Food Safety Consideration to Achieve Global Health Outcomes under Food Security Issues

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Abstract

Food safety mainly depends on improving global health outcomes and to ensure the sustainable food security. Food safety issues should be reducing the food risks of starvation, unstable economics and foodborne illness in food security framework. This chapter presents a review on FSQA, global health, food security together with relationship intricacies between the three concepts in order to present practical solution to these problems. Contamination, microbial pathogens, chemical and physical contaminants and toxins are common cause of foodborne diseases and they prevail in low and middle income countries. The benefits which have been postulated in this chapter are improved food availability, increase in consumer confidence and decrease the postharvest losses. This is spelled under capacity building, partnership, education and other supports that must be put in place to empower communities and other stakeholders to prevent risks. It is found that academics are seeking biosensors for disease diagnosis and blockchain technology for traceability as innovation to enhance food safety system. This chapter puts forward a strengthened system on purposeful international intervention regarding food safety and security towards containing foodborne illness as part of an overall prevention strategy in health promotion globally.

Keywords: Food security, Food safety, Foodborne illness, Hazards

Cite this Article as: Firdous N, Farooq U, Rehman S, Ahmad S, Sibt-e-Abbas M, Abid J, Azhar M, Shaukat M and Ahmad M, 2025. Food safety consideration to achieve global health outcomes under food security issues. In: Farooqi SH, Kholik K and Zaman MA (eds), One Health Horizons: Integrating Biodiversity, Biosecurity, and Sustainable Practices. Unique Scientific Publishers, Faisalabad, Pakistan, pp: 40-48. https://doi.org/10.47278/book.HH/2025.91

A Publication of Unique Scientific Publishers

Chapter No: 25-006

Received: 15-Feb-2025
Revised: 08-Apr-2025
Accepted: 21-May-2025

Introduction

It is impossible to comprehend food security and food safety in light of nutritional goals that must be met for global health. Whereas food security ensures that a population has adequate access to adequate quantities of adequate quality and conveniently accessible and readily available foods. In food safety consideration, food safety ensures that the food is not hazardous to the health of humans or animals as shown in figure (1). Due to confirmed high incidences of food borne illnesses worldwide, food safety should be a central cause in public health and food security strategies. The World Health Organization (WHO) has asserted that unsafe food threatens economic development, deepens poverty, and diminishes nutrition in the low and middle income countries. In a move to level up and place food safety within the broader category of food security this chapter analyses the role of food safety in international health plus features, challenges, innovative strategies and government requirements (WHO, 2021).

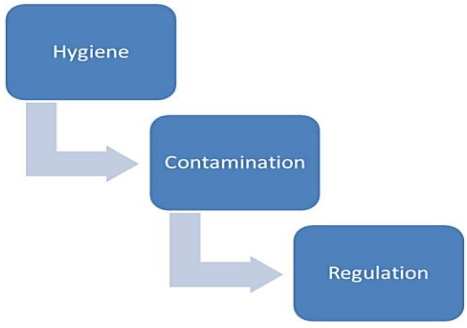

Fig. 1: Food Safety Consideration

Introduction to Global Health and Food Safety

Food safety incorporates all measures that need to be taken to assure that food is safe, free from hazards and fit for human consumption as it plays central role towards promoting world health since it concerns wellbeing of people as well as functionality of food chains. These hazards may comprise physical (pesticides, heavy metal, and food additives), biological (bacteria, viruses, and parasites), or mechanical (foreign bodies). All these issues are critical to attaining international health goals, sustaining population health, and fostering economic stability (Havelaar et al., 2015). The topic of food safety is key to the concept of global health, human health sustainability, and the food security systems. Foreign objects, germs, viruses, parasites and pesticide residues and heavy metals are all required to make food safe for consumption. It is imperative to mitigate these risks for the health of the public, economic stability, as well as to meet those international health goals shown in Figure 2 (WHO, 2022).

Fig. 2: Steps for improving food safety

Food Safety Impact on Global Health Issues

Foodborne risks enhance the global disease prevalence and impact and affect especially children, the elderly, and immune compromised individuals (Fung et al., 2018). Foodborne illnesses remain an emerging health menace with an estimated 600 million people falling ill annually, and 420,000 of those dying from the related complications, based on the World Health Organization's global statistics and, upset by the poor health standards and weak food laws posed by developing states (Grace, 2015). If ever there was a synergy between public health as a concept and food safety than in the current situation. Aflatoxin raises the incidences of chronic diseases such as cancer and liver diseases whilst microbial hazards such as Salmonella and Escherichia coli remain a frequent source of outbreaks. This dual duty emphasizes the need for comprehensive food safety rules (King et al., 2017).

Regulatory and Policy Framework

One Health Approach

The One Health strategy emphasizes the interdependence of human, animal, and environmental health and attempts to prevent foodborne zoonosis and antibiotic resistance by addressing dangers at their source (Mudenda et al., 2023).

Global Strategies

Organizations such as the World Health Organization and the Food and Agriculture Organization (FAO) have developed frameworks like the Codex Alimentarius to standardize food safety standards globally (Mudenda et al., 2023).

Food Safety Integration in to Food Security Strategies

Enhancing Food Systems

Food waste results in significant contamination risks and resource losses. Stronger regulation and efficient recycling procedures can ensure the safety of food that has been rescued.

Empowering Production System

Modern farming techniques like precision and organic farming help lower pollution exposure. Improving post-harvest processing and storage also reduces microbial development and deterioration. To address regional disparities in food safety, initiatives to expand capacity such as establishing food testing facilities in low and middle income countries are crucial (Di Renzo et al., 2015).

Role of Food Safety in Communicable and Non-communicable Disease

Preventing both communicable and non-communicable diseases (NCDs) requires that individuals eat food free of harmful viruses and chemical pollutants. Safe food systems reduce the incidence of foodborne illnesses, chronic diseases, and antimicrobial resistance (AMR), which contributes to the achievement of global health goals. Prevention of chronic disorders and infectious diseases are important for public health due to food safety (Di Renzo et al., 2015).

Communicable Diseases prevention through Food Safety

Bacteria, viruses and parasite are the common food borne pathogens which are responsible for food borne diseases. According to the WHO, about half a million people around the globe perish from food-related diseases annually, and developing countries have the highest fatalities (WHO, 2022).

Bacteria: The most frequent bacterial agents responsible for serious foodborne diseases consist of *Salmonella, Escherichia coli* and *Listeria monocytogenes*. Especially if children and elderly people get infected with these bugs, symptoms such as fever, diarrhoea, and abdominal cramp might be fatal (WHO, 2022).

Parasites: Parasites like *Toxoplasma Gondi* and *Cryptosporidium* are connected to undercooked meat and contaminated water, and they can cause major issues, particularly in individuals with compromised immune systems shown in Figure 3 (Robertson, 2005).

Viruses: Contaminated food and drink are frequent ways for hepatitis A and norovirus to spread, causing liver damage and, in severe cases, gastrointestinal distress (Robertson, 2005).

Impact on Vulnerable Population

Children under five are account for 40% of the global burden of foodborne illness due to repeated infections and nutrient loss, often resulting in stunted growth and impaired cognitive development. Older adults and pregnant women are particularly susceptible to foodborne diseases due to weakened immune systems (Havelaar et al., 2015).

Mitigating Non-Communicable Diseases through Food Safety

Unsafe food exposes people to toxins, food additives, and chemical contaminants, which leads to the development of non-communicable diseases (NCDs) in addition to infectious diseases (Afoakwah et al., 2024).

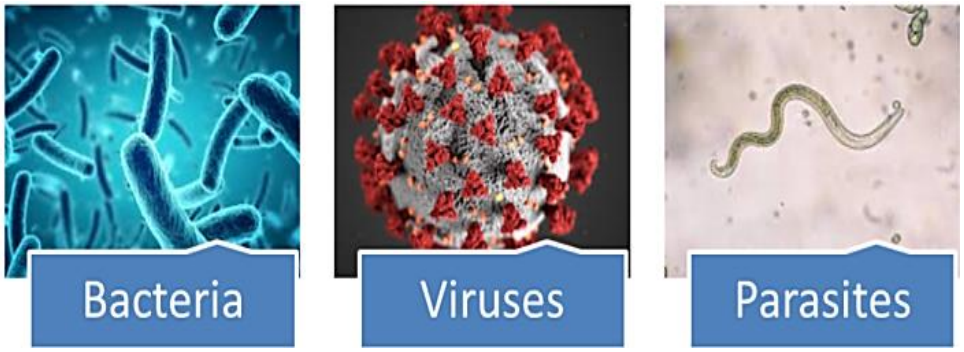

Fig. 3: Pathogens like bacteria, Viruses, Parasites causes foodborne communicable diseases

Chemical Contaminants

1. **Mycotoxins**: Strong carcinogens linked to liver cancer are aflatoxins, which are created by molds in grains and nuts that are not properly maintained. Additionally, they impair immunological function, increasing a person's vulnerability to infections (Unnevehr and Grace, 2013).
2. **Heavy Metals**: Toxins like lead, mercury, and cadmium, which are frequently present in contaminated water or soil, can build up in the food chain and have detrimental effects on neurological development, especially in young children (ATSDR, 2022).
3. **Pesticides and Agrochemicals**: Overuse of pesticides in agriculture results in toxic residues in food, which have been connected to cancer and diabetes as well as hormone disruption (Weber, 2020).

Integrated Strategies for Disease Prevention

A robust food safety framework is essential for preventing both communicable and non-communicable diseases;

- **Strengthening Food Safety Standards:** To keep an eye on the food production, processing, and distribution of food, governments and international organization should impose stringent rules (de Fátima Ferreiro et al., 2021).
- **Consumer Education**: Educating customers on safe food handling techniques lowers the chance of contamination by enabling them to make knowledgeable decisions.
- **Innovative technology**: Food safety monitoring can be improved by implementing technology like Nano sensors for disease detection and block chain for traceability (Xu et al., 2022).
- **International Cooperation:** Countries can work together to standardize food safety rules, particularly when tackling cross-border issues like AMR (de Fátima Ferreiro et al., 2021).

Importance of Food Safety in Achieving Health Outcomes

Health outcomes are inextricably connected to food safety. Foodborne infections, which are a leading source of morbidity and mortality globally, are brought on by consuming contaminated food. The World Health Organization (WHO) reports that 420,000 people die from foodborne illnesses worldwide per year, affecting one in ten people. In LMICs, where hazards are increased by poor hygiene standards, insufficient infrastructure, and no regulatory supervision, the burden is disproportionately greater. Children under five are especially at risk, as they bear 40% of the burden of foodborne illnesses worldwide. Malnutrition, delayed cognitive development, and chronic health issues are from foodborne illnesses (Grace, 2015). The fight against non-communicable diseases (NCDs) also involves food safety. For example, NCDs including cancer and cardiovascular disorders have been connected to the overuse of food additives and chemical pollutants. By addressing these hazards with strict food safety regulations, chronic disease can be avoided and long-term health is encouraged (Unnevehr and Grace, 2013).

Interconnection between Food Safety, Food Security, and Public Health

Public health, food security, and food safety are closely related. The availability, affordability, and accessibility of enough wholesome food to satisfy everyone's nutritional needs is referred to as food security. However, without guaranteeing that the food is safe to consume, food security cannot be entirely achieved. By decreasing its accessibility (e.g., financial losses from medical expenses), acceptability (e.g., consumer mistrust of food systems), and availability (e.g., food recalls), unsafe food compromises food security (Afsana et al., 2022).

Pillars of Interconnection

The three pillars of interconnection are:

1. Availability

Food safety affects food availability by lowering spoilage and post-harvest losses. Food insecurity can be made worse by improper handling procedures, a lack of cold storage, and contamination during manufacturing or transit that makes food unfit for human consumption. Because there is less edible food available, unsafe food has a direct impact on food availability. Significant post-harvest losses result from contamination in the food supply chain, whether from toxins, infections, or chemical dangers. Aflatoxin, for example, can make huge amounts of grains unsafe for human eating, leading to waste and reduced food supplies (FAO, 2020).

2. Accessibility

Communities and households suffer financially as a result of unsafe food. Economic access to food is restricted, especially in LMICs, by the expenses of healthcare, lost productivity, and trade restrictions brought on by food safety concerns. Aflatoxin poisoning, for instance, lowers the marketability of staple commodities like peanuts and maize and increases economic insecurity (Grace, 2023).

3. Utilization

The ability of the body to extract nutrients from meals is referred to as utilization. Malnutrition can result from eating unsafe food that contains pollutants, infections, or chemicals, especially for sensitive populations including the elderly, pregnant women, and children. Proper utilization, a crucial aspect of food security, depends on safe food. Food contamination can cause illnesses that affect the body's capacity to absorb nutrients, hence compromising nutritional results. Maintaining food safety improves food's nutritional content and promotes public health shown in Figure 4 (Unnevehr and Grace, 2013).

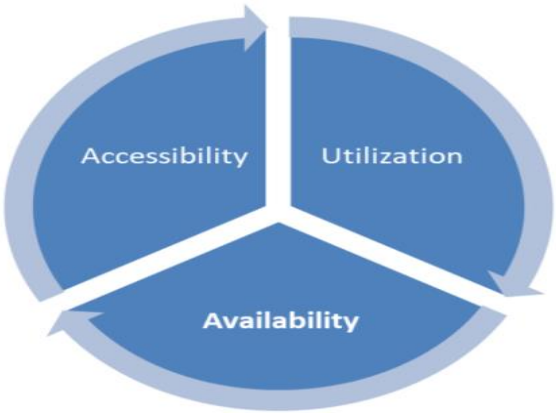

Fig. 4: Pillars of Interconnection

Role of Food Safety in Public Health Emergencies

COVID-19 stands for both the novel coronavirus disease 2019 and its official virus name remains SARS-CoV-2. Public health emergencies, such as the COVID-19 pandemic, emphasize that how important food safety is to maintaining positive health outcomes. Disruptions to the food supply chain during the epidemic raised the possibility of food contamination and highlighted the need for strict food safety regulations. Measures including improved traceability, improved hygiene, and effective communication were crucial to lowering these risks (Pressman et al., 2021).

Challenges of Food Safety in Food Security

The relationship of food safety and food security system works together to produce sufficient safe food. Food safety needs to benefit and never slow down efforts to bring safe food to everyone worldwide. Food safety is essential for preventing foodborne illnesses and protecting the general public's health. Food security is the state in which there is always an adequate supply of nutritious food for everyone. However, achieving food security is a challenging endeavor that relies on several factors, chief among them being food safety (Sadati et al., 2021). Globalization, climate change, contamination sources, and the need for effective legal and regulatory frameworks are all factors that contribute to food safety issues, which can have a significant impact on food security by causing a decline in agricultural productivity, foodborne illnesses, and public trust in food systems.

Contamination Sources

Numerous factors can lead to food contamination, which could jeopardize food safety and security. Physical, chemical, and biological are the three broad categories into which these sources can be divided.

Biological Hazards

Foodborne illness is mostly caused by harmful microorganisms, such as bacteria, viruses, parasites, and fungi. Pathogen can penetrate into food at many stages such as manufacturing, processing, transportation, and consumption which include *Salmonella, Escherichia coli, Listeria* and *Norovirus*. Poor hygienic practices, negligent food handling, and insufficient cooking are common contributors of infection. Biological hazard contamination-induced foodborne outbreaks can result in illness, monetary loss, and a drop in public trust in food safety (WHO, 2022).

Chemical Hazards

These are dangerous substances that occur naturally or are produced by industrial, agricultural, or food processing operations. Pesticides, food additives, heavy metals (including lead and mercury), and mycotoxins are examples of common chemical hazards. Long-term health problems like cancer, neurological damage, and developmental problems can result from these toxins building up in food. Food safety is a threat when food is rendered unsafe by chemical residues especially where chemical use regulations are weak (WHO, 2023).

Physical Hazards

Physical contamination occurs when food comes into contact with other objects such as metal, glass, plastic or wood etc. These materials may meet food products during handling, processing or packing of the food products. Even though compared to biological or chemical contamination physical hazards are rare they can harm and make the food uneatable. It means that clients might suffer from food recalls, financial loss, and food safety concerns due to existence of such risks in their foods (FDA, 2023).

Climate Change and Its Impact on Food Safety

The study reveals clearly how climate change poses a threat to food safety and security. Climate change is a major concern with regard to food safety because each of the stages of food production, processing, transportation, and storage which is influenced by global temperature increases, shifting precipitation, and pronounced weather volatility (Duchenne-Moutien and Neetoo., 2021).

Temperature enhancement: *Salmonella* and *Campylobacter* are two bad bacteria that tend to increase in growth in food products due to high temperatures. This is worse for consumable products such as meat, child, fruits and all other food products that have a short shelf life. Apart from reducing the shelf-life of food stuffs, high temperature increases the risk of contamination if it is not properly stored (FDA, 2023).

Distribution of water and water quality: Climate change depletion of water makes it scarce and reduces agricultural productivity as well as

food security. Water scarcity and quality complicates to crops, irrigation infrastructure and food processing complicates efforts to ensure food procurement with zero contact with dirty water. Further, waterborne infections may occur when germs contaminate water sources due to flood occurrence as a consequence of natural disasters (WHO, 2019).

Severe weather: Food supply networks and systems in workflows can be disturbed by natural disasters such as hurricanes, droughts and floods. If such happening happens, then food supply, crop productivity and even some infrastructures in the fields might be affected. Yet these disruptions compromise food security by reducing people's access to food and creating conditions that are easily contaminated, and hence cause foodborne diseases (Smith et al., 2020).

Emergence of Risks of Food Safety in Global World

Food safety is at present threatened due to a rapidly evolving food trade and complex food webs resulting from global world with the possible risks involved such as

Longer food supply chains: Since global food industry supply chain is often long and complex, the probability of food spoilage during processing and transportation is high. Cross border contamination at a much faster rate may make it harder to track and handle food safety issues. An example of random source food distribution system is the global supply web, which poses a challenge to the identifications of a food source implicated in an outbreak because food items can pass through various countries with varying policies on food safety (Godfray et al., 2010).

Emerging and novel pathogens: Some diseases for example foot-and-mouth disease have been known to spread with the transport of cattle across borders thus exposing new stocks and possibly new health problems to a particular population. The global interchange of food also facilitates the spread of novel infections which affect the human health.

Cultural and regulatory differences: Countries have very different laws governing food safety which is considered safe in one country may be illegal in another. Global differences in pesticide regulations, food additives, and hygiene standards might complicate the management of food safety. Due to these disparities, efforts to ensure global food security may be more challenging and consumer confidence in food safety may be damaged (Godfray et al., 2010).

Policy and Regulatory Frameworks for Food Safety

In order to address the above-mentioned concerns, food safety regulations and practices must be successful. Governments and international organizations use stringent legislation, supervision initiatives, and public awareness efforts to largely guarantee food safety.

National and international regulatory system: There must be clear and enforceable food safety regulations in every country that address every stage of food production, from farm to table. The European Food Safety Authority (EFSA) and the U.S. Food and Drug Administration are two regulatory agencies that set food safety standards and inspect compliance (FDA, 2020). **International Coordination**: International cooperation through agencies like the Codex Alimentarius Commission and the World Health Organization (WHO) aids in standardizing food safety laws and promoting trade. These groups help nations enhance their food safety systems and offer guidance on food safety standards (WHO, 2023). Harmonizing food safety regulations across nations is still difficult, though especially given the complexity of the world's food networks.

Public Awareness and Education: Reducing the risk of foodborne illnesses requires educating both food producers and consumers about proper food handling, preparation, and storage techniques. At the individual and community levels, public health initiatives and training initiatives are essential for enhancing food safety (FAO, 2021). As part of larger public health initiatives, governments and non-governmental organizations must give food safety education top priority in order to guarantee that food security is maintained.

Food Safety and Nutrition

Food safety more specifically means the steps, laws, and rules that are in place to ensure food is not infected with hazardous bacteria, viruses, chemicals, or fungi etc. Healthy diets that will help to decrease incidence of food borne diseases and other nutritional disorders are safe and well balanced diets that will enhance growth and development. "From Farm to Table" encompasses all aspects ranging from the production in farms through processing, preservation and use of the foods. Appropriate measures of food safety eliminate health risks and halt food-borne disease epidemics that are in a way a public health advantage (WHO, 2020).

Nutrition, therefore, deals with feeding the body as a machine with the fuel that will enable it have the most efficient performance it requires. It is very important for people to have access to healthy meals and right amounts of macronutrients and micronutrients in their foods (FAO, 2018). The relevance between nutrition and food safety through achieving results for health is important to appreciate. Well-balanced diet ensures that the population involves adequate energy and nutrient essentials for growth, immunity, and overall health while safe food reduces incidences of food borne diseases. Although a nutrient dense food could provide the body with nutrients, the above food could introduce some bad bacteria due to unsanitary food processing. For example, undiagnosed food borne illnesses including salmonellosis that is caused by Salmonella bacteria can cause dehydration, gastrointestinal complications and nutritional deficiencies. On the other hand, consuming safe and healthy foods enhance the health of people and reduce their possibility of getting a disease or developing nutrient-deficiency related ailments (Weber, 2020).

Challenges of Food Safety Impacting Nutrition

Significant progress has been made in food safety protocols, yet problems still exist that might jeopardize food safety and nutrition. A critical issue is food contamination by harmful microorganisms, chemicals, or poisons that can occur at many stages of food production. Environmental pollutants, unsafe agricultural practices, and inadequate food handling can all contribute to these contaminants. The overuse of pesticides in agriculture, for example, has raised concerns about chemical residues in food because these chemicals can enter the food chain

and cause endocrine disruption, cancer, and other long-term health issues (FAO/WHO, 2023).

Heavy metals such as arsenic, lead, and mercury can also contaminate food items, particularly in regions with hazardous agricultural practices or inadequately controlled industrial waste disposal. Another major issue that continues to endanger global health is microbial contamination of food. Foodborne infections involving Salmonella, Listeria, and Escherichia coli affect millions of people globally. These viruses often enter food through improper handling, inadequate storage, and inadequate cooking temperatures (WHO, 2023).

Steps for Enhancing Nutrition

Several strategies can be employed to enhance food safety and nutrition.

- **Safe agriculture practices:** As food safety begins at the farm level, implementing safe agricultural practices is essential to preventing contamination. It assures the appropriate applied of pesticides, the sound management of fertilizer and the assurance that irrigation water supply is clean and free from adulterants. Further, a study which compares the yields in the organic agricultural practices which use few synthetic pesticides will establish the probability of pesticide residues in foods reducing (FAO, 2018).
- **Appropriate handling and storage**: Food borne illnesses result from poor food handling and storage techniques that prevail in our societies today. Food workers have to demonstrate proper knowledge of things like hand washing, avoiding the transfer of germs between foods, and the efficient handling of food and storage of food at the appropriate temperature in order to protect people from getting sick from food. To help lower the risk of foodborne illness the World Health Organization (WHO) has established a checklist on how to handle foods safely (WHO, 2020).
- **Fortification of food:** Supplementation of foods is crucial in an endeavor to boost the intake of foods with a high content of vitamins. However, fortification makes it necessary to look at aspects of food safety in equal regard because no contaminants should be introduced. For instance, iron, can help eliminate anemia especially amongst high risk groups such as women and children, when incorporated in our daily foods like rice and wheat but there is danger if care is not taken that it does not introduce dangerous substances or any form of bacteria into the food chain (FAO, 2018).
- **Monitoring and Surveillance**: Good surveillance systems play a central role when it comes to the prevention and early identification of food borne infections. They allow quick responses in epidemic tracking, and the identification of pollution sources that are of concern to the general public. Measures to making food safe all through food chain is essential in ensuring that food is safe for consumption and that it has not lost its nutritional value through food poisoning (Weber, 2020).
- **Public education and awareness**: Reduction of cases of food borne diseases entails informing the public about appropriate diets. A public health awareness has to be created which involves different levels of governments, health sector, both national and international non-government organizations, to cascade interested general public about the importance of food in maintaining good health. It means that alongside advertising such topics as proper hand washing or correct way of food preparation, every aware campaign should focus on such practices as washing fruits and vegetables, avoiding raw meat, or making sure that the food is properly cooked (WHO, 2020).

Fig. 5: Strategies used to improve nutrition and food safety

International and Regional Frameworks for Food Safety

Acknowledged as an alarming global issue, the problem of food safety requires the development of both intergovernmental collaboration and legislation. In order to establish standard and achieve food safety concern internationally, several national policy, regional strategy and even international food safety policy has been formulated. These framework aims at enhancing provision of trade, health and food security among countries describe in Table 1 (Grace et al 2015).

Regional Food Safety Regulations

Regional Approaches

It is necessary to distinguish between the frameworks that adapt the generally applicable standards in the international space to solve specific food safety problems in a region (Han et al., 2020).

African Union: To this end the AU seeks to undertake particular treats such as mycotoxin contamination that presents various threats to trade and health in African countries through the like of PACA.

European Union: The European Union is one of the few areas that possesses one of the highest levels of food safety in the international plane owing to legislation such as the General Food Law (Regulation EC 178/2002). RASFF is the system used by the EU to address food safety events as they occur.

ASEAN Framework: To encourage business and protect the interest of the consumers in the ASEAN region, the Association of the South East Asian Nations is in the process of developing food safety.

Novel Methods Development in Food Safety

Advancement of new technologies in food safety are to be

Blockchain Technology for Traceability

Blockchain technology has been transformative in the food safety and quality assurance industry since it puts more light into the supply chain. Purchase to consumption, each step of the food chain is recorded in an immutable digital database popularly known as block chain (Xu

et al., 2022). This reduces the impact of food safety accidents, as victims of contaminated food can quickly know from where to source food. Research has it that, blockchain has been found to boost consumer confidence as well as the time taken to identify the source of contamination (Galvez et al., 2018). For instance, Walmart fast increased response time to contaminated Lush Green Vegetables using blockchain to track food items (Kamilaris et al., 2019).

Table 1: Framework of food safety for international standards

Codex Alimentarius	The Codex Alimentarius was established in 1963 by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) to provide a collection of internationally recognized standards, regulations, and guidelines for the safety and quality of food. The objectives of Codex Alimentarius include protecting consumer's health and promoting fair commerce (Lee et al., 2021).
Global Standards	Internationally Codex standards provide a scientifically sound reference for food safety information including labeling issues, food additives, pollutants, and limitations on pesticide residues. (FAO and WHO, 2020) New Problems: Codex is always evolving to solve new issues in the area of food security like the application of nanotechnology in the foods and AMR. As such, these adjustments will make the framework useful and relevant in maintaining public health. The Codex is recognized by WTO as the most standard set for food markets and it is crucial for maintaining the confidence of the consumers in the food chains and adjusting food safety related trade minorities.
WHO Guidelines	WHO employs technical recommendation using surveillance systems and capacity enhancing frameworks for food hygiene. Its aim is to decrease rates of food borne diseases and the consequences that they have on the citizens of the world. Preventing Disease: Some of the germs causing food borne disease include Salmonella and Listeria monocytogenes for which the World Health Organization has provided handy operational toolkit. Monitoring Networks: WHO supports the monitoring of foodborne diseases and promotes the exchange of data around the world through programs such as the Global Foodborne diseases Network (GFN) (WHO, 2022). Capacity Building: WHO assists member nations source food inspectors and enhance their laboratory capacity as they strengthen their food safety systems.
FAO Guidelines	In addition to focusing on agricultural practices and their impact on food safety, the Food and Agriculture Organization (FAO) offers guidelines for sustainable and safe food production methods; Good Agricultural Practices: New techniques of farming such as integrated pest management and farm water management that minimize sources of pollution are supported by FAO. Sustainable system: Recognizing that food production should not compromise the environment, FAO encourages the use of ecological sound activities.

Biosensors for Pathogen Detection

A biosensor uses both electronics and biologic materials like enzymes or antibodies to create detectable output. The presence of biosensors is a guarantee of rapid, accurate and economical methods in detection of foodborne pathogen. Such devices quickly indicate a specific pathogen, e.g., *Salmonella*, or *E. coli,* by utilizing enzyme or antibody recognition chains. Biosensors have high sensitiveness and specificity, and short testing time compared to other laboratory techniques. Another new technology is portable biosensors that may be deployed wherever and can be used to provide a timely check for food-borne pathogens from areas that may be underserved (Singh et al., 2023).

Machine Learning and Artificial Intelligence

Mature technologies in the field of machine learning and artificial intelligence are applied in preventing threats in the area of food safety. These techniques enable application of proactive treatments since the mechanisms scan the vast databases for patterns and trends of contamination. For instance, AI can approximate possible future food borne outbreaks and monitor temperatures of transported foodstuffs to avoid spoilt food. Furthermore, those specialized image recognition systems are incorporated into artificial intelligence in an endeavor to detect pollutants, and defects on foods and goods during processing (Birmpa et al., 2020).

Nanotechnology for Food Packaging

Nanotechnology is also changing food packaging through the incorporation of antimicrobial agents to the packaging materials and thus increasing shelf life and decreasing the rates of food borne diseases. For instance, through nano composites it would be easy to prevent growth of pathogens such as Listeria monocytogenes in food distribution and storage. Furthermore, smart packaging with nanosensors for giving real-time food freshness permits customers to make decisions (Kumar et al., 2018).

Technology of Internet

Internet connected devices swallow streams data and reports it to computer systems in the cloud for people interested and organizations to monitor and control it in case of distinctive transformation. This method is extremely profiting in cold chain management because it keeps perishable commodities within acceptable temperature limits. Indian supply chain has specialization in incorporation of IoT into the food safety chain for constant check of temperature, humidity and pH level (Balamurugan et al., 2021).

Conclusion

To sum up with food safety for reaching of the global health objectives, especially topics connected with food security. Food safety risks are not only entwined, but they necessarily require consideration at all stages of production, processing, distribution, and consumption given

the current global architecture of food systems. It has been ascertained that in order to achieve the global health goals, different facets of food safety have to be accorded high levels of priority including FSMS and GAP. In this regard, the global society can only rise to the challenge by collectively mobilizing its human, material and financial resources in order to become an active partner for the enhancement of the food security and safety, that is the farming systems of the contemporary world. For achieving enhanced food security, stakeholders such as governments, international organizations, civil society, and the corporate population need to work collectively to enhance smallholder farmer productivity, increase and transform food systems' capacity for adaptation to shocks and stresses, and meet food safety requirements. Reading, writing, and arithmetic is not enough; food security and quality is fundamental and revered for it provides adequate food sufficient, wholesome and safe to support economic growth, preserve health, and lead to attaining the sustainable development goals. Lastly, indicates that sustainable improvements in global health cannot occur through food safety considerations without the mutual engagement of these related topics in terms of sustainability, food security, and justice.

References

Afoakwah, N. A., Mahunu, G. K., & Osei-Kwarteng, M. (2024). Safe Food and Non-Communicable Diseases in the Global South. In *Food Safety and Quality in the Global South* (pp. 95-122). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-97-2428-4_4

Afsana, K., Jolly, S.P., Akhter, F. (2022). Nutrition, Food Safety and Global Health. In: Kickbusch, I., Ganten, D., Moeti, M. (eds) (Pp 1-28) Handbook of Global Health. Springer, Cham. https://doi.org/10.1007/978-3-030-05325-3_93-1

Agency for Toxic Substances and Disease Registry (ATSDR) (2022). *Toxicological profile for cadmium*. U.S. Department of Health and Human Services. https://www.atsdr.cdc.gov/toxprofiles/tp5.html

Baker, S., Thompson, K., Carter, R., Williams, J., & Smith, A. (2021). Emerging foodborne pathogens and global health. *Food Safety International Review, 15*(2), 12–19.

Balamurugan, J., Aravind, J., & Sukumaran, P. (2021). Role of IoT in food safety: A comprehensive review. *Journal of Food Science and Technology, 58*(4), 1234-1247. https://doi.org/10.1007/s13197-021-04858-4

Birmpa, A., Sfika, V., & Vantarakis, A. (2020). Artificial intelligence systems for food safety management: New perspectives and challenges. *Trends in Food Science & Technology, 102*, 206-215. https://doi.org/10.1016/j.tifs.2020.06.014

Codex Alimentarius Commission (2019). *General principles of food hygiene.* Food and Agriculture Organization of the United Nations/World Health Organization.

de Fátima Ferreiro, M., Salavisa, I., de Sousa, C., & Bizarro, S. (2021, September). Social Innovation in Food Systems: Towards Food Security and Sustainability. In *Proceedings of the 16th European Conference on Innovation and Entrepreneurship (ECIE 2021)* (Vol. 1, pp. 321-328).

Di Renzo, L., Colica, C., Carraro, A., Cenci Goga, B., Marsella, L. T., Botta, R., & De Lorenzo, A. (2015). Food safety and nutritional quality for the prevention of non-communicable diseases: the Nutrient, hazard Analysis and Critical Control Point process (NACCP). *Journal of translational medicine*, *13*, 1-13.

Duchenne-Moutien, R. A., & Neetoo, H. (2021). Climate change and emerging food safety issues: a review. *Journal of Food Protection*, *84*(11), 1884-1897.

FAO (2018). *The State of Food Security and Nutrition in the World 2018*. Food and Agriculture Organization of the United Nations. Rome: FAO. https://openknowledge.fao.org/server/api/core/bitstreams/f5019ab4-0f6a-47e8-85b9-15473c012d6a/content

FAO (2020). The state of food security and nutrition in the world: Transforming food systems for affordable healthy diets. Food and Agriculture Organization of the United Nations. https://openknowledge.fao.org/server/api/core/bitstreams/9a0fca06-5c5b-4bd5-89eb-5dbec0f27274/content

Food and Agriculture Organization (FAO) (2021). *Climate change and food safety*. FAO Issue Paper. https://openknowledge.fao.org/server/api/core/bitstreams/a4fd8ac5-4582-4a66-91b0-55abf642a400/content

Food and Drug Administration (FDA) (2020). *Food safety and inspection services*. FDA.gov.https://books.google.com.pk/books?id=Hi1kAgAAQBAJ&lpg=PR1&ots=UVR_ehFLpm&dq=Food%20and%20Drug%20Administration%20(FDA).%20(2020).%20Food%20safety%20and%20inspection%20services.%20FDA.gov.%20&lr&pg=PA104#v=onepage&q&f=false

Fung, F., Wang, H. S., & Menon, S. (2018). Food safety in the 21st century. *Biomedical journal*, *41*(2), 88-95.

Galvez, J. F., Mejuto, J. C., & Simal-Gandara, J. (2018). Future challenges on the use of blockchain for food traceability analysis. *Trends in Analytical Chemistry, 107*, 222-232. https://doi.org/10.1016/j.trac.2018.08.011

Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., Pretty, J., Robinson, S., Thomas, S. M., & Toulmin, C. (2010). Food security: The challenge of feeding 9 billion people. *Science, 327*(5967), 812–818.

Grace, D. (2015). Food safety in developing countries: Research gaps and opportunities. *International Journal of Environmental Research and Public Health, 12*(9), 10490-10512. https://doi.org/10.3390/ijerph120910490

Grace, D. (2023). Burden of foodborne disease in low-income and middle-income countries and opportunities for scaling food safety interventions. *Food Security, 15*(6), 1475-1488. https://doi.org/10.1007/s12571-023-01391-3

Han, G., Yan, S., & Fan, B. (2020, August). Regional regulations and public safety perceptions of quality-of-life issues: Empirical study on food safety in China. In *Healthcare* (Vol. 8, No. 3, p. 275). MDPI.

Havelaar, A. H., Kirk, M. D., Torgerson, P. R., Gibb, H. J., Hald, T., Lake, R. J., ... & Devleesschauwer, B. (2015). World Health Organization global estimates and regional comparisons of the burden of foodborne disease in 2010. *Epidemiology and Infection, 143*(11), 2477-2488. https://doi.org/10.1017/S0950268815000778

Kamboj, S., Gupta, N., Bandral, J. D., Gandotra, G., & Anjum, N. (2020). Food safety and hygiene: A review. *International journal of chemical studies*, *8*(2), 358-368.

Kamilaris, A., Fonts, A., & Prenafeta-Boldú, F. X. (2019). The rise of blockchain technology in agriculture and food supply chains. *Trends in Food Science & Technology, 91*, 640-652. https://doi.org/10.1016/j.tifs.2019.07.034

King, T., Cole, M., Farber, J. M., Eisenbrand, G., Zabaras, D., Fox, E. M., & Hill, J. P. (2017). Food safety for food security: Relationship between global megatrends and developments in food safety. *Trends in Food Science & Technology*, *68*, 160-175.

Kumar, P., Maheshwari, M., & Chauhan, M. K. (2018). Nanotechnology for food packaging: Recent trends and future perspectives. *Journal of Nanomaterials, 2018*, 1-12. https://doi.org/10.1155/2018/6726183

Lee, J. G., Lee, Y., Kim, C. S., & Han, S. B. (2021). Codex Alimentarius commission on ensuring food safety and promoting fair trade: Harmonization of standards between Korea and codex. *Food Science and Biotechnology*, *30*(9), 1151-1170. https://doi.org/10.1007/s10068-021-00943-7

Mudenda, S., Chabalenge, B., Daka, V., Mfune, R. L., Salachi, K. I., Mohamed, S., & Matafwali, S. K. (2023). Global strategies to combat antimicrobial resistance: a one health perspective. *Pharmacology & Pharmacy*, *14*(8), 271-328.

Pressman, P., Naidu, A. S., & Clemens, R. (2020). COVID-19 and food safety: risk management and future considerations. *Nutrition Today*, *55*(3), 125-128. DOI: 10.1097/NT.0000000000000415

Robertson, L. J. (2005). *Foodborne protozoan parasites*. *International Journal of Food Microbiology*, 103(2), 207–227. https://doi.org/10.1016/j.ijfoodmicro.2004.12.032

Sadati, A. K., Nayedar, M., Zartash, L., & Falakodin, Z. (2021). Challenges for food security and safety: a qualitative study in an agriculture supply Chain Company in Iran. *Agriculture & Food Security*, *10*, 1-7.https://doi.org/10.1186/s40066-021-00304-x

Singh, P., Pandey, V. K., Srivastava, S., & Singh, R. (2023). A systematic review on recent trends and perspectives of biosensors in food industries. *Journal of Food Safety*, *43*(5), e13071.

Smith, D. R., Wang, J., & Zhang, Y. (2016). *Heavy Metals in Food Safety*. *Journal of Environmental Science*, 18(4), 243-257.

Smith, P., Brown, R., Wilson, T., Adams, M., & Green, L. (2020). Climate change and food safety: A comprehensive review. *Environmental Health Perspectives, 128*(10), 107–115.

United Nations Food and Agriculture Organization (FAO). (2021). *Climate change and food security: Risks and opportunities*. FAO Report. https://openknowledge.fao.org/server/api/core/bitstreams/a4fd8ac5-4582-4a66-91b0-55abf642a400/content

Unnevehr, L., & Grace, D. (2013). Aflatoxins: Finding solutions for improved food safety. *Global Food Security, 2*(2), 184-190. https://doi.org/10.1016/j.gfs.2013.04.004

Weber, G. M. (2020). Challenges in the prevention of foodborne illness. *Building the Future of Food Safety Technology*, 67-77.

WHO. (2019). *Waterborne Disease Related to Unsafe Water and Sanitation*. World Health Organization. https://iris.who.int/bitstream/handle/10665/370026/9789240075610-eng.pdf

WHO. (2020). *Food Safety*. World Health Organization. https://www.who.int/health-topics/food-safety. WHO food safety page https://www.who.int/news-room/fact-sheets/detail/food-safety

WHO. (2021). *Global strategy for food safety 2022–2030*. World Health Organization. https://www.who.int/publications/i/item/9789240057685

World Health Organization (WHO) (2023). *Foodborne diseases*. WHO Fact Sheet. https://www.who.int/news-room/fact-sheets/detail/food-safety

World Health Organization (2018). Waterborne disease related to unsafe water and sanitation. *Geneva, Switzerland: World Health Organization. https://www.scirp.org/reference/referencespapers?referenceid=2494227]*.

World Health Organization (2023). Report 2022: pesticide residues in food-Joint FAO/WHO Meeting on Pesticide Residues. World Health Organization. https://www.who.int/publications/i/item/9789240069602

Xu, Y., Li, X., Zeng, X., Cao, J., & Jiang, W. (2022). Application of blockchain technology in food safety control : current trends and future prospects. *Critical Reviews in Food Science and Nutrition*, *62*(10), 2800-2819.

Zhao, X., Lin, C. W., Wang, J., & Oh, D. H. (2022). Advances in biosensor technologies for pathogen detection in foods. *Journal of Microbial Biotechnology, 45*(1), 56-69.