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# Risk Factors and Outcomes of Food Poisoning in Africa

Ntambwe Malangu

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## Abstract

Food poisoning is one of the common health problems in most African countries. This review was conducted to describe the situation in Africa with regard to specific risk factors and outcomes of food poisoning in the African setting based on published literature.

It is noted that food poisoning in Africa involves the staple foods used throughout the continent, but due to lack of surveillance systems, the actual burden of food poisoning is unknown. While the general mechanisms of food poisoning apply to the African settings, inherent issues specific to the African context include macro-environmental issues such as infrastructural problems, inadequate policy environment and lack of regulatory food control systems, leading to unsafe foods being sold in the streets. In addition, individual sociodemographic factors, including the age, gender, health status and lack of food safety knowledge among the population and food handlers and preparers, as well as the country's contextual factors such as unsafe harvesting practices, are all associated with the occurrence of food poisoning in Africa.

Also due to a lack of surveillance systems and population-based studies, the outcomes of food poisoning are not adequately documented. It is clear that food poisoning is responsible for a significant number of health facility visits and hospitalisations as well as deaths. Moreover, several long-term effects such as cancers and other conditions affecting children, pregnant women and the elderly have been also reported.

To conclude, food poisoning is one of the major causes of morbidity in Africa. Several risk factors influence its occurrence. It is recommended that the control systems that are lacking should be instituted and that public education should be conducted so that hygienic and safe food handling practices can be implemented. Moreover, the preservation of the sources of food, namely the fauna and flora ecosystems, as well as environmental media, namely air, soil and water, should be considered not only as a necessity but as a shared responsibility that each human being should accept every day in the way he or she lives, make decisions and eat.

**Keywords:** Food poisoning, risk factors, Africa

# 1. Introduction

## 1.1. Definition and mechanisms of food poisoning

Food poisoning is a term applied to an acute intestinal disease acquired by the consumption of food or drinks (e.g. juice, water, wine). The toxic agents responsible for food poisoning include the following: microorganisms that occur naturally in humans, animals and/or the environment; parasites, in particular intestinal worms and others that can be transmitted through contaminated food and water; contaminants, adulterants and poisoning agents that can occur in food through normal modes of contamination or by deliberate addition; naturally occurring toxins that occur in food naturally or produce toxins inside the food through normal biological processes; agro-chemical and veterinary drug residues as a result of their purposeful use; spores and prions such as the bovine spongiform encephalopathy or its human variant responsible for the Creutzfeldt-Jakob disease; persistent organic pollutants that accumulate in soil, plants, animals and the human body; and heavy metals such as lead, mercury, cadmium and others; and various allergens [1–5].

## 1.2. How does food poisoning occur?

Food poisoning is often confused with food allergy and food adverse effects, which are, respectively, an immune-mediated reaction and a clinically abnormal response, attributed to an exposure to a food or food additive [1, 6]. Food poisoning results from exposures to toxic agents present in the food that may lead to harmful effects based on the reaction of the body to these agents or the food itself. Exposures may happen through ingestion, contact or transdermal, or inhalation. The resulting effects of the exposure may be localized, or generalized; they may also be topical or systemic [7, 8].

At the core, the adverse functional or morphological changes observed upon clinical or histopathological examinations are almost invariably a consequence of biochemical lesions [9]. This means that, in general, toxicity arises from interaction of the offending toxic element or its derivatives with molecular sites of the host system that leads to the derangement of the biochemical processes involved in the normal function and regulation of the cells, tissues, organs and systems of the body. Hence, it is the overloading of the biochemical processes, because of the simple presence or the excessive quantities of the offending toxic agent, beyond the capacity of the host systems to adapt and restore to these processes at their normal level that leads ultimately to cell, tissue, or organ injury or the elucidation of the toxic effects as signs and symptoms [10–12].

The most common microorganisms involved in food poisoning are bacteria such as *Bacillus cereus*, *Staphylococcus aureus*, *Clostridium botulinum*, *Vibrio cholerae*, *Escherichia coli* and *Shigella* species and others that produce toxins that cause foodborne intoxications. *Listeria monocytogenes* can grow at temperatures below 5°C and so can multiply in refrigerated food but can be eradicated by thorough cooking and by pasteurization. Other microorganisms such as *Norovirus* and *Rotavirus* as well as parasites such as *Giardia* spp. and *Cyclosporidium* spp. can also be involved [13]. The main reason why microorganisms predominate in causing food

poisoning is that they have the ability to grow in the foods and to dwell there even when reduced to spores, particularly bacteria. Moreover, even when bacteria do not grow in the food itself, they may be carried by the foods that are notoriously known to be involved in outbreaks of dysentery [14, 15]. It is important to note that most foods carry microorganisms, but some foods are more prone in being potential carriers of food poisoning microorganisms; these foods are principally raw meat, poultry, milk, seafood and raw vegetables [16, 17].

The microorganisms inducing food poisoning are often associated with the gut of humans, animals and birds. *Clostridium perfringens* forms part of the normal gut flora and is widely present in food and the environment. Its spores can survive heating to standard cooking temperatures particularly when food is kept warm for prolonged periods after cooking; its effects are mediated by an enterotoxin produced by the bacterium after ingestion. It should be noted that any food contaminated with faeces has the potential to cause food poisoning as well as contact with ill animals [18, 19]. It should be noted that *Campylobacter* spp. is the commonest reported food poisoning caused by bacteria worldwide. It typically causes fever, diarrhoea and abdominal cramps. The infection is often contracted by eating undercooked poultry, unpasteurized milk, untreated water and food that has been contaminated. Two species account for the majority of infections: *Campylobacter jejuni* and *Campylobacter coli* [20, 22].

Raw meat is often a direct food poisoning hazard as it contains microbes; it is also an indirect factor of food poisoning through cross-contamination of cooked meats, other foods and water. It has been established that raw meat can contain *Salmonella* that may affect food handlers or they may transfer to other foods. It is also known that *Salmonella* may grow in meat products kept at room temperatures; products such as meat pies, sausages, cured meats (ham, bacon and tongue) and sandwiches are prone to this effect as they are normally allowed to stand at room temperatures during or before being processed or cooked [23–25]. Besides meat, water, a major component of most foods and drinks, is often contaminated as explained above or it may be polluted from its sources and thus carry with it substances that may cause food poisoning [26–28].

Furthermore, substances released in foods by insects, bacteria or other living microorganisms, hence called "toxins", may also cause food poisoning. This is well documented in the case of mushroom toxins and ciguatera fish poisoning. With regard to fish, the toxin is produced by a marine alga *Gambierdiscus toxicus*. Ciguatera fish poisoning occurs when toxins created by dinoflagellate microorganisms are passed up the marine food chain and bioaccumulate in large fish such as barracuda, grouper, red snapper, kingfish, coral trout and others [29, 30]. It is important to note that these toxins are not destroyed through cooking, smoking or freezing, they are odourless and tasteless and do not alter the appearance of the fish.

Another type of fish poisoning is scombroid poisoning, which results from improper handling and refrigeration of fish containing high levels of naturally occurring histidine. Contamination with bacteria will convert the amino acid histidine into histamine, causing symptoms similar to allergic reactions, which occur very rapidly; the symptoms include headache, abdominal cramps, diarrhoea, itching, flushed face, dry mouth, heart palpitations and difficulty breathing. Scombroid poisoning affects fish from the Scombridae family, such as tuna, mackerel, skipjack and bonito. It can also affect other species, such as herring, bluefish and sardines [31–33].

The other type of fish poisoning is shellfish poisoning that is associated with species found in temperate and tropical areas, such as oysters, clams, cockles, mussels, scallops, crabs and lobsters. These fishes ingest toxins produced by dinoflagellates and produce diarrheic shellfish poisoning, neurotoxic shellfish poisoning or even paralytic shellfish poisoning, which is characterised by the numbness of face arms and legs, loss of coordination and dizziness. In severe cases, respiratory failure and paralysis may occur, leading to death; sometimes, amnesic shellfish poisoning occur, which produces seizures, muscle weakness or paralysis and disorientation. Permanent short-term memory loss has been observed and, in severe cases, can lead to coma or death [30, 33].

Finally, puffer (Fugu) fish poisoning is caused by a tetrodotoxin accumulating mainly in the liver, intestines and ovaries of puffer fish, ocean sunfish, globe fish and porcupine fish. Symptoms of poisoning include profuse sweating, salivation, headache, hypothermia, heart palpitation as well as neurological symptoms, such as numbness, loss of coordination, tremors and paralysis [29].

Chemicals such as pesticides, fungicides, preservative agents, food additives, colorants and taste-enhancing or altering chemicals may also cause food poisoning [34]. Some pesticides such as lindane and thiosulfan have been covertly and illegally used to harvest fish from rivers in some countries. Similarly, carbofuran was used to harvest birds for the bush meat trade in some countries in East Africa. The poisoned fish and bush meat are sold to unsuspecting customers who may be subsequently poisoned [35–38].

It should be noted that some of these chemicals found in foodstuffs in small doses but taken more frequently can lead to chronic poisoning, whereas the others when ingested in high doses may result in acute food poisoning. This occurs when recently treated and unwashed fruits or vegetables that are contaminated with pesticides are eaten [39, 40].

The above remarks suggest that in most cases, the exact mechanism of toxicity is not known, but the time between the exposure and the resulting toxic effects determines whether an exposure is acute or chronic. In an acute poisoning incident, the effects occur almost immediately after an exposure or conventionally within 24 hours. When the effects of toxicity appear or become apparent after 1 day to several years later from the actual date of first intake of the offending agent, this is referred to as "chronic poisoning" [41].

Furthermore, the exposures may be deliberate or accidental. Deliberate exposures occur when the victims expose themselves to toxic agents with the intention to harm themselves or to seek attention from the people close to them [41]. This could happen when a person decide not to preheat or warm the food before eating with the very intent of falling sick to get the attention or sympathy of their loved ones or avoid performing certain acts. This kind of exposure results in suicide or para-suicide depending on whether the victim had or did not have actual intention to die. Other instances are simply bizarre like the old practice of adding tablets of lead to wines, despite knowing the dangers of acute lead poisoning [42–45].

On the other hand, food has been used to intoxicate other people. This deliberate exposure whereby the manipulation of food or drink by a third party, whether adulteration, contamination or addition of high doses of a chemical, drug or other substances in order to harm the

intended victim is usually done for criminal or emotional purposes [46]. Motivations for criminal poisoning include the desire to rob, to punish someone, to benefit financially, get political power, to end the miserable life of a loved one, to eliminate an enemy or to simply to terrorise [46–50].

For instance, it is well accepted that the Emperor Claude was poisoned by his wife, who gave him a meal of poisonous mushrooms of *Amanita phalloides*, which contain amanitin polypeptides, so that upon his death, his son, Nero could become the king. Amygdalin, a glycoside yielding hydrocyanic acid (HCN) through hydrolysis, is present in the family of Rosacea species such as in certain seeds of apples, cherries, peaches and plums. HCN is a chemical that inhibits the action of the enzyme cytochrome oxidase and prevents the uptake of oxygen by cells. As little as 0.06 g can cause death in humans; hence, it has been reportedly used as an assassination weapon in the famous killing of the Russian monk, Grigori Yefimovich Rasputin [48, 51].

Some would resort to criminal deliberate intoxication in order to get attention as in the case of Munchausen syndrome by proxy [52, 53]. Many authors have reported on drug-facilitated sexual assaults where a variety of medicines and drugs of abuse have been added in drinks or foods/meals of unsuspecting victims (Gilfillan, 1965; Douglas et al., 1992; Uges, 2001; Weber et al., 2009) [54–56]. The author is also aware of cases where food poisoning has been perpetrated with the intent to kill. In one dramatic case, a woman crushed a glass bottle and added the fine particles in the porridge and gave it to the three children of a widowed man she wanted to marry. The two kids younger than 5 years old died due to severe intestinal haemorrhages; the girl who was 7 years old survived as she did not eat much as she sensed that something was not right with the porridge.

Accidental food poisoning occurs when the victims unwittingly ingest the offending food or drink with no intent or expectation of harm [57]. This occurs due to negligence, lack of knowledge or simply as a random event. Sometimes it might be due to a confusion of pills looking as candies or edible legumes with their look-alike toxic species. Such a case happened in South Africa, where the author attended to children aged 4 to 8 years old who had ingested colourful multivitamin sugar-coated tablets and colourful chlorpromazine tablets that found at municipal dumpsite. They had mistaken them for candies and ate or swallowed them; two of the seven children died.

Similarly, there was an outbreak in Cambodia where adult villagers confused the edible *Melientha suavis* with the non-edible and toxic *Urobotrya siamensis*, both plants from the Opiliaceae family [58]. In other settings, mass poisoning incidents have occurred through eating of birds carrying a toxic substance from plants. This happened in Algeria more than 50 years ago. Edmond Sargent, one of the leading African toxicologists, proved through experimental study that the poisonous birds or pigeons of Algeria had been carriers of cotinine, a poisonous alkaloid that is not harmful to the birds but to the humans who ate these birds [59, 60].

Other famous cases include the mass intoxication of Greek soldiers by eating honey from *Rhododendron ponticum* and *Rhododendron flavum*. The honey grown from these plants had high doses of diterpene grayanotoxins. In other settings, people have been intoxicated from teas brewed from plant parts or after consuming leaves, flowers or seeds from toxic plants

(Dickstein and Kunkel, 1980; Bain, 1985; Joskow et al., 2006) [61–63]. Accidental food poisoning incidents have been reported after people consumed recently sprayed maize that was obtained illegally. The author knows of an incident in South Africa where 10 family members where brought at the hospital after consuming such maize. Of the 5 children younger than 7 years who ate this food, 2 died.

## 2. Risk factors for food poisoning

With regard to food poisoning, several factors play a role in its occurrence. These factors include the individual factors such as their age, gender, socioeconomic status, their residence, health status and others; other factors include the contextual country and place of residence together with the characteristics of their macro- and micro-environment as explained below.

In the macro-environment, the chemicals and biological agents are found in environmental media such as water, soil, air and food itself. Moreover, there are interactions between these media with regard to food poisoning. For instances, crops grown in soils that are polluted by heavy metals and other chemicals as well as those sprayed with toxic pesticides may contain high levels of these chemicals that may lead to acute or chronic poisoning based on the circumstances of consumption [64, 65].

Several contextual determinants affect the occurrence of food poisoning; these include the accessibility, the availability, the affordability of controlled chemicals and drugs that may be used for instance in para- or suicide, criminal food poisoning or harvesting of fish or hunting. Other associated determinants are the seriousness of the rule of law and the enforcement of food control regulations. Sadly, in African settings, even controlled chemicals such as pesticides and pharmaceuticals can be found and brought from the streets in most cities. And as discussed further, foods vended in the streets are one of the major risk factors for food poisoning [66–69].

Foods and drinks form part of the micro-environment as they are found in the house where people live and at other settings, such as workplaces and places of entertainment. The presence of foods in the household means that accessibility and availability are guaranteed. Hence, if the storage and means of preparations are inadequate, the foodstuffs or drinks may be subjected to spoilage, contamination or chemical degradation and fermentation that would render them prone to cause food poisoning. This observation is equally true for restaurants and other food-serving venues [69–71].

If any of these areas in the micro-environment have food likely to cause poisoning, the only determinant that will trigger the occurrence of food poisoning will be the individual circumstances including how susceptible the person is to the toxic agents in the offending food, the freedom of choice they have, which is linked to their economic status and the amount of offending food consumed [72–74].

Furthermore as explained by Haddon [75], several factors are involved in the three phases of a poisoning event. These phases are the pre-event, the event and the post-event. It is noted that

factors in the pre-event phase contribute to the likelihood or the possibility that a poisoning event may occur; the factors mediating in the event phase affect the likelihood that a poisoning event or an injury will actually occur and how severe it would be. Finally, the factors in the post-event phase influence the outcomes or consequences of the poisoning event once it has occurred.

In the case of acute food poisoning, the factors in the 'pre-event phase' include the whole political and regulatory frameworks that ensure that crops and foods standards of quality and safety are respected by producers, importers and retailers in such a way that consumers can have access to foods that are safe and nutritious [76, 77].

In the event phase, the sociodemographic, socioeconomic and psychosocial factors of the potential victims of poisoning determine whether they will consume foods that will lead to a poisoning event. These include their age, gender, socioeconomic status, how hungry they are and the type and state of foods available to them. While, in the post-event phase, the factors in this phase include the promptness and quality of care that the victims of food poisoning will receive in line with the existing health care system [78].
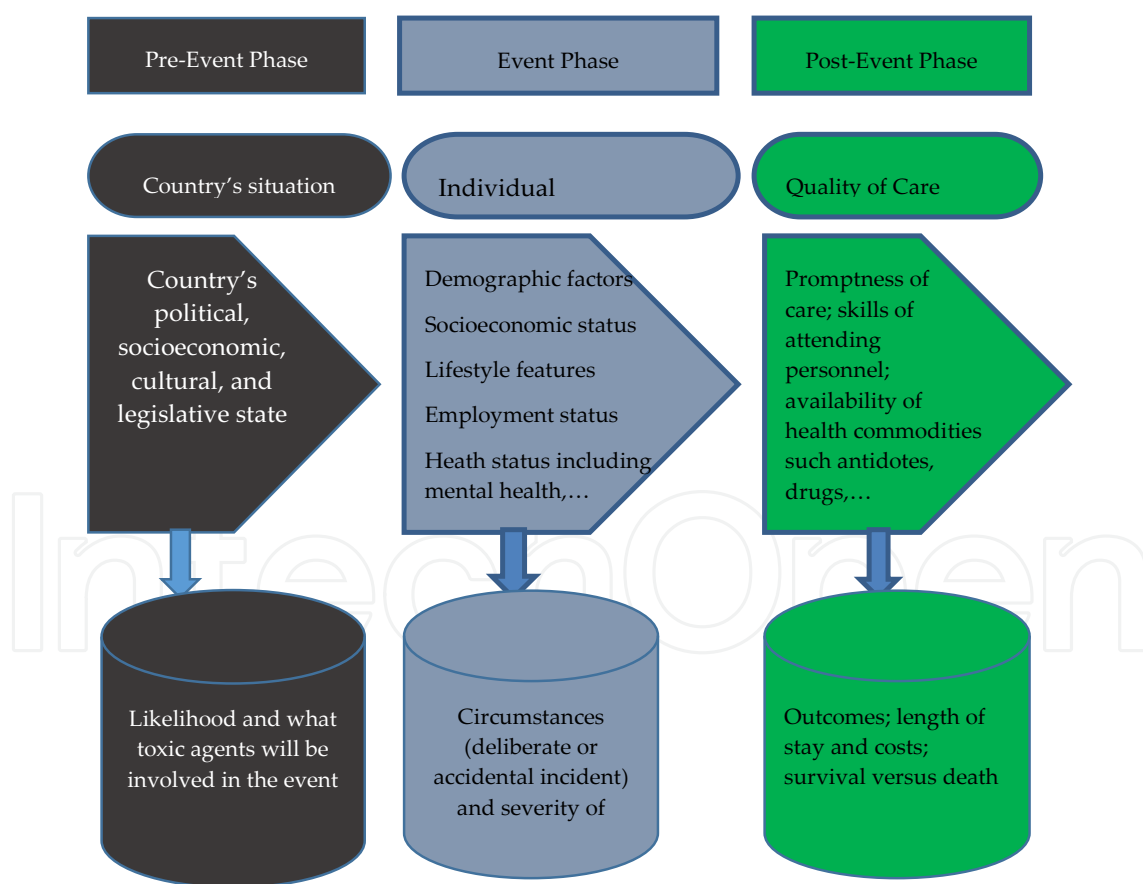


Source: Malangu (2011). Acute poisoning in three African countries: Botswana, South Africa and Uganda. Available at: http://hdl.handle.net/10386/674.

**Figure 1.** Phases of a poisoning incident.

The above phases of poisoning event are intertwined in their interactions; the country' context, the individual characteristics and the status of offending foodstuffs combine to determine whether a food poisoning occurs or not. Whether the country is experiencing food shortage or there is food for everyone depends on the economic situation and on the distribution of income across various segments of the populations [79–81]. As depicted below, the country's context and the characteristics of an individual interact to produce the type of poisoning as well as the outcomes of the incident.
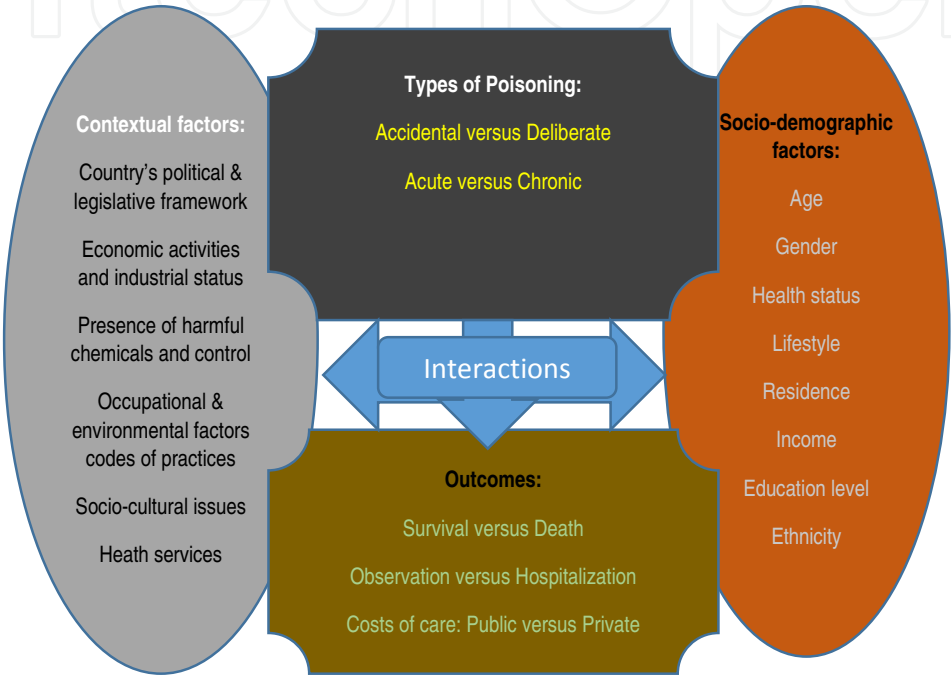


Source: Malangu, N. (2014). Contribution of plants and traditional medicines to the disparities and similarities in acute poisoning incidents in Botswana, South Africa and Uganda. African Journal of Tradition Complement Altern Medicine 11(2): 425–438.

**Figure 2.** Risk factors involved in the occurrence of a poisoning incident.

With regard to sociodemographic factors of individuals, a comparative study of acute poisoning in three countries reported that females were more significantly affected by food poisoning than men in Botswana and Uganda, as well as in South Africa although the difference was not statistically significant. With regard to age, food poisoning occurred in ≤10% of cases and affected more young adults aged 20 to 30 years in South Africa; more adults aged over 30 years in Uganda; while in Botswana food poisoning affected equally children younger than 12 years old and adults over 30 years [78].

The above findings suggest that the contextual circumstances of individuals in their respective countries affected the onset of food poisoning. It also suggests that all strata of populations are susceptible to food poisoning particularly to staphylococcal food poisoning. However, the severity of symptoms may vary depending on the amount of the offending agent consumed in the food and the general health status of affected individuals. Hence, the young and elderly,

because of their weak immune status or defence mechanisms, are more likely to develop more serious symptoms [82–84].

Moreover, although noroviruses have been reported as a leading cause of sporadic cases and outbreaks of acute gastroenteritis across all age groups, a systematic review estimated that 12% of all cases of sporadic acute gastroenteritis caused by *Norovirus* occur in children [85].

With regard to socioeconomic and regulatory factors, in the African region, poverty is considered as the underlying cause of consumption of unsafe foodstuffs that are likely to cause food poisoning because it exacerbates food safety problems through unsanitary living conditions in rapidly growing urban centres, lack of access to clean water, unhygienic transportation and storage of foods and low education levels among consumers and food handlers, together with a false sense of invulnerability as people eat unsafe foods with the belief that nothing will happen to them [86–89]. The poor environmental conditions, particularly unsafe sanitation systems, exacerbate the situation as explained above.

Interestingly, most countries do not have appropriate policies and legislation to deal with street vending [90]. Even when national legislation and regulations exist, there is a limited capacity and capabilities to control the quality of both locally produced and imported foodstuffs [91]. It has been documented that several street food vending facilities often do not meet proper hygiene standards, in large part because of weak regulatory systems, inadequate food safety laws, lack of financial resources to invest in safer equipment and lack of education for food handlers [92]. Because street food is frequently cooked well in advance of consumption, it is prone to contamination from exposure to dust, flies, bacteria and their spores. The handling and processing of foods by the preparers who may be carrying germs open opportunities for contamination of food if adequate precautions are not implemented [93, 94].

Yet because of inadequate coordination between surveillance, food laboratories and food inspection services, there is a disorganised sampling and quality control of foodstuffs. Furthermore, the emphasis is on sampling for enforcement purposes and often there is no systematic monitoring for food contaminants as well as no surveillance systems capable of identifying common agents of foodborne diseases [95, 96].

Moreover, food safety control laboratories generally do not exist in some countries; and when they do exist, they do not function as a result of lack of human, material and financial resources. In addition, most of the public health laboratories in the African region lack the capacity to test for chemical contaminants and naturally occurring toxins [97, 98]. There is a lack of skilled inspectors who have relevant competencies and means to do their work properly [97, 99, 100].

With regard to environmental factors, it is also established that they contribute to the occurrence of food poisoning. As explained above, food may serve as a carrier of either the microorganisms (bacteria, parasite or virus) or chemicals that ultimately elicit the symptoms of food poisoning. Several well-known examples of food poisoning in which the environment has a strong influence include the case of *Salmonella* spp. and heavy metals poisoning from drinking water. Contamination of surface and ground waters by pesticides is a clear example of the influence of poor environmental management resulting in poisoning [34, 40, 102]. Other examples are *S. aureus*, a bacterium that causes food poisoning, and
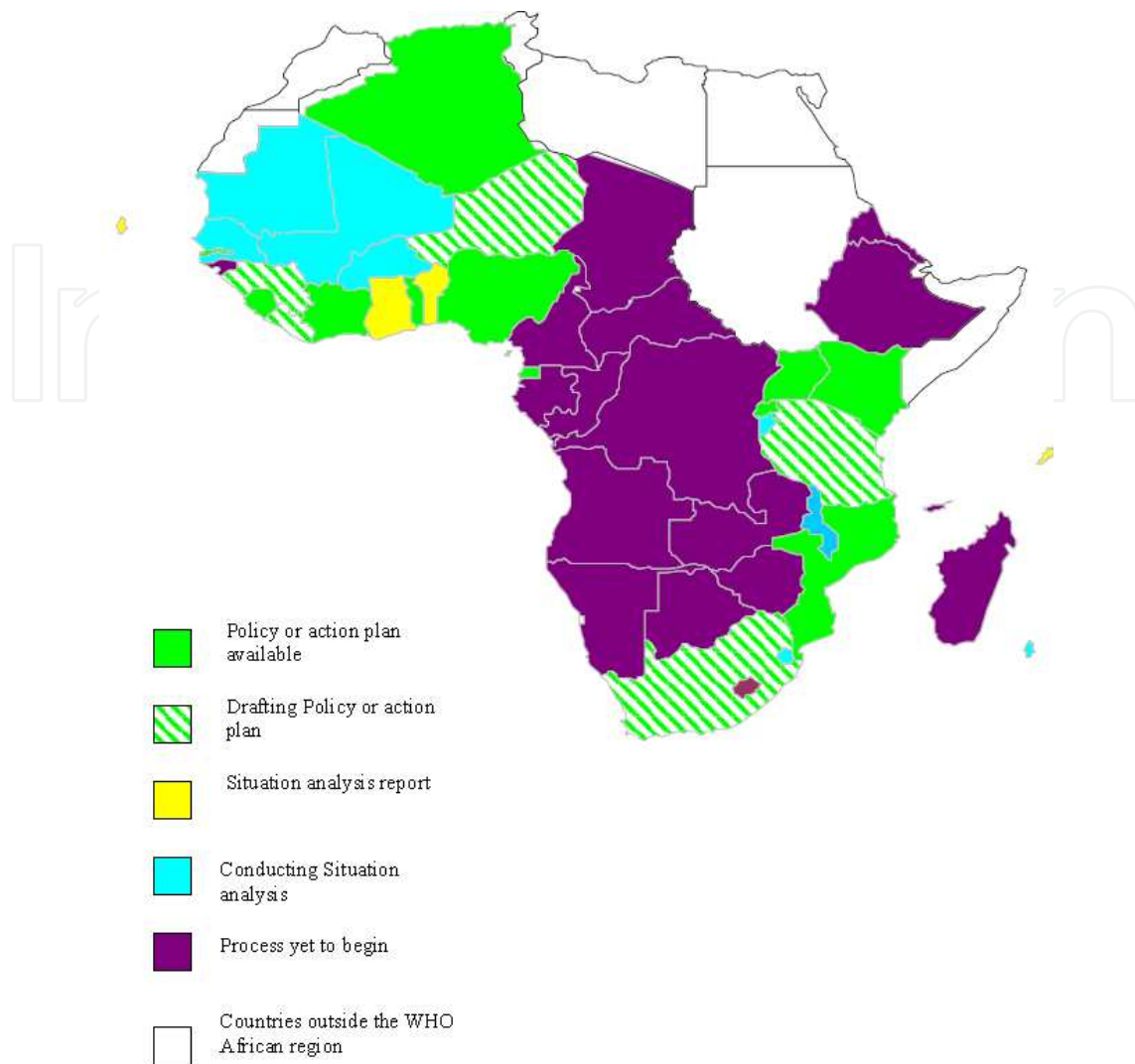
**Figure 3.** Status of food policy formulation in Africa.

*S. aureus,* a bacterium that is commonly found in the environment (soil, water and air) and also found in the nose and on the skin of humans. It is established that food handlers carrying enterotoxin-producing *S. aureus* in their noses or on their hands are regarded as the main source of food contamination via direct contact or through respiratory secretions when proper hygiene is not maintained [103].

This situation is not unique to Africa. A survey of food from retail markets and dairy farms in Turkey was performed between 2007 and 2008. Enterotoxigenic *S. aureus* was found in at least 10% of samples of meat and unpasteurised milk but in less than 10% of samples of dairy and bakery products [104]. While in an Italian survey performed between 2003 and 2005, also less than 10% of samples of dairy products and meat products were tested positive for *S. aureus*

 [105]. In Japan, a retail survey performed between 2002 and 2003 found 17.6% of raw chicken were tested positive for *S. aureus* [106].

Another case involves *Vibrio* species that grow naturally in marine environments worldwide and are able to survive and replicate in contaminated bodies of water particularly those with increased salinity. The *V. cholerae* "O1 and O139" produce cholera toxin, which is responsible for the onset of cholera. Asymptomatically, infected humans can also be an important reservoir for this organism in areas where *V. cholerae* disease is endemic. It has been reported that water contaminated with human faeces or sewage is the main route of infection, but some cases have resulted from the consumption of fish and other seafood products [107, 108].

In the case of seafood, it is known that some of them are susceptible to surface or tissue contamination originating from the marine environment due to polluted waters from broken sewage, overboard sewage discharge and sewage run-off after heavy rains or flooding. Moreover, during various processing and preparation activities, contamination of seafood by pathogens with a human reservoir can occur. Other contributing factors may include inappropriate storage and transportation at inappropriate temperatures and cross-contamination through contact with contaminated seafood or seawater [109].

In the case of agricultural products, several reports have been written about fungal toxins, namely mycotoxins such as aflatoxins, which pose a serious challenge as they contaminate various agricultural commodities either before harvest or under post-harvest conditions [110, 111]. Generally, tropical conditions such as high temperatures and moisture, unseasonal rains during harvest and flash floods are favourable to fungal growth and production of mycotoxins. Additionally, poor harvesting practices, improper storage and less than optimal conditions during transport and storage at market places can also contribute to fungal growth and increase the risk of mycotoxin production. Hence, chronic poisoning due to foodstuffs containing aflatoxins has been reported [112–115].

Similarly, food processing factors play a role in the onset of food poisoning mediated by meat. For instance, the level of bacterial contamination associated with live animals can be amplified through slaughtering plant operations. During transportation, the animals infected with *Salmonella* do shed it and thus contaminate other animals. The level of contamination is believed to increase during the containment of the animals in holding pens before slaughter [116]. After slaughter, the subsequent dressing of meats increases the spread of *Salmonella* on meat surfaces and by the time the meat is in retail outlets, contamination levels may have increased by up to 20% [17].

Street vending of foods is also a major risk factor for food poisoning. The major concern with street foods is their safety, mainly because vending is done in places that may have poor sanitation and inappropriate utensils. Street foods in some African countries have been tested for various microorganisms including faecal coliforms, *E. coli*, *S. aureus*, *Salmonella* spp. and *B. cereus*. It is noted that *E. coli* and *S. aureus* were recovered in a significant proportion of the food, water, hand and surface swabs tested in Harare. Samples of fufu and other staple foods tested in Accra yielded positive results and counts for *E. coli* and *S. aureus*. One study reported that of 511 street food items examined in Accra, up to 69% contained bacteria. In the same

study, *Shigella sonnei* was isolated from macaroni, *Salmonella arizonae* from meat-based soup and *E. coli* from macaroni, tomato stew and rice. In a separate study, it was observed that over 26% of street food samples analysed in Nigeria contained *B. cereus*, whereas 16% contained *S. aureus* [117–120].

In North Africa

The following discussion illustrates the issues about mycotoxins. These substances are ingested orally but they may also be inhaled and may be transdermally absorbed. Of the more than 400 mycotoxins identified in the world, ochratoxin A (OTA) is one of the most prevalent. It is a ubiquitous mycotoxin produced by several fungal species belonging to the genera *Aspergillus* such as *Aspergillus ochraceus* and *Penicillium* such as *Penicillium verrucosum*, is responsible for chronic food poisoning in North Africa [120, 121]. OTA contaminates several agricultural products such as wheat, barley, rice and sorghum, cereal-derived products, dried fruits, spices, beer and wine. Additionally, OTA was found in high amounts in animal feeds. Because of its long elimination half-life (about 35 days in serum), as a consequence of its binding to plasma proteins, its enterohepatic circulation and its reabsorption from urine, OTA is the most detected mycotoxin in human blood. Its human exposure has been clearly demonstrated by its detection in human blood and urine (Zimmerli and Dick, 1995; Zaied et al, 2011) [122–124]. Its adverse effects in a variety of animal species have been described, such as teratogenicity, immunotoxicity, genotoxicity and mutagenicity [125, 126]. Its most important toxic effect in humans is nephrotoxicity; it was implicated in the human "Balkan endemic nephropathy" which is similar to the Tunisian chronic interstitial nephropathy of unknown aetiology in many aspects [127, 128].

In Tunisia, a clear correlation has been established between the consumption of OTA-contaminated food and nephropathy; it has been speculated that this is due to the favourable climatic, geographic, social and economic conditions that Tunisia provides for the growth and survival of this toxigenic fungi [127–129]. Similarly, studies from Morocco have detected that of 60 samples of grains of cereals sold in Morocco, 40% to 55% of samples of corn, wheat and barley were contaminated by OTA. In a follow-up study by the same authors, 10% of samples of corn flour sold in Rabat exceeded the maximum recommended limits for aflatoxins [130, 131].

In East Africa

The following discussion illustrates the role of food handlers in the onset of food poisoning. In Ethiopia, the prevalence of intestinal parasites among food handlers was found to be 29.1% to 63% [132]. This high prevalence has been attributed to poor personal hygienic practices and poor environmental sanitation. Of concern is that in one study, 6.5% of food handlers working in the kitchens had been suffering from diarrhoea at the time of the survey. And the microorganisms associated with the diarrhoea were identified as *Entamoeba histolytica*, *Giardia lamblia* and larva of *Strongyloides stercoralis*. It is important to note that food handlers can directly transmit *Giardia* to consumers if they do not exercise appropriate hygiene practices [131, 133].

In Central Africa

The following discussion illustrates how food poisoning can result from the way the food is harvested. The use of plant-based poisons to harvest fish and bush meat has been in Africa

since centuries. Plants such as *Tephrosia* sp. and *Mundulea sericea* were used throughout tropical Africa; but in recent years, because of their ease of accessibility, availability and affordability, synthetic chemicals are used to harvest fish in the Democratic Republic of the Congo and Cameroon and to kill birds and animals even vultures in several African countries [134–137].

In southern Cameroon, some respondents in a survey claimed that eating fish harvested with the use of synthetic chemicals induced vomiting and stomach pains, and in some cases even death (reference). It is also reported there that a massive killing of cane rats (*Thryonomys* spp.) has been performed using pesticides. These rats were subsequently eaten as bushmeat. A major incident of human deaths due to eating fish contaminated with pesticides occurred around Lake Victoria and ultimately prompted authorities to take action against this fishing method [136–140].

In West Africa

The influence of lack of knowledge and relevant equipment for safe handling of food processing activities as well as cultural ethos in the onset of food poisoning is plausible as shown in the following reports. In Nigeria, it has been reported that the unhygienic states of some restaurants have contributed to the onset of foodborne diseases. It is known that in some parts of Nigeria, food poisoning is believed to be associated with evil spirit, malice or curses. Moreover, an urban adult Nigerian eat food from street vendors regularly because it is easily available, affordable and usually fresh [141–144].

However, street-vended foods pose some risks due to lack of basic infrastructure and services, such as potable water and reliable electricity, as well as poor knowledge of basic food safety measures. In addition, there are other issues such as poor drainage systems, unsanitary waste disposal systems, presence of flies and apparent lack of facilities for food protection [118, 120, 145, 146]. Inappropriate personal hygiene practices such as the use of unwashed fingers to feel foodstuffs or sometimes to dish out augur a high potential for contamination in the handling and preparation of foods. Moreover, an investigation about food poisoning among three families in Kano due to yam flour consumption showed that the use of certain unsafe preservatives for the processing of yam flour was responsible for the incident [142–144, 147]. Furthermore, the lack of regulatory monitoring of foodstuffs results in unsafe foodstuffs being sold in the market. For instance, a recent survey of heavy metal levels in commonly consumed canned and non-canned beverages available in the Nigerian market indicated a high prevalence of beverages with levels of heavy metals that exceed the maximum contaminant levels (MCLs) for these metals [148–150].

In Southern Africa

The influence of food processing factors in the occurrence of food poisoning is illustrated as follows. Botswana is one of the leading beef cattle–rearing countries in Africa. Although as a semi-desert, the country is fairly free from most tropical diseases that are associated with heavy rainfall and high humidity, foodborne diseases which have been reported in Botswana to be mainly associated with poor handling as well as lack of awareness with regard to safety of food [151]. It has been observed that the meat exported from the country undergoes extensive scrutiny by both local and international experts under the supervision of the Botswana Meat Commission and the European Commission (EEC); yet *Salmonella* spp. has been isolated in local abattoirs, which process meat for local consumption [151, 152].

In Mozambique, cassava is one of the main staple foods in some areas where it is harvested from August to October each year. Bitter cassava, which is high in cyanogenic glucoside content, is mostly produced and harvested. Hence, indigenous knowledge has taught communities that sun drying preceded or not by fermentation is the process that helps to lower the cyanogenic glucosides [153]. Sometimes this is not done. Consequently poisoning may result from this mishap. In 1981, the first epidemic of Konzo was reported in Mozambique; over 1,100 cases occurred in northern Nampula Province. This condition, Konzo, is characterised by the sudden onset of irreversible spastic paraparesis. Epidemiological findings showed that this was associated with prolonged high dietary cyanogenic glucoside consumption and a diet deficient in sulphur amino acids. Laboratory findings confirmed that people in the affected areas had high serum thiocyanate concentrations [154–157]. Sadly, Konzo is reportedly still spreading to new areas in Mozambique; it is being diagnosed outside major agricultural crises, with persistent cases and smaller epidemics. Affected communities continue to suffer cyanide intoxication at the time of the cassava harvest [158–160].

## 3. Outcomes of food poisoning

### 3.1. Short-term outcomes

Like any other health condition, food poisoning can be measured in terms of morbidity and mortality. However, due to the lack of population-based data, it is not possible to establish exactly the mortality rate due to food poisoning; rather, it is the case fatality rate (CFR) that is calculated from the number of people who have been affected after eating the offending food. The morbidity due to food poisoning can be measured by its incidence and prevalence.

Usually, the prevalence of acute food poisoning in patients attending health facilities has been determined as well as the factors associated with such episodes. In several African countries, the prevalence of acute food poisoning in patients seen at Emergency Departments of hospitals ranges from 0.5 to 11.5% [72, 73, 78, 161, 162]. As for chronic food poisoning, it is even more difficult to estimate its prevalence because of the diagnostic limitations [67, 163]. However, as explained below, the prevalence of health conditions resulting from chronic food poisoning can also be estimated.

In general, morbidity and mortality are higher in elderly individuals due to their increased susceptibility, age-associated comorbidities such as decreased immunity, decreased production of gastric acid and intestinal motility, malnutrition, lack of exercise. It has been reported that elderly persons are more likely to die from food poisoning events implicating toxin-releasing bacteria [7, 14].

It is estimated that over 3 million cases of acute food poisoning and 20,000 deaths occur annually due to exposure to pesticides in foods [164]. The following observations illustrate the extent of the problem in some African countries. It has been reported that more than 200,000 people die of food poisoning annually in Nigeria from foodborne pathogens [23, 165].

In the case of cholera, several outbreaks have been reported in African countries. In refugee camps, because of unsanitary conditions, environmental contaminants and improper food handling, outbreaks of foodborne diseases are common. Notable examples include the July 1994 outbreak, in which 14,000 deaths were recorded in refugee camps in Goma, Democratic Republic of the Congo. Another outbreak in April 1997 led to a total of 1,521 deaths among 90,000 Rwandan refugees residing in temporary camps in the Democratic Republic of the Congo, yielding a CFR of 1.69% [166, 167].

In Angola, an outbreak of cholera in February 2006 was reported in several provinces including the capital city, Luanda. In total, 26,979 cases were identified and 1,085 deaths were registered or a CFR of 4% [168]. In South Africa, an outbreak of cholera from November 2008 to April 2009 was resulted in over 12,000 suspected cases, 1,144 laboratory-confirmed cholera cases and 57 deaths, a CFR of 0.5% [169]. Previously, a breakdown in the drinking water pipeline system in a South African suburb caused an outbreak of typhoid, causing illness in nearly 4,000 persons as well as several deaths [170].

Recent data show that cholera is ever present in African countries. As shown in the Figure 4, the most affected countries are the Democratic Republic of the Congo, Mozambique, Kenya, Nigeria and Tanzania. The most recent report suggests that the cumulative number of cases of cholera in Tanzania was 4,835 cases that resulted in 68 deaths, a CFR of 1.4% [171].
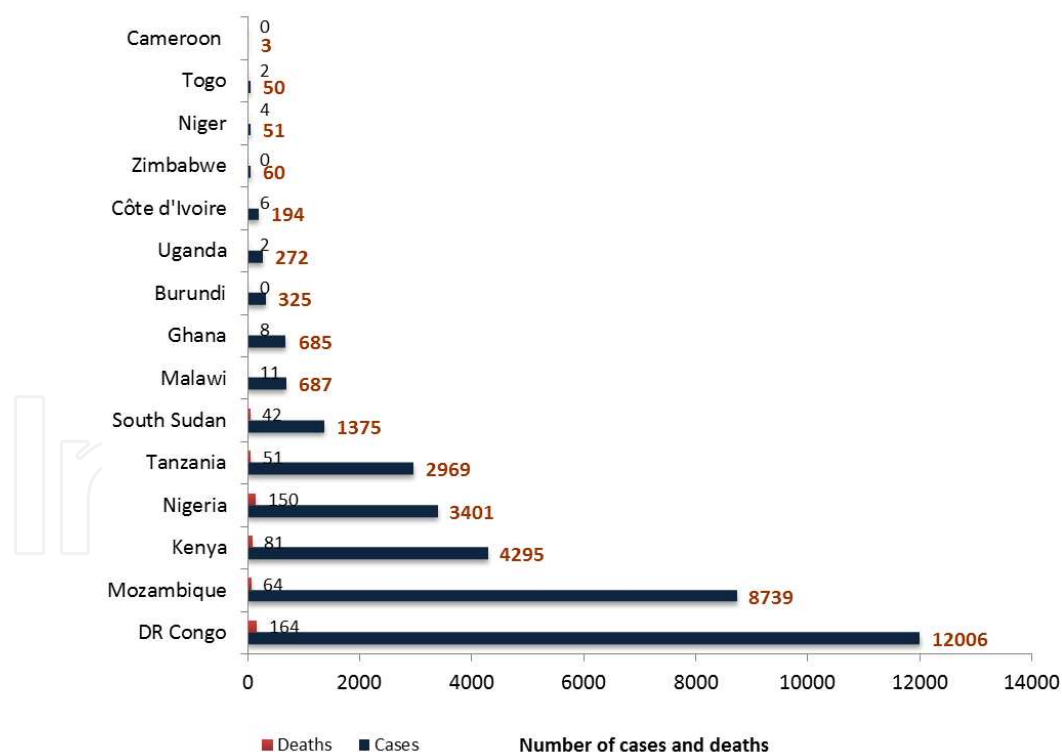


Source: WHO/AFRO (2015). Epidemic alert and response. Available online at: www.afro.who.int/en/clusters-a-programmes/dpc/epidemic-a-pandemic-alert-and-response/outbreak-news/4764-outbreak-bulletin-vol-5-issue-5-31-october-2015.html.

Figure 4. Cholera cases and deaths in African countries, January to September 2015.

With regard to mycotoxins, the outbreak of acute aflatoxicosis in Kenya in 2004 was one of the most severe food poisoning events involving contaminated maize; it has affected a total of 317 people resulting in a massive CFR of 39% [113, 172].

In Madagascar, acute food poisoning associated with consumption of fish or other marine animals contaminated by ciguatera is common from October to May each year. In 2013, a total of 116 cases and 1 death (CFR: 0.8%) were reported [173].

Finally with regard to incidence of food poisoning, the following Table 1 illustrates the situation in several African countries.

| Country | Annual incidence per 1,000 inhabitants | | |
|---|---|---|---|
| | Minimum | Mean | Maximum |
| Ethiopia | 1.22 | 5.36 | 10.73 |
| Zimbabwe | 26.83 | 33.75 | 40.78 |
| Cuba | 11.45 | 19.00 | 28.82 |
| Brazil | 22.12 | 26.88 | 32.18 |
| Mexico | 66.00 | 79.20 | 95.00 |
| Thailand | 39.64 | 48.45 | 58.56 |
| India | 3.26 | 5.44 | 8.41 |
| Malaysia | 12.02 | 20.72 | 32.29 |
| Tunisia | 32.11 | 36.89 | 41.67 |
| Egypt | 8.39 | 10.11 | 12.15 |

Source: World Health Organization (2002). World Health Statistics 2002. WHO, Geneva.

**Table 1.** Incidence of foodborne salmonellosis in some countries.

The mean incidence of foodborne salmonellosis ranges from 5.36 to 79.20 per 1,000 people [174]. This suggests that the morbidity due to this type of food poisoning is important in the African continent. As will be discussed further, this requires interventions particularly because long-term effects may also result from food poisoning.

## 3.2. Long-term outcomes

### 3.2.1. Chronic poisoning

There are some evidence built from data of the last 50 years that chronic poisoning due to dietary aflatoxins, heavy metals, pesticides and other organic compounds has resulted in people being affected by several conditions. Mycotoxins are toxic and carcinogenic metabolites produced by fungi that colonize food crops; aflatoxins, the most prevalent mycotoxins have been linked to liver cancer and have also been implicated in child growth impairment and

acute intoxication as reported above. On the other hand, fumonisins have been linked to oesophageal cancer and neural tube defects; ochratoxin A has been associated with renal diseases as described above [175–178].

There is evidence that the above conditions that affect some African populations may have resulted from exposures to the above chemicals through food and other means. In the case of aflatoxin, its presence has been detected in human breast milk of women from Sub-Saharan Africa and Arab countries [110, 111, 130, 179–182]. Similarly, the presence of endocrine disruptors, who are consumed through polluted waters and contaminated fishes and bush meat, has been confirmed also from analyses of breast milk, umbilical cords samples of women and children from several African countries [183–186].

With regard to heavy metals, their implication in chronic poisoning through the food chain has been demonstrated and explained above. The health consequences are also multiple; in the case of mercury, its neurotoxicity has been noted since the Mina Mata incident in Japan [187]. To date, it is now established that it causes cognitive deficits at low exposure levels and severe psychiatric and neurologic effects at very high levels of exposure. Its toxic effects on the kidney, cardiovascular and immune systems are well known as well as its developmental neurotoxicity in case of in utero exposure [188–191].

Consumption of fish contaminated with mercury is one of potential sources of human exposure besides mining and the use of mercury-containing cosmetics used for skin lightening in Africa [192, 193].

Another heavy metal, lead, it is a naturally occurring heavy metal whose exposure is associated with several adverse effects across different population subgroups. From several studies, the effects of lead on neurodevelopment and, in particular, its negative effects on intelligence quotient and behaviour have been documented [190, 191, 194, 195]. More recently, lead has been associated with other adverse health impacts, such as increased risks of attention deficit hyperactivity disorder in children and cardiovascular mortality in adults [196, 197]. Although foodstuffs have not been reported as major sources of exposures to lead, lead was found in contaminated dust and soils that growing children may consume or inhale as well as in contaminated ceramics, crayons, pencils and piped water [188, 198].

With regard to pesticide exposure among African populations, it is a public health concern because of their uncontrolled use coupled to weak regulatory enforcement [175, 199]. In addition, there is a lack of competencies to use them appropriately due to lack of training and access to relevant safety information and personal protective equipment [200]. Pesticides are used for pest control in several environments, such as in the home and in various forms of agriculture. It is not surprising that pesticides used in agriculture have been detected in rivers and lakes that are located around farming communities [201, 202].

Human exposure to pesticides used in agriculture is reportedly higher among farmworkers and their families. In a study conducted in Kenya, it was reported that breast milk samples taken from non-farmer urban Kenyan mothers up to 4 weeks postpartum had detectable levels of nine organochlorine pesticides including dichlorodiphenyltrichloroethane (DDT) (and its metabolite dihydrodiphenylethane (DDE), dieldrin and lindane. Similarly, DDT was also

detected in breast milk of mothers residing in some areas of Kwazulu, South Africa and Ghana [203]. Collectively, these studies suggest both historical and ongoing pesticide exposures in individuals through agriculture and dietary sources [77, 184, 202, 203].

### 3.2.2. Sequelae

Several sequelae have been described in populations exposed to specific toxic agents. For African populations that have been exposed to several classes of pesticides through agriculture, the environment and foods, it is expected that they may experience similar adverse effects. Well-established sequelae include neurotoxicity, endocrine-disrupting adverse effects and birth defects documented agricultural communities [204–207].

With regard to heavy metals, it is estimated that each year 9,129 to 119,176 additional cases of bladder cancer, 11,844 to 121,442 of lung cancer and 10,729 to 110,015 of skin cancer worldwide are attributable to inorganic arsenic in food [208].

Other sequelae include stunted growth in children or being chronically underweight, susceptibility to infectious diseases and hepatocellular carcinoma (HCC) or liver cancer. This cancer is the third leading cause of cancer deaths worldwide, with roughly 550,000–600,000 new HCC cases globally each year [209]. Aflatoxin exposure in food is a significant risk factor for HCC [175, 210].

## 4. Public health interventions

Food poisoning is a health condition that is multifactorial; it therefore requires a multi-sectoral approach in addressing it. The interventions should be targeted to address the risk factors discussed above. For food poisoning, the youth, from teenagers to young adults, particularly those with any psychiatric or psychological disorder, those with history of child abuse and those who are addicted to any substance, constitute a high-risk group for deliberate self-poisoning, whereas the children, the elderly and pregnant women constitute a high-risk group for accidental events with a high fatality potential [211, 212]. Thus, the two public health approaches, namely the individual-centred approach or 'high-risk strategy', and the population-based approach or 'population-based strategy' need to be implemented synchronically to address food poisoning [213].

In order to reduce the prevalence and incidence of food poisoning as well as its related mortality, multiple approaches ought to be implemented. Based on the population-based strategy, these include legislative measures, public educational programmes and establishment of poison or toxicological information centres and services and the establishment of surveillance systems [78, 214, 215]. Reports from several other settings have shown that legislative measures that restricted access to toxic agents resulted in a decrease in mortality associated with the targeted agents [212, 215–217].

In addition, good agricultural, manufacturing or processing practices can help in preventing and addressing food poisoning. For instance, in the case of aflatoxins, the risk of contamination

of food and feed in Africa is increased by environmental and agronomic factors. Environmental conditions especially high humidity and temperature favour fungal proliferation as well as drought conditions. In the same vein, some inappropriate agricultural practices such as extended field drying and leaving the harvested crop in the field prior to storage facilitate fungal infection and insect infestation [218, 219].

For the above reasons, agronomic management practices that can reduce the risk of aflatoxin development such as the use of resistant varieties, crop rotation, well-timed planting, weed control, pest control especially control of insect pests and avoiding drought and nutritional stress through fertilization and irrigation should be implemented. Similarly, measures to control aflatoxins through the use of appropriate pesticides and the implementation of effective post-harvest initiatives, such as rapid and proper drying, proper transportation, adequate packaging and insect control during storage, should also be considered [220, 221].

Other practical approaches include the reduction of the frequency of consumption of 'high risk' foods (especially maize and groundnut) by consuming a more varied diet and diverting aflatoxin-contaminated foods to animals using clay-locking systems [222]. Of even more programmatic interest is the health education of the public and millers who should avoid blending visibly contaminated products to reduce the overall risk of spreading mycotoxins [218, 223].

Similarly, in order to reduce pesticides related poisoning from the food chain, several measures can also be contemplated such as encouraging the use of less hazardous and cost-effective pesticides currently available; establishing a national programme to monitor applicators' exposure and use of personal protective equipment; ensuring the respect of the correct time lag of crops that have been sprayed; and ensure proper disposal of obsolete, unused or unwanted pesticides and wastes [224].

Based on high-risk strategy, managerial decisions at facilities' level can be implemented such as assessment of the health status of food handlers, the audit of food-serving facilities based on the Hazard Analysis Critical Control Point (HACCP) approach. This approach is well known for its use in identifying points where controls could be applied to prevent or eliminate these microbiological hazards or reduce them to acceptable levels [225].

The implementation of HACCP has been reported in some settings on the African continent but it is not widely used particularly in food outlets frequented by the majority of people or businesses [226–228]. This failure is reflective of the general lack of enforcement of regulatory and legislative texts relating to foodstuffs in Africa [168, 214]. This is an area where advocacy is required from the civil society and other community voices to ensure that authorities are called upon to enforce existing legislation [96, 229].

Some authors have suggested the ' four Cs' namely cleaning, cooking, chilling and avoiding cross contamination as the backbone for basic hygiene, food preparation and storage. This suggestion is supported by findings from surveys that reported that at least three-quarters of the public had never heard of the most common causes of food poisoning and believe they are

unlikely to get food poisoning from food cooked at home; yet the majority of them did not store raw meat properly and/ or wash their hands after handling raw meat or fish [230–233].

With regard to epidemiological surveillance, it is necessary to assess the magnitude of the food poisoning problem and its major risk factors in defined contexts. Based on the findings, evidence-based interventions could then be designed and implemented [90]. Together with the establishment of a food poisoning surveillance system, national or regional toxicovigilance centres should be funded so that they can collect, aggregate, analyse, and report on food and other causes of acute and chronic poisoning with specific focus on deliberate poisoning. These centres should serve both the public and clinicians with relevant information for the management of poisoning events [78].

With regard to academic training, there is a need to create awareness on the issues of food production, processing, distribution, handling and cooking among all people studying towards a degree in any field of science, particularly for those in agricultural and health sciences. Public education and awareness campaigns aimed at the whole population are required so that risks about various types, sources and consequences of food poisoning are communicated regularly to influence behaviour change [234–238]. Public education programs should also strive to increase the population's awareness of the general risks of poisoning at home. This includes designing messages dealing with appropriate storage of foods and other products in the home, and explaining what to do in case of a suspected poisoning incident.

## 5. Concluding remarks

Food poisoning is a significant cause of both short-term and long-term morbidity; it is equally a cause of observed and insidious morbidity. While short-term consequences of food poisoning include hospitalisations, out-of-pocket expenses, loss of productivity and deaths; its long-term consequences include dreadful diseases, such as cancers, birth defects and more indirect deaths.

For this reason, the contribution of the human element in the occurrence of food poisoning is worrying, particularly because of the existence of unsafe harvesting, uncaring handling, unhygienic food-serving facilities, unhealthy processing practices and criminal use of foods. Yet all these issues and practices can be addressed with available technologies, systems and evidence-based practices within the national and international regulatory frameworks.

Given the reliance of the human race on foods for its survival and the fact that every food that humans eat comes ultimately from the natural environment; the implementation of hygienic and safe food handling practices and the preservation of all fauna and flora ecosystems as well as environmental media, namely air, soil and water, is not only a necessity but a shared responsibility that each human being should shoulder every day in the way he or she lives, make decisions and eat.

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