate the meat.⁶⁰ Not only customers but even the butchers display the products without any form of coverage to protect them from flies.⁶¹ Most display joins had numerous flies hovering over the meat. The worst has been found with the sellers of the food where raw meat and other food products are been taken with the same equipment used to serve cooked food.⁶² This has been said by the researcher as a source of cross-contamination.

Unlike Ghana where many customers are not likely to buy food with many flies hovering around it, Nigerian consumers wake up one morning and they were advised throughout social media to rather eat food with many flies hovering around them. This was a result of many people who consumed chicken falling ill even news reported this and many photos showed disintombing truckloads of chicken which were said not to be right for human consumption. Nothing as such happened in Ghana but rather imported products have been implicated by the social media in Ghana to be contaminated with some viruses of which there was no proof.

Comparing Food Safety of Nigeria and Ghana

The burden of foodborne illness leads to over 75% of death in Africa which is much higher compared to other continents due to several factors including inadequate access to health facilities.⁹⁰ Nigeria as a populous and transiting African country from lower to middle-income status as a matter of urgency must increase its food safety concerns due to the risk of an upsurge in foodborne illnesses.¹²¹ Havelaar et al⁹⁰ stated that the Nigerian region of the World Health Organization (WHO) monetary expenses have increased as a result of the high foodborne illness which usually arises from diarrheal

diseases and helminths. In the same way, WHO reported a higher incidence of diarrheal cases in Ghana.¹⁸ The safety of most foodstuffs in Ghana and Nigeria is altered and this occurs at any point along the food chain continuum, especially at the point of sales.¹²² However, the treatment of foodstuffs by consumers highly reduces the risk of contamination.¹²³ Though a lot of measures and policies have been established by the Nigerian government regarding food safety, they are not well enforced.¹²⁴ Okoruwa and Onuigbo-Chatta¹²⁴ assert that these policies' coordination amongst various state stakeholders is poor and that inspection, as well as surveillance, has rarely improved. Recently research added that data collection, analysis, and dissemination of reports concerning food safety by the majority (95%) of state agencies were not done but only a little percentage of them were able to combat outbreaks with the well-organized system.¹²⁵ In Ghana, the assurance of food safety is ensured by several governmental bodies, a central body being the Food and Drug Authority.¹²⁶ It is involved in inspecting products, manufacturing companies, and licensing and monitoring products to ensure compliance with food safety standards. However, knowledge of good hygiene practices is very poor amongst food handlers due to low standards of education in Ghana¹²⁷ which agrees with what Grace et al⁹⁸ reported in Nigeria. Moreover, research on microbial food safety of food is declining and thus more studies ought to be conducted.⁸⁹ In both Ghana and Nigeria, food safety studies focused on only urban areas especially Accra in Ghana and Nigeria, which is in the south and central region. Most studies reported that in Nigeria, the origin of foodborne illnesses occurs as a result of insufficient food safety originates from vendors and ready-to-eat foods. In Ghana, however, food safety issues were reported amongst commercially sold street foods and most seriously in institutional catering food services.¹⁸ Moreover, microbial safety of ready-to-ready foods as well as chemical contaminations in vegetables and fruits especially originating from pesticides have been reported.¹²⁸ This necessitates adequate reports and awareness in both countries to improve food safety concerns.

Conclusions

Food safety is a major concern in Sub-Saharan Africa due to the absence of standard cognizance, education, and maintenance of a hygienic environment, which are effective ways to improve food safety. The literature reviewed in this work showed that the most predominant etiological agents isolated in Ghanaian and Nigerian foods are *Enterobacter* spp., *Pseudomonas* spp., *Campylobacter* spp., *Escherichia coli*, *Staphylococcus* spp., *Aspergillus flavus*, and *Aspergillus niger*. This research work unveiled that food safety challenges do not only involve food poisoning but also pinpointed others such as post-harvest losses, food contamination, poor climatic conditions, financial constraints, and the dormant nature of food laws.

It is very promising that with an active advancement and improvement in technology, good personal hygiene practices, and proper education, challenges to food safety in Sub-Saharan African counties would be curtailed. Despite all these challenges food production in Sub-Saharan Africa is gradually becoming higher, the ministry in charge of Agriculture together with other bodies has put in place urgent measures to tackle these challenges. The growth in Agriculture has helped to reduce poverty in Sub-Saharan African countries such as Ghana and Nigeria. These interventions have led to some countries such as Ghana becoming self-sufficient.

This research work unveiled that food safety challenges do not only involve food poisoning but also pin-pointed others such as post-harvest losses, food contamination, poor climatic conditions, financial constraints and the dormant nature of food laws. Improper handling of food at the local markets and vending sites is a great cause of food contamination in SSA, however, there is not much attention to the application of food safety standards. The food industry has more room for improvement. Good hygiene Principles need to be regulated and enforced. The FDA is a national regulatory body under the Ministry of Health with the power to implement food policies and ensure the safety and wholesomeness of food for consumers. They, therefore, need to strengthen their policies and make them active. People found of producing unwholesome food products should be punished and products ceased. The Ghana Standards Authority is also a body that ensures consumer protection and improved quality and reliability of food. In Nigeria this is not an exception, food laws are relaxed. The National Agency of Food and Drug Administration and Control (NAFDAC) is a regulatory authority with the mandate to regulate and control the manufacture, importation, exportation, advertisement, distribution, sale and use of food. The Standards Organization of Nigeria is also responsible is a body which aims at preparing standards relating to products, measurements, materials and processes among others. It is very pathetic to realize that in all these bodies contaminated foods are still produced and sold in local markets. This calls for the need to probe into the role played by these Authorities in ensuring food safety. There is not much data about food safety in Ghana and Nigeria. Most works centered on food safety at the consumption level and did not give directions for future research.

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Author Contributions

All authors contributed equally to the literature search and writing of the manuscript, and have finally approved the manuscript for publication.

Availability of Supporting Data

All data used for the study have been included in this article.

Consent for Publication

All authors have consented to the publication.

REFERENCES

- King T, Cole M, Farber JM, et al. Food safety for food security: relationship between global megatrends and developments in food safety. *Trends Food Sci Technol*. 2017;68:160-175.
- WHO. *World Health Organization: Global Status Report on Food Safety 2015*. World Health Organization; 2015.
- WHO. *Investing to Overcome the Global Impact of Neglected Tropical Diseases: Third WHO Report on Neglected Tropical Diseases 2015*. Vol. 3. World Health Organization; 2015.
- Unnevehr L, Hirschhorn N. *Food Safety Issues in the Developing World*. The World Bank; 2000.
- Wunsch N-G, ed. Global food safety testing market from 2017 to 2025, by food type (in million U.S. dollars). 2022. Accessed March 23, 2022. <https://www.statista.com/statistics/1286148/global-food-safety-testing-market-by-food-type/>.
- Chaves R, et al. *Food Safety, in Current Developments in Biotechnology and Bioengineering*. Elsevier; 2017:245-259.
- Mercado G, Hjortso CN, Honig B. Decoupling from international food safety standards: how small-scale indigenous farmers cope with conflicting institutions to ensure market participation. *Agric Human Values*. 2018;35:651-669.
- Bicaba Z, Brixiová Z, Ncube M. Can extreme poverty in Sub-Saharan Africa be eliminated by 2030? *J Afr Dev*. 2017;19:93-110.
- Lokpobiri H. Nigerian Agriculture Promotion Policy 2016–2020: towards a new paradigm for domestic food security and Foreign Exchange earnings in agricultural production. *Public Policy Adm Res*. 2019;9:47-57.
- Kyei S, Appiah E, Ayerakwa EA, Antwi CB, Asiedu K. Microbial safety implications of in-use topical diagnostic ophthalmic medications in eye clinics in Ghana. *J Optom*. 2019;12:263-271.
- Udomkun P, Wiredu AN, Nagle M, Bandyopadhyay R, Müller J, Vanlauwe B. Mycotoxins in Sub-Saharan Africa: present situation, socio-economic impact, awareness, and outlook. *Food Control*. 2017;72:110-122.
- Adeyeye SAO. The role of food processing and appropriate storage technologies in ensuring food security and food availability in Africa. *Food Sci Nutr*. 2017;47:122-139.
- Druilhe Z. Fertilizer subsidies in sub-Saharan Africa. 2017.
- van Ittersum MK, van Bussel LG, Wolf J, et al. Can sub-Saharan Africa feed itself? *Proc Natl Acad Sci*. 2016;113:14964-14969.
- Akuu JA, Danyi D, Dapaah C. Factors associated with poor food safety compliance among street food vendors in the Techiman Municipality of Ghana. *Afr J Food Sci*. 2017;11:50-57.
- Akabanda F, Hlorts EH, Owusu-Kwarteng J. Food safety knowledge, attitudes and practices of institutional food-handlers in Ghana. *BMC Public Health*. 2017;17:40.
- Balali GI, Yar DD, Afua Dela VG, Adjei-Kusi P. Microbial contamination, an increasing threat to the consumption of fresh fruits and vegetables in today's world. *Int J Microbiol*. 2020;2020:1-13.
- Ababio PF, Lovatt P. A review on food safety and food hygiene studies in Ghana. *Food Control*. 2015;47:92-97.
- Quansah JK, Kunadu APH, Saalia FK, Díaz-Pérez J, Chen J. Microbial quality of leafy green vegetables grown or sold in Accra metropolis, Ghana. *Food Control*. 2018;86:302-309.
- Alemu A. Microbial contamination of currency notes and coins in circulation: A potential public health hazard. *Biomed Biotechnol*. 2014;2:46-53.
- Addis M, Sisay D. A review on major food borne bacterial illnesses. *J Trop Dis*. 2015;3(4):176-183.
- Magna EK, et al. Determination of heavy metals and potential health risk assessment of honey harvested from the tamale metropolis of Ghana using atomic absorption spectrophotometer (AAS). *Pollution*. 2018;121:51522-51525.
- Owusu-Kwarteng J, Wuni A, Akabanda F, Jespersen L. Prevalence and characteristics of *Listeria monocytogenes* isolates in raw milk, heated milk and nunu, a spontaneously fermented milk beverage, in Ghana. *Beverages*. 2018;4:40.
- Duedu KO, Yarnie EA, Tetteh-Quarcoo PB, Attah SK, Donkor ES, Ayeh-Kumi PF. A comparative survey of the prevalence of human parasites found in fresh vegetables sold in supermarkets and open-air markets in Accra, Ghana. *BMC Res Notes*. 2014;7:836.
- Tortoe C, et al. Systematic approach for the management and control of food safety for the street/informal food sector in Ghana. *Food and Public Health*. 2013;3:59-67.
- Futagbi G, et al. Microbial quality of mangoes from selected markets in Accra, Ghana. *New York Sci J*. 2016;9:32-37.
- Blankson GK, Mill-Robertson FC. Aflatoxin contamination and exposure in processed cereal-based complementary foods for infants and young children in greater Accra, Ghana. *Food Control*. 2016;64:212-217.
- Darko S, Mills-Robertson FC, Wireko-Manu FD. Fungal contamination of foods prepared in some hotels in the Kumasi metropolis. *Int Food Res J*. 2017;24:860-867.
- Adinortey CA. *Antibiotic Resistance, Phylogenetic Grouping and Virulence Potential of Escherichia coli Isolated From Clinical and Environmental Samples From the Cape Coast Metropolis of the Central Region of Ghana*. University of Cape Coast; 2014.
- Saba CKS. *Identification and Molecular Characterization of Bacteria Isolated From Human, Animal, and Food Origins From the Northern Region of Ghana*. Universidad Complutense de Madrid; 2013.
- Kunadu AP-H, et al. Microbiological quality and antimicrobial resistance characterization of *Salmonella* spp. in fresh milk value chains in Ghana. *Int J Food Microbiol*. 2018;277:41-49.
- Acheampong BE. *Assessment of Food hygiene Practices by Street Food Vendors and Microbial Quality of Selected Foods Sold. A study at Dunkwa-On-Offin, Upper Denkyira East municipality of the central region*. 2015.
- Ababio PF, Taylor KD, Swainson M, Daramola BA. Effect of good hygiene practices intervention on food safety in senior secondary schools in Ghana. *Food Control*. 2016;60:18-24.
- Malik BA. *Assessing the Food Safety Knowledge of Food Handlers of the Ghana School Feeding Programme in Tamale Metropolis, Ghana*. 2018.
- Mensah P, Yeboah-Manu D, Owusu-Darko K, Ablordey A. Street foods in Accra, Ghana: how safe are they? *Bull World Health Organ*. 2002;80:546-554.
- Annan-Prah A, et al. Street foods: handling, hygiene and client expectations in a World heritage Site Town, Cape Coast, Ghana. *Afr J Microbiol Res*. 2011;5:1629-1634.
- Yeboah-Man D, Kpeli G, Akyeh M, Bimi L. Bacteriological quality of ready-to-eat foods sold on and around University of Ghana campus. *Res J Microbiol*. 2010;5:130-136.
- Feglo P, Sakyi K. Bacterial contamination of street vending food in Kumasi, Ghana. *J Med Biomed Sci*. 2012;1:1-8.
- Atter A, Ofori H, Anyebuno GA, Amoo-Gyasi M, Amoa-Awua WK. Safety of a street vended traditional maize beverage, ice-kenkey, in Ghana. *Food Control*. 2015;55:200-205.
- Pesewu GA, et al. *Bacteriological assessment of the quality of raw-mixed vegetable salads prepared and sold by street food vendors in Korle-Gonno, Accra Metropolis, Ghana*. *J Health Sci*. 2014;2:560-566.
- Yeleliere E, Cobbina SJ, Abubakari ZI. Review of microbial food contamination and food hygiene in selected capital cities of Ghana. *Cogent Food Agric*. 2017;3:1395102.
- Sonaiya E. Fifteen years of family poultry research and development at Obafemi Awolowo University, Nigeria. *Paper presented at: Village Chickens, Poverty Alleviation and the Sustainable Control of Newcastle Disease*. ACIAR. 2009, p. 15.
- Ogunde OM, Rapheal OM, Abiodun AM. Effects of municipal waste disposal methods on community health in Ibadan – Nigeria. *Polytechnica*. 2018;1:61-72.
- Adeyemi D, et al. Evaluation of the levels of organochlorine pesticide residues in water samples of Lagos Lagoon using solid phase extraction method. *J Environ Chem Ecotoxicol*. 2011;3:160-166.
- Odeyemi OA. Public health implications of microbial food safety and foodborne diseases in developing countries. *Food Nutr Res*. 2016;60:1-2.
- Iwu AC, Uwakwe KA, Duru CB, et al. Knowledge, attitude and practices of food hygiene among food vendors in Owerri, Imo State, Nigeria. *Occup Dis Environ Med*. 2017;05:11-25.
- Ezirigwe J. Much ado about food safety regulation in Nigeria. *J Sustain Dev Law Policy*. 2018;9:109-132.
- Onyeneho SN, Hedberg CW. An assessment of food safety needs of restaurants in Owerri, Imo State, Nigeria. *Int J Environ Res Public Health*. 2013;10:3296-3309.
- Nnebue C, Adogu PU, Ifeadike C, Ironkwe O. Assessment of the food hygiene practices of food handlers in the Federal Capital Territory of Nigeria. *Trop J Med Res*. 2014;17:10.
- Faremi F, Olatubi M, Nnabuife G. Food safety and hygiene practices among food vendors in a tertiary educational institution in South Western Nigeria. *Eur J Nutr Food Saf*. 2018;8:59-70.

51. Idoga PE, Toycan M, Zayyad MA. Analysis of factors contributing to the spread of cholera in developing countries. *Eurasian J Med.* 2019;51:121-127.
52. Dan-Nwafor CC, Ogbonna U, Onyiah P, et al. A cholera outbreak in a rural north central Nigerian community: an unmatched case-control study. *BMC Public Health.* 2019;19:112.
53. Orisakwe OE, Oladipo OO, Ajaezi GC, Udowelle NA. Horizontal and vertical distribution of heavy metals in farm produce and livestock around lead-contaminated goldmine in daret and Abare, Zamfara State, Northern Nigeria. *J Environ Public Health.* 2017;2017:3506949.
54. Adeleke S. Food poisoning due to yam flour consumption in kano (Northwest) Nigeria. *Online J Health Allied Sci.* 2009;8:1-3.
55. Tirima HG. *Unprecedented Lead Poisoning Outbreak in Zamfara, Nigeria: A Multidisciplinary Humanitarian Response to an Environmental Public Health Disaster in a Resource-Scarce Setting.* University of Idaho; 2014.
56. Okiei W, et al. Determination of copper and lead in water samples from Zamfara state, Nigeria by linear sweep anodic stripping voltammetry. 2016.
57. Nwosu LC, et al. Arsenic exposure from bean seeds consumed in Owerri Municipality, Imo State, Nigeria: can Insect Pest detoxify the metalloid during infestation? *Jordan J Biol Sci Short Commun.* 2018;11:113-116.
58. Pepple N. Environment and food poisoning: food safety knowledge and practice among food vendors in garki, Abuja – Nigeria. *J Health Educ Res Dev.* 2017;05:12.
59. Oludare AO, et al. Knowledge and food handling practices of nurses in a tertiary health care hospital in Nigeria. *J Environ Health.* 2016;78:32-39.
60. Umar A, Sambo M, Sabitu K, Iliyasu Z, Sufiyan M, Hamza K. Personal and food hygiene practices among street-food vendors in Sabon-gari local government area of Kaduna State, Nigeria. *Arch Med Surg.* 2018;3:77.
61. Nwanta J, et al. Abattoir operations and waste management in Nigeria: A review of challenges and prospects. *Sokoto J Vet Sci.* 2008;7:61-67.
62. Obidiegwu C, et al. *Public Health Challenges in Somachi Main Abattoir Owerri, Nigeria: A Review and Field Activity Report.* 2019;1:1-7.
63. Sovo C, Flowers K, Man C. Climate change and food security. CSIS Briefs. 2019. <https://www.jstor.org/stable/pdf/resrep22593.pdf?acceptTC=true&coverpage=false>
64. Coulibaly BS. Foresight Africa: top priorities for the continent in 2019. Africanportal; 2019.
65. Mahami T, Odonkor S. Food safety risks associated with tertiary students in self-catering hostels in Accra Ghana. *Int J Biol Pharm All Sci.* 2012;1(4):537-550.
66. Dun-Dery EJ, Addo HO. Food hygiene awareness, processing and practice among street food vendors in Ghana. *Food Public Health.* 2016;6:65-74.
67. Animah P. *Management of Children's Faecal Matter and Its Implications for Cholera Outbreak in the Cape Coast Metropolis.* University of Ghana; 2018.
68. Asamoah CS, Mensah EK. Analysis of typhoid fever surveillance data, Cape Coast Metropolis, 2016. *Pan Afr Med J.* 2017;1:21.
69. Ishak WW, et al. Sex and Natural Sexual Enhancement: Sexual techniques, Aphrodisiac Foods, and Nutraceuticals. In: Ishak (Ed.), *The Textbook of Clinical Sexual Medicine.* Springer; 2017;413-432.
70. Ankar-Brewoo GM, Siaw MO. Health risks associated with lead exposure in frequently consumed foods. *Archivos de Medicina.* 2019;4:4.
71. Bempah CK, Asomaning J, Boateng J. Market basket survey for some pesticides residues in fruits and vegetables from Ghana. *J Microbiol Biotechnol Food Sci.* 2012;2:850.
72. Bempah CK, et al. Monitoring of pesticide residues in fruits and vegetables and related health risk assessment in Kumasi Metropolis, Ghana. *Res J Environm Earth Sci.* 2011;3:761-771.
73. Akomea-Frempong S, Ofosu IW, Owusu-Ansah EDGJ, Darko G. Health risks due to consumption of pesticides in ready-to-eat vegetables (salads) in Kumasi, Ghana. *Int J Food Contam.* 2017;4:13.
74. Donkor A, Osei-Fosu P, Dubey B, Kingsford-Adaboh R, Ziwu C, Asante I. Pesticide residues in fruits and vegetables in Ghana: a review. *Environ Sci Poll Res.* 2016;23:18966-18987.
75. Abakari G, Cobbina SJ, Yeleliere E. Microbial quality of ready-to-eat vegetable salads vended in the central business district of Tamale, Ghana. *Int J Food Contam.* 2018;5:3.
76. Twum E. Microbial quality of fresh beef sold in the Birim North district of the Eastern region of Ghana. 2016.
77. Kumar PS, Yaashikaa PR. Agriculture pollution. In advanced treatment techniques for industrial wastewater. *IGI Global.* 2019;2019:134-154.
78. Monney I, Agyei D, Owusu W. Hygienic practices among food vendors in educational institutions in Ghana: the case of Konongo. *Foods.* 2013;2:282-294.
79. Dwumfour-Asare B, Agyapong D. Food hygiene and safety practices (FHSP) among street food vendors in a low-income urban community of a metropolis in Ghana. *Int J Sci Technol.* 2014;2:38.
80. Cobbina SJ, Kotochi MC, Korese JK, Akrong MO. Microbial contamination in vegetables at the farm gate due to irrigation with wastewater in the tamale metropolis of Northern Ghana. *J Environ Prot.* 2013;04:676-682.
81. Asumang P, Akoto Delali J, Wiafe F, et al. Prevalence of gastrointestinal parasites in local and exotic breeds of chickens in Pankrono-Kumasi, Ghana. *J Parasitol Res.* 2019;2019:5746515.
82. Adzitey F, Mireku D, Huda N. Assessment of selected heavy metal concentration in fresh and grilled beef - A case study in East Legon, Ghana. *Int J One Health.* 2018;4:40-44.
83. Luure P, Asare W, Cobbina S, Duwiejua A, Nkoom M. Microbial contamination of Ghanaian cedi notes from traders of the Tamale Central Market, Ghana. *Microbiol Res J Int.* 2015;5:139-145.
84. Adams A, Lawson B. Prevalence of *Ascaris lumbricoides* among food vendors on a university campus in Ghana. *J Sci Technol.* 2014;34:63-74.
85. Monney I, et al. Food hygiene and safety practices among street food vendors: an assessment of compliance, institutional and legislative framework in Ghana. *Food Public Health.* 2014;4:306-315.
86. Matangue MTA, Saize HTD, de Sousa LS. Quantitative microbial risk assessment arising from consumption of salad crops irrigated with contaminated water by human sewage in the influence valley. Paper presented at: Euro-Mediterranean Conference for Environmental Integration, 2017; Springer.
87. Barker SF, Amoah P, Drechsel P. A probabilistic model of gastroenteritis risks associated with consumption of street food salads in Kumasi, Ghana: Evaluation of methods to estimate pathogen dose from water, produce or food quality. *Sci Total Environ.* 2014;487:130-142.
88. Mensah GI, Vicar EK, Feglo PK, et al. Bacteriological Quality and antibiotic residues in raw cow milk at producer level and milk products at sale points in the Northern Region of Ghana. *Int J Trop Dis Health.* 2019;34:1-10.
89. Saba CKS, Gonzalez-Zorn B. Microbial food safety in Ghana: a meta-analysis. *J Infect Dev Ctries.* 2012;6:828-835.
90. Havelaar AH, Kirk MD, Torgerson PR, et al. World Health Organization global estimates and regional comparisons of the burden of foodborne disease in 2010. *PLoS Med.* 2015;12:e1001923.
91. Akeredolu I. Mothers' nutritional knowledge, infant feeding practices and nutritional status of children (0-24 months) in Lagos State, Nigeria. *Eur J Nutr Food Saf.* 2014;4:364-374.
92. Adebayo FO, Balogun MA. Current trend in the nutritional rehabilitation of pediatric protein energy malnutrition (PEM) in Sub-Sahara Africa: A Nigerian Case Study. *Rehabil Sci.* 2018;3:1.
93. Ocheke I, Thandi P. Malnutrition in acutely ill children at the paediatric emergency unit in a tertiary hospital in Nigeria. *Niger Med J.* 2015;56:113.
94. Omari R, Frempong G. Food safety concerns of fast food consumers in urban Ghana. *Appetite.* 2016;98:49-54.
95. Cissé G. Food-borne and water-borne diseases under climate change in low- and middle-income countries: further efforts needed for reducing environmental health exposure risks. *Acta Trop.* 2019;194:181-188.
96. Yen E, et al. *Food Safety in Kenya: Focus on Fruits and Vegetables.* Intl Food Policy Res Inst; 2018.
97. Deb P. Environmental pollution and the burden of Food-Borne diseases. *Food-borne Diseases.* Elsevier; 2018;473-500.
98. Grace D, Mahuku G, Hoffmann V, Atherstone C, Upadhyaya HD, Bandyopadhyay R. International agricultural research to reduce food risks: case studies on aflatoxins. *Food Secur.* 2015;7:569-582.
99. Okojie PW, Isah EC. Sanitary conditions of food vending sites and food handling practices of street food vendors in Benin City, Nigeria: implication for food hygiene and safety. *J Environ Public Health.* 2014;2014:701316.
100. Omojokun J. Regulation and enforcement of legislation on food safety in Nigeria. *Mycotoxin and Food Safety in Developing Countries.* 2013;251-268.
101. Akintaro O. Food handling, hygiene and the role of food regulatory agencies in promoting good health and development in Nigeria. *Int J Health Med Inf.* 2012;1:1-8.
102. WHO. *World Health Organization Estimates of the Global Burden of Foodborne Diseases: Foodborne Disease Burden Epidemiology Reference Group 2007-2015.* World Health Organization; 2015.
103. Adekunle BJ. *Food Hygiene and Intestinal Parasitism: A Comparative Study of Hospital-Based and School Food Handlers in Ibadan, Nigeria.* Faculty of Pathology; 2008.
104. Ejechi BO, Ochei OP. Bacteriological safety assessment, hygienic habits and cross-contamination risks in a Nigerian urban sample of household kitchen environment. *Environ Monit Assess.* 2017;189:298.
105. Oyejemi OT, Agbaje MO, Okelue UB. Food-borne human parasitic pathogens associated with household cockroaches and houseflies in Nigeria. *Parasite Epidemiol Control.* 2016;1:10-13.
106. Ayenigbara IO, Ayenigbara GO, Adeleke RO. Contemporary Nigerian public health practice: prevention and surveillance are key to combating cholera. *GMS hygiene and infection control.* 2019;14:Doc16.
107. Adagbada AO, Adesida SA, Nwaokorie FO, Niemogha MT, Coker AO. Cholera epidemiology in Nigeria: an overview. *Pan Afr Med J.* 2012;12:59.
108. Aminu M, Medugu JB. Increased cholera outbreaks in Nigeria: a review. *Ghanaian Population.* 2014;47:47-64.

109. Gidado S, Awosanya E, Haladu S, et al. Cholera outbreak in a naïve rural community in Northern Nigeria: the importance of hand washing with soap, September 2010. *Pan Afr Med J.* 2018;30:30.
110. Kehinde Peter A, Umar U. Combating diarrhoea in Nigeria: the way forward. *J Microbiol Exp.* 2018;6:191-197.
111. Ogbo FA, Page A, Idoko J, Claudio F, Agho KE. Diarrhoea and suboptimal feeding practices in Nigeria: evidence from the national household surveys. *Paediatr Perinat Epidemiol.* 2016;30:346-355.
112. Efunshile AM, Ezeanosike O, Onyekachi ONI, Ugwu MI, König B, Robertson LJ. Apparent absence of Giardia infections among children under 5-years of age with acute watery diarrhoea in Abakaliki, Nigeri. *Epidemiol Infect.* 2018;147:e58.
113. Alonso CA, Zarazaga M, Ben Sallem R, Jouini A, Ben Slama K, Torres C. Antibiotic resistance in Escherichia coli in husbandry animals: the African perspective. *Lett Appl Microbiol.* 2017;64:318-334.
114. Agwa O, Uzoigwe C, Wokoma E. Incidence and antibiotic sensitivity of Bacillus cereus isolated from ready-to-eat foods sold in some markets in Portharcourt, Rivers state, Nigeria. *Asian J Microbiol Biotechnol Environ Sci.* 2012;14:13-18.
115. Okonko I, et al. Incidence of multi-drug resistant (MDR) organisms in some poultry feeds sold in Calabar Metropolis, Nigeria. *Electrc J Environ Agric Food Chem.* 2010;9:514-532.
116. Adeyanju GT, Ishola O. Salmonella and Escherichia coli contamination of poultry meat from a processing plant and retail markets in Ibadan, Oyo State, Nigeria. *Springerplus.* 2014;3:139.
117. Akan JC. Organophosphorus pesticide residues in vegetable and soil samples from alau dam and gongulong agricultural areas, Borno State, Nigeria. *Int J Environ Monit Analysis.* 2013;1:58.
118. Shaibu I, Akunyili D. *NAFDAC bans 30 agrochemical products.* Vanguard; 2008. 14: p. 2008.
119. Adeyemi M, Bawa M, Muktar B. Evaluation of the effect of calcium carbide on induce ripening of banana, pawpaw and Mango cultivated within Kaduna Metropolis, Nigeria. *J Chem Soc Nigeria.* 2018;43:108-118.
120. Umar A, Sambo M, Sabitu K, Iliyasu Z, Sufiyan M, Hamza K. Personal and food hygiene practices among street-food vendors in Sabon-gari local government area of Kaduna State, Nigeria. *Nigerian J Basic Clin Sci.* 2019;3:77.
121. Jaffee S, et al. *The Safe Food Imperative: Accelerating Progress in Low-and Middle-Income Countries.* World Bank Publications; 2018.
122. Nordhagen S. Food safety perspectives and practices of consumers and vendors in Nigeria: A review. *Food Control.* 2022;134:108693.
123. Paudyal N, Anihouvi V, Hounhouigan J, et al. Prevalence of foodborne pathogens in food from selected African countries – a meta-analysis. *Int J Food Microbiol.* 2017;249:35-43.
124. Okoruwa A, Onuigbo-Chatta N. *Review of Food Safety Policy in Nigeria.* safety; 2021. 110.
125. Tehinse JF, Stephen OA. *A Report of the Assessment of Foodborne Disease Surveillance and Response System in Nigeria 2021.* Nigeria Federal Ministry of Health–Food Safety & Quality Programme; 2021.
126. Food and Drugs Authority Ghana. *Food safety.* Food and Drugs Authority Ghana. 2022. Accessed 2022. <https://fdaghana.gov.gh/food.php>.
127. Ackah M, et al. Socio-economic profile, knowledge of hygiene and food safety practices among street-food vendors in some parts of Accra-Ghana. *Internet J Food Saf.* 2011;13:191-197.
128. Amoah P, Drechsel P, Abaidoo RC, Ntow WJ. Pesticide and pathogen contamination of vegetables in Ghana's urban markets. *Arch Environ Contam Toxicol.* 2006;50:1-6.