White Paper

Integrated Food Chain Surveillance for Enhancing Food Safety- A Model Approach

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PREFACE

The genesis of the White Paper entitled "Integrated food chain surveillance for enhancing food safety- a model approach" goes back to 2007 when ILSI India had organised a Seminar on "Regulatory Systems for Risk Assessment for Food Safety for Public Health" in New Delhi, India. The Seminar was participated by the experts from Regulatory Departments, R & D Institutions, Food industry from India, US, Canada, Japan, and European Union besides international organizations including the Food and Agriculture Organization of the United Nations.

Safety of food and water is of paramount importance in the public health domain. Safety concerns include all those hazards which make food injurious to health. These hazards arise from improper agricultural practices, poor hygiene at all stages of the food chain, lack of preventive controls in food processing operations, misuse of chemicals, contaminated inputs including water, or inappropriate storage and handling practices. Specific of these food hazards are chemical and microbiological contaminants, biological toxins, pesticide residues, veterinary drug residues, and allergens.

It is therefore, imperative that a National Food Control System should be such that the consumer is protected from unsafe food. The National Food Control System, therefore, must be effective and comprehensive with science-based food law and regulations; and an institutional structure which is active and responds to the needs of food safety management.

Keeping the aforesaid considerations in view the current report has attempted to capture some of the critical areas of operation that need to be addressed holistically.

It is well recognised that an efficient and integrated food safety surveillance programme encompasses the importance of collecting data on food contaminants and food borne disease outbreaks, monitoring their impact, and predicting the future of foodborne disease burden for informing prevention and control strategies. The key element in the integrated food chain surveillance is the sharing, integrating and interpretation of food borne disease surveillance data in the human, animal, and food sectors. The focus of the surveillance includes microbial hazards and also antimicrobial resistance monitoring.

The integrated food chain surveillance is a complex and highly resource intensive programme that can be established only under the presence of a coordinated multisector operational framework involving food, animal and human health/disease sectors. Some developed countries with well-structured multisector surveillance framework have applied this surveillance approach.

The application, feasibility and usefulness of this surveillance system has been explored from a developing country perspective including India through a review of literature and designing a suitable activity plan of the integrated food chain surveillance in the Indian context. The integrated food chain surveillance is one such approach for

assessing food borne risks throughout the food chain based on integrated surveillance data from food producing animals' disease surveillance, human health surveillance and food safety surveillance activities. However, the approach is very resource intensive and relies on diverse information sources from multiple sectors for integrating surveillance data that can pose challenges of generating and providing appropriate quality and accurate data to the regulator/decision maker.

The existing surveillance programmes for food borne events in India have the basic infrastructure for investigating and responding to food borne events. In order to adopt the integrated food chain surveillance system, several elements/components under the existing framework are yet to be built in/strengthened. The availability of adequate resources and a robust multisector-coordinated surveillance and response framework together with appropriate data sharing mechanisms are critical requirements. The white paper has suggested some concrete actions for India such as creation of a national integrated food safety and food borne disease surveillance programme for the entire food chain under the umbrella of an appropriate authority. The paper has also suggested that existing collaboration and partnerships between food, animal and human health sectors have to be strengthened/enhanced and core surveillance capacities identified so that existing resources can be utilized in an effective manner to address food safety challenges in a holistic way.

Identifying and prioritizing categories of data that need to be included are scientific data (from monitoring food samples in the food chain), food control and enforcement data (regulatory compliance data from market surveillance, industry), clinical surveillance data (human and animal), environmental monitoring data, and trends in food borne events (diseases, contamination incidents) besides focussing on appropriate capacity building areas.

It is hoped that the readers of this White Paper will get an insight into the pros and cons of the issues concerning integrated food chain surveillance system for strengthening food safety systems at the national level.

Dr. B K Nandi
Chairman, ILSI India

LIST OF ABBREVIATIONS

AMR	Antimicrobial Resistance
BCISFP	British Columbia Integrated Surveillance of Foodborne Pathogens
CDC	Centre for Disease Control and Prevention
CODEX	Codex Alimentarius
COVID	Coronavirus Disease
DAHD	Department of Animal Husbandry and Dairying
DANMAP	Danish Integrated Antimicrobial Resistance Monitoring and Research Programme
EC	European Commission
ECDC	European Centre for Disease Prevention and Control
EFSA	European Food Safety Authority
FAO	Food and Agriculture Organization
FSAI	Food Safety Authority of Ireland
FSER	Food Safety Emergency Response
FSSAI	Food Safety and Standards Authority of India
ICAR	Indian Council of Agricultural Research
ICMR	Indian Council of Medical Research
IDSP	Integrated Disease Surveillance Programme
IEC	Information, Education, and Communication
ILSI India	International Life Sciences Institute India
LMICs	Low-and Middle- Income Countries
MoHFW	Ministry of Health and Family Welfare
NAAS	National Academy of Agricultural Sciences
NADRS	National Animal Disease Reporting System
NARMS	National Antimicrobial Resistance Monitoring System for Enteric Bacteria
NCDC	National Centre for Disease Control
OIE	Office International des Epizooties (World Organization for Animal Health)
RRTs	Rapid Response Teams
SDG	Sustainable Development Goals
SE Asia	Southeast Asia
SOPs	Standard Operating Procedures
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
WHO	World Health Organization
WOAH	World Organization for Animal Health

BACKGROUND AND OBJECTIVES

An efficient food safety surveillance programme recognizes the importance of collecting data on food contaminants and food borne disease outbreaks, monitoring their impact, and predicting the future of foodborne disease burden for informing prevention and control strategies. Recently, the World Health Organization (WHO) has described the concept of integrating food chain surveillance data to better understand risks across the food chain. The integrated food chain surveillance system is being recognized as a holistic approach in various developed countries for controlling food safety risks across the entire food chain. The key element in the integrated food chain surveillance is the sharing, integrating and interpretation of food borne disease surveillance data in the human, animal, and food sectors. The focus of the surveillance is on microbial hazards and also includes antimicrobial resistance monitoring.

The integrated food chain surveillance is a complex and highly resource intensive programme that can be established only under the presence of a coordinated multisector operational framework involving food, animal and human health/disease sectors. Thus, few developed countries with well-structured multisector surveillance framework have applied this surveillance approach. On the other hand, its application in developing countries with limited resources and surveillance capacities is a challenging task.

Based on the above background, it was proposed to develop a White Paper on integrated food chain surveillance for enhancing food safety- a model approach at the request of the International Life Sciences Institute India (ILSI India) with the following components: basic concepts in food safety surveillance, the nature of the food chain and food safety issues with a focus on developing countries, aims and objectives of integrated food chain surveillance for food safety, framework for establishing a multisector food chain surveillance infrastructure and mechanism to identify food safety risks, and developing a model action/activity plan.

The application, feasibility and usefulness of this surveillance system is explored from a developing country perspective including India through a review of literature and designing a model activity plan of the integrated food chain surveillance in the Indian context and incorporates:

1. **Brief review of:**
   - **Current status of global food safety concerns.**
   - **The nature of the food chain and occurrence of food hazards risks at various stages from production to consumption.**
   - **The importance of surveillance and monitoring in ensuring food safety.**
   - **The concept of integrated food chain surveillance and description of its elements.**
2. **Application of the integrated food chain surveillance system in the Indian context:**
   - **Review of existing food safety concerns and food safety and food borne disease surveillance programmes in India.**
   - **Development and establishment of integrated food chain surveillance system in Indian context: Identifying requirements and designing a model activity/action plan.**

EXECUTIVE SUMMARY

Food safety is an important public health problem. Concerns for food safety have increased globally in recent times with new/emerging food safety risks and increase in the volume of international food trade. In order to protect consumer health and ensure fair trade practices "national food control systems" have been established in several countries.

The importance of surveillance and monitoring for collection and analysis of food contamination and food borne disease data for implementing control measures is well recognized. Recently, the WHO has described the concept of integrated food chain surveillance as a holistic approach for controlling food safety risks across the entire food chain. However, it is a highly resource intensive programme that can be established only under the presence of an effective governance framework with multisector involvement and data sharing mechanisms which may be limiting or inadequate in developing countries.

The upsurge of food borne zoonosis and antimicrobial resistance as a result of changes in the food system and increase in consumption of animal derived foods has been documented in several international reports. An integrated, multidisciplinary based surveillance approach that considers the entire food chain is thus important for food safety assurance.

This review highlights the problem of contamination with microbial pathogens at various points in the food chain during their production, harvesting, processing, transportation or during preparation at home level.

Different methods of food borne surveillance exist that aim at investigation of presence/occurrence of food contaminants (market surveillance), epidemiological investigation of food borne diseases (food borne disease surveillance), and investigation of animal diseases (zoonotic disease surveillance). These surveillance programmes assess magnitude of public health problem caused by the food borne pathogens, high risk foods, risky food practices, and vulnerable populations and most importantly enable formulation of appropriate control measures.

Over the last decades the concept of cross-sectoral collaboration between food, animal and the human health sector is emerging as a viable approach for ensuring food safety across the food chain. The WHO has introduced integrated food chain surveillance system which involves collection, analysis and interpretation of data from animals, food and humans in a multisector framework and applies mainly to assessment of microbiological hazards, food borne zoonosis and antimicrobial resistance. The key elements for its establishment include:

- **Creation of a multisector team**
- **Defining objectives**
- **Creating a database**
- **Developing multisector coordination and communication**
- **Data sharing**
- **Analysis and interpretation mechanisms**
- **Identification of priority pathogens and foods**
- **Creating a surveillance bulletin**
- **Setting up approaches for performing risk analysis**
- **Monitoring and evaluation of the programme**

In India, adopting the integrated food chain surveillance system is a challenging task with the emerging food safety concerns such as food borne zoonosis, existing surveillance frameworks and financial resources and difficulties in developing linkages to surveillance and response systems across multiple sectors. The existing surveillance and monitoring programmes in India that investigate, assess and report food safety and food

borne diseases are functioning under the operational frameworks established under:

- **FSSAI**
- **ICMR-FoodNet**
- **Integrated Disease Surveillance Programme**
- **National Animal Disease Reporting System**

Although these surveillance programmes have the basic infrastructure for investigating and responding to food borne events several elements/components required for establishing the framework for integrated food chain surveillance system are yet to be built in the existing systems mainly with respect to multisector linkages and data sharing mechanisms.

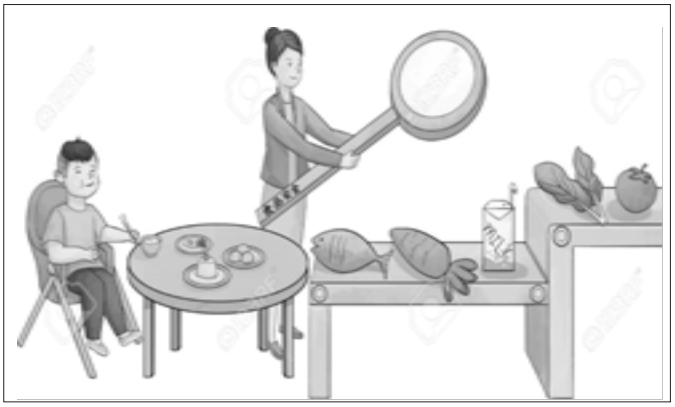
An attempt has been made to explore the possibility of designing an integrated food chain surveillance model in the Indian context using the guidelines provided by the WHO. Critical areas for developing such a plan include operational framework with multisector coordination and communication mechanisms for identification of priority food borne pathogens and diseases, laboratory infrastructure, data collection, storage, transfer and sharing, existence of functional risk analysis framework, data analysis and interpretation and monitoring and evaluation plans.

Developing, establishing and sustaining an integrated food chain surveillance system in Indian context call for several commitments that can be fulfilled only under the availability of adequate resources and a robust multisector coordinated surveillance and response framework.

The integrated food chain surveillance relies on diverse information sources from multiple sectors for integrating surveillance data. Generating and providing appropriate quality and accurate data to the regulator/decision maker is crucial. In view of limited resources, it is imperative that the collaboration and partnerships between food, animal, and human health sectors is initially strengthened/enhanced. In this way the interconnectedness between the environment, animal and human health on the epidemiological nature of food borne risks across the food chain and in the Indian context can be well associated.

The burden of food borne diseases from microbial and chemical sources have to be fully understood and analysed in the Indian context so that appropriate food safety and food borne disease surveillance programme can be evolved.

Creation of a national integrated food safety and food borne disease surveillance programme for the whole of food chain on the model of integrated food chain approach is perhaps a reasonable approach so that a full-fledged surveillance system devoted to food safety and food borne events can emerge in India.



CHAPTER 1

LITERATURE REVIEW

1.1 Current Status of Food Safety Concerns Globally

Food safety is defined as the assurance that the food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use (WHO/FAO 2009). Food safety is an integral part of food and nutrition security and thus linked to achievement of several sustainable development goals (SDGs) (UN 2015). Food safety is important not only for public health but also for the purpose of regulation which works through inspection, education, and surveillance.

Well known factors of food safety threats include inappropriate agricultural practices, poor hygiene at any stage of the food chain, lack of preventive controls during processing and preparation of the food, incorrect use of the chemical materials, contaminated raw materials, food and water and inappropriate storage (FAO 2003a).

Food borne hazards have taken on new dimensions, with complex food safety challenges emerging around the globe (FAO, UNEP, WHO, and WOAH 2022). Hazards, including zoonotic and non-zoonotic pathogens and chemical contaminants, can enter the food chain at any point, from production to the time of consumption. The WHO estimated that unsafe food can cause acute or chronic illnesses resulting in more than 200 diseases, ranging from diarrhoea to cancers to permanent disability or death (WHO 2022). Such unsafe food has been shown to contain harmful levels of bacteria, viruses, parasites, chemical or physical substances. Food animals or products resulting from animals ill with zoonotic diseases can also cause food borne illnesses.

The recent decade is witnessing an upsurge in food chain contamination with new and known microbial pathogens that are reappearing through new exposure routes in the form of food borne zoonosis and antimicrobial resistance causing public health concerns. Intensification of livestock production, increasing supply of fresh vegetables, fruit, and animal-sourced foods in markets especially in low to middle income countries (LMICs) for enhanced nutritional benefits and increasing potential human health risks of antimicrobial resistance from agriculture pose new food borne disease risks in the food chain (Waage et al 2022, WHO 2022).

The recent COVID-19 outbreak is an example of a food system-driven emerging disease affecting large volumes of human populations (Sahoo et al 2022). Climate change events have considerable impact on safety of food as well as water and thus occurrence of food borne diseases (FAO 2020). Food safety risks associated with natural disasters and emergencies are mainly linked to unsafe food storage and cross contamination from the environment or from people during food handling (Tirado et al 2010). Use of newer technologies in food production and processing, demographic changes and changes in consumer food consumption patterns are other important drivers.

Food safety and control systems in several countries are constantly changing and evolving with new policies and practices to address the challenges of new and emerging food safety risks and growing complexity of the food chain.

1.2 The Nature of the Food Chain and Occurrence of Food Hazard Risks at Various Stages of Production to Consumption

The food chain involves all the diverse and complex interactions that ultimately bring food sources from producer to consumer. The principle stages in a food production/supply chain as outlined by FAO (2006) and WHO (1998) include the following:

- **Primary production (acquisition of raw materials, supply of agricultural inputs and equipment, pesticides, veterinary drugs, fertilizers, animal feeding stuffs, cultivation and harvesting of major food crops/raw materials from natural resources, raising of animals/fish)**
- **Primary food processing (on-farm, dairies, abattoirs, grain mills, etc.)**
- **Secondary and higher forms of food processing (fermenting, baking, canning, freezing, drying, etc.)**
- **Food distribution (national/international, import/export), food retailing (shops, supermarkets, etc.), food catering (restaurants, street foods, hospitals, schools, etc.)**
- **Domestic food preparation and consumption**

In several South East Asian regions including India, the food supply chain is very fragmented with a complex network and several stakeholders operating at different levels. Often inefficient use of resources deployed in food chains particularly storages facilities, routes and modes of transportation, as well as manpower impact food safety and quality (Sharma et al 2020).

1.2.1 *Food Safety Issues in the Food Supply Chain*

Foods may be contaminated at any point in the food chain: i) during production of crops or food producing animals, ii) processing into final products and distribution to consumer, or iii) as a result of cross-contamination from food handlers or individuals preparing the food. Reservoirs for food borne pathogens can be environment, animal or humans.

Understanding the interaction between the contaminated food, the human/animal host and the microbial pathogen is important for assessing the transmission pathway of the pathogen and thus the cause and source of food borne disease. Few examples of food safety concerns and their occurrence are given below:

Food Grains

During primary production grains such as cereals, spices, nuts and oilseeds can become a significant source of contaminants such as natural toxins (mycotoxins, alkaloids), bacterial pathogens, heavy metals (arsenic and cadmium) and pesticide residues. Temperature, moisture and relative humidity often present major conducive conditions for contaminants such as mycotoxins to enter food grains during primary production (Bhat 2003). Crop stress such as insect damage, bird damage, drought stress, and untimely harvest, kernel damage during harvesting, inadequate drying to safe moisture levels and storage under unhygienic conditions, transportation with inadequate protection from rain or other environmental pollutants are conditions that lead to contamination (Kumar and Kalita 2017).

Fresh Produce

Fresh produce such as vegetables and fruits have high potential for contamination with microbial pathogens from animal waste, manure, compost, dust, soil, irrigation water, faeces, insects, wild or domestic animals, and human activity (Machado-Moreira et al 2019). ***Animal waste*** is a major vehicle for transmitting pathogenic bacteria to the produce via soil and irrigation water. Such high pathogen risk foods and animal derived foods frequently get contaminated due to lack of cold storage facilities or frequent breakdown of power supply to maintain cold temperatures.

Soils polluted by industrial wastes, fertilizers, or water used for irrigation often carry toxic heavy metals such as arsenic, lead and cadmium that may be taken up by the plants grown on such soils. Several food borne disease outbreaks have been reported due to consumption of fresh produce. Pathogenic bacteria especially *Listeria monocytogenes* and *Clostridium botulinum* present in the soil, *Salmonella enterica* serovar *Typhimurium*, *E. coli* O157: H7, *Shigella* spp., *Listeria*, parasites such as *Cryptosporidium* spp. and *Cyclospora* species, and hepatitis A virus and norovirus are the major causes of diseases associated with the consumption of faecal contaminated vegetables and fruits (Macieira et al 2021).

Animal Derived Foods

Food safety concerns from animal derived foods have been the subject of much international deliberation in the recent decade. Of particular concern has been the emerging risks and human health burden from food borne zoonosis and antimicrobial resistance. In the 2012 the World Organization for Animal Health (OIE) listed 30 notifiable zoonotic diseases out of which 13 are foodborne zoonotic diseases (Berman 2013). Food borne zoonosis is emerging in view of increased consumption of animal source food such as dairy, eggs, fish and meat especially in low and middle-income counties, driven by population growth, urbanization, and increased income (Leahy et al 2022).

Food-producing animals (e.g., cattle, poultry, pigs) are the major reservoirs for many foodborne pathogens, the most common being *Campylobacter* species, *Salmonella enterica*, Shiga toxin-producing strains of *Escherichia coli*, and *Listeria monocytogenes* and toxic chemicals (e.g., agrochemicals, pesticide, heavy metals, etc.) (Heredia and García 2018). These hazards can enter meat food chain at various points, such as at production site, from livestock feed, slaughter house, packing plant, during manufacturing, processing, retailing, catering, and during home preparation, and may make food unsafe. Cross contamination can occur during processing through infected food handlers, contaminated raw agricultural products or food contact surfaces. Many of zoonotic pathogens are commonly found in the intestines of healthy food-producing animals (EFSA).

Emergence of Antimicrobial Resistant (AMR) Bacteria

AMR caused by the use of antimicrobials both in human and veterinary medicine is recognized as one of the most important threats to human health in developing countries including India (Taneja and Sharma 2019). These are largely used to prevent occurrence of diseases in food producing animals such as poultry, pigs and calves. AMR occurs when microbes (bacteria, fungi, and viruses) alter their physiology or genetic makeup following frequent contact with antimicrobial agents (Samtiya et al 2022).

Antimicrobial-resistant bacteria as well as antimicrobial resistance genes (transfer in pathogenic bacteria) may contaminate food at any stage from farm/field to consumption. AMR transfer to humans occurs through consumption of contaminated food and improper food handling. Important food borne disease causing antibiotic-resistant pathogens include *Salmonella*, *Campylobacter* and *E.coli*. Poultry, eggs, pork, meat are the largest sources of AMR associated food borne diseases (WHO 2011). Non-animal food sources for contamination with AMR include *Salmonella*-contaminated leafy greens, stem vegetables, tomatoes, and melons that are contaminated through animal waste or contaminated water.

1.2.2 *Approaches to Enhance and Ensure Food Safety in the Food Chain*

In order to protect consumer health and ensure fair trade practices, national food control systems have been established in several countries. An effective and comprehensive national food control system with science-based food laws and regulations and an institutional structure which is active and responds to the needs of food safety management has always been emphasized for ensuring food safety to the consumer (ILSI India 2007).

Key Principles for Ensuring Food Safety

The key principles as defined by FAO (2006) underscoring food control activities in ensuring food safety to the consumer include

- **Recognition of farm to table/food chain approach through shared responsibility and interaction of all stakeholders**
- **Risk-, science- and evidence based approach in decision making, risk analysis approach for prioritizing interventions**
- **Surveillance, investigation, emergency preparedness and response to food borne disease outbreaks and other food related incidents**
- **Enforcement and compliance programs with elements of risk based inspection**
- **Access to adequate laboratory capacity and capability**
- **Stakeholder engagement**
- **Food safety and quality information, education and communication (IEC) programmes**

The food chain approach relies on sharing of responsibility of safe, healthy and nutritious food along the entire food chain by all involved with the production, processing, trade and consumption of food (FAO 2003b). An integrated, multidisciplinary approach that considers the entire food chain is thus important for food safety assurance. The international fora such as the WHO and FAO emphasize use of risk-based approaches based on risk analysis to facilitate decision making in food safety regulations. Three interrelated elements of risk analysis include risk assessment, risk management and risk communication which have the overall objective to ensure public health protection (BOX1) (CAC 2007).

BOX 1. CODEX Risk Analysis Framework (CAC 2007)

Risk Assessment: **It is a scientifically based process of qualitative or quantitative estimation, including attendant uncertainties, of the probability of occurrence and severity of known or potential adverse health effects in a given population based on, (i) hazard identification, (ii) hazard characterization, (iii) exposure assessment, and (iv)risk characterization. Data from the food borne disease surveillance and response system is primarily used to identify hazards identification and assess exposure.**

Risk Management: **It is a process, distinct from risk assessment, of weighing policy options in consultation with all interested parties, taking into consideration the risk assessment and other factors relevant to protecting the health of consumers.**

Risk Communication: **It is the interactive exchange of information and opinions throughout the risk analysis process concerning hazards and risks, risk-related factors and risk perceptions, among risk assessors, risk managers, consumers, industry, the academic community and other interested parties. It includes the explanation of risk assessment findings and the basis of risk management decisions.**

1.3 Importance of Surveillance and Monitoring Programmes in Ensuring Food Safety

Surveillance is defined as the ongoing systematic collection, collation, analysis and interpretation of data, followed by the dissemination of information to all those involved so that directed actions may be taken (WHO 2017a). The purpose of food safety surveillance as conducted by national food control authorities is to ensure compliance with regulatory standards (FSAI 2009). This is brought about by the following tasks:

- **Supporting food inspection activities**
- **Ensuring compliance with regulatory limits for microbial and chemical contaminants in food**
- **Ensuring compliance of foods with regulatory restrictions on the use of food additives and similar ingredients and processing technologies**
- **Ensuring the authenticity of certain foods.**
- **Assessing effectiveness of food safety programs**
- **Providing evidence for informed actions and programmes to prevent /reduce incidence of food-borne disease**
- **Providing information and evidence to help inform public and improve consumer confidence**

Food contamination monitoring involves systematic collection, analysis and dissemination of data to provide information on levels of contaminants in foods and time-trends in contamination and their extent of compliance to food control requirements of the food safety legal provisions in the country. Such information is utilised for applying/initiating preventive and control measures through surveillance programmes. Thus, food safety and foodborne disease surveillance are often integrated with food monitoring data along the food production chain. Such integrated information greatly facilitates risk analysis under the food control system. Surveillance may be carried out at any point in the entire food production, processing, distribution, preparation and consumption chain. The three main areas where surveillance is carried out for food safety control purposes are:

- **Investigation of presence/occurrence of food hazards/contaminants: Market surveillance**
- **Investigation of food borne diseases / outbreaks in humans: Food borne disease surveillance**
- **Investigation of diseases in animal populations: Zoonotic disease surveillance**

1.3.1 Market Surveillance

Market surveillance involves activities carried out by food control authorities to ensure that products on the market conform to the legal requirements of food control regulations and comply with the national health and safety requirements (FSAI 2009, FSSAI 2017). Samples are collected as part of routine inspections or randomly collected from retail or whole sale outlets or as part of food borne disease outbreaks. It enables monitoring and control of the market and helps in improving corrective measures and penalties. Market surveillance facilitates in enabling various food market stakeholders including manufacturers, importers, distributors, retailers, consumers, etc. to share information about the presence of unsafe non-food products in the domestic market thus helping food control authorities to identify these products and thereby strengthen the national market surveillance efforts (EC 2017).

1.3.2 Food Borne Disease Surveillance

Foodborne disease surveillance is dedicated to assess the incidence and prevalence of pathogens associated with food in order to provide information to public health authorities to prevent and control food-related disease outbreaks and improve the safety and quality of food products (Guzewich et al 1997). The primary goal of surveillance for

foodborne diseases is the prompt identification of any unusual clusters of disease potentially transmitted through food, which might require a public health investigation or response (WHO 2017a). The main activities of foodborne disease surveillance include monitoring disease trends, estimating burden, identifying and controlling outbreaks, high-risk foods and poor food preparation practices and vulnerable groups, determining foodborne transmission pathways for specific pathogens, assessing food safety programs, and providing information and evidence to help policymakers with prevention strategies (Ford et al 2015). Event-based surveillance, indicator-based surveillance and laboratory-based surveillance are three important disease reporting systems in food borne disease surveillance (WHO 2017a, Ford 2015).

1.3.3 Animal/Zoonotic Disease Surveillance

Zoonotic disease surveillance is the ongoing systematic and timely collection, analysis, interpretation, and dissemination of information about the occurrence, distribution, and determinants of diseases transmitted between humans and animals especially from animal derived foods. Animal disease/ food borne zoonotic surveillance relies on active surveillance for collecting primary data using a defined protocol to perform actions that are scheduled in advance (Bisdorff et al 2017). Sources of data and information for food borne zoonotic surveillance system include private veterinary practices, abattoirs, poultry slaughterhouses, veterinary hospital's registries, etc.

1.4 WHO Initiatives for Strengthening of Surveillance and Response Systems for Food Borne Diseases

The WHO in its efforts to strengthen surveillance and response systems for food borne diseases in various countries introduced guidance documents/modules. These guidance documents provide options of strengthening the surveillance system of countries and help them in preparing the response to food safety challenges depending upon their food borne surveillance capacity. Examples of these guidance documents are given below.

Stage 1 Booklet: **Using indicator- and event-based surveillance to detect foodborne events** is applicable to countries who have established surveillance programme and are in the process of building its core structure by establishing different surveillance programmes (WHO 2017a).

Stage 2 Booklet: **Strengthening indicator-based** surveillance is applicable for countries who have in place the indicator- and event-based surveillance systems, capacity to undertake rapid risk assessments of acute food borne events and epidemiological investigations and laboratory capacity to identify food borne pathogens (WHO 2017b).

Stage 3 Booklet: **Integrating surveillance data to better understand risks across the food chain-specific guidance on sharing data in order to better understand risks in the food chain** is for countries who already have a fully functional surveillance and response system in the health sector and are ready to move towards integrated food chain surveillance. The focus in stage 3 is on the routine and systematic sharing of data from the health sector with the animal health and food safety sectors (WHO 2017c).

1.5 The Concept of Integrated Food Chain Surveillance

The epidemiology of foodborne outbreaks is changing from acute and local to diffused and widespread (e.g., geographically dispersed in many places at once) chiefly due to production intensification and wide distribution of food (Antunes et al 2020). Thus, for placing food safety control measures it is essential not only to identify the source and type of pathogen causing the disease but also the transmission route/pathway of that pathogen. Search for surveillance approaches that can integrate contamination data across the food chain environment of pathogen, animal and human involvement are gaining much relevance.

Globally, increased focus is emerging on the use of cross-sectoral structured collaboration and coordination between human, animal and food systems as a viable approach for ensuring food safety and human and animal health (Johnson et al 2018). The integrated food chain surveillance is one such multisector coordinated approach that is applied across the whole of food chain. In this way it integrates surveillance data from environment (food and feed), animal, and human disease sectors and helps in understanding the interconnectedness between them. Thus, Integrated food chain surveillance concept is recognized as a holistic and systems-based approach that is closer to achieving One Health approach (FAO, UNEP, WHO, and WOAH 2022).

1.5.1 Objectives and Application

As mentioned before integrated food chain surveillance is the collection, analysis and interpretation of data from animals, food and humans and applies mainly to assessment of microbiological hazards (WHO 2017c). It expands on traditional surveillance system by monitoring and comparing the multiple components of a system in the food chain such as food, animal and environment to better understand the sources of disease and transmission routes (Galanis et al 2012). Integration of surveillance data across the food chain and assessing the relative contribution of food, animal health/disease to human food borne diseases through rapid risk assessment is the key step towards identifying, prioritization and assessment of effective prevention and control measures. Thus, in this way this approach aids in better understanding of food hazard risks across the food chain.

The main objectives of the integrated food chain surveillance system include: monitoring the occurrence of priority foodborne pathogens along the food chain, identifying, investigating and responding to health risks along the food chain by sharing information on human, food and animal sources and evolving inter- and intra-agency partnerships required to respond to health risks along the food chain (WHO 2017c).

Use of data shared across the food chain provides the scientific basis for performing risk analysis and enables in identification of appropriate strategies for controlling and preventing food borne diseases in humans. Data from integrated food chain surveillance has been used for source attribution which aids in estimation, identification and relative contributions of the most common food categories responsible for illnesses caused by specific pathogens (David et al 2013). Because various data sources ranging from epidemiology, laboratory to data from food borne disease outbreaks are used in source attribution, the integrated food chain surveillance greatly facilitates in identifying appropriate control strategies across the food chain.

Since various stakeholders operate in the food chain, establishing multisector coordination so as to enable sharing and use of detailed information from the monitoring of food and animals is a basic requirement of the integrated food chain surveillance system (Ford et al 2015). Generally data is derived from population-based surveillance systems, sentinel surveillance or even data from ad-hoc studies. The integrated food chain surveillance

is currently established in few developed countries mostly for *Salmonella* and anti-microbial resistance that have been responsible for causing food borne zoonosis in several developing and developed countries (David et al 2011). Different approaches adopted in these countries involve data sharing across the animal, food and human health sectors as shown below.

Denmark: In Denmark integrated food chain surveillance has been established for antimicrobial resistance and Salmonellosis. Denmark has a national, integrated surveillance programme called DANMAP, which annually evaluates antimicrobial agent consumption and the incidence of resistant bacteria in Denmark. The DANMAP programme is a joint initiative of the National Food Institute, Statens Serum Institut, the National Veterinary Institute and the Danish Medicines Agency (DANMAP/DTU).

USA: In the USA, integrated food chain surveillance has been established under the National Antimicrobial Resistance Monitoring System for Enteric bacteria (NARMS). This is an interagency partnership among state and local public health departments, Centres for Disease Control and Prevention, the US Food and Drug Administration and the US Department of Agriculture (CDC 2023). The programme tracks changes in antimicrobial susceptibility of enteric pathogens (including foodborne pathogens *Salmonella* and *Campylobacter*) in humans, retail meats and food animals. NARMS data are used by FDA to make regulatory decisions designed to preserve the effectiveness of antibiotics for humans and animals.

Canada-British Columbia: In the British Columbia, integrated food chain surveillance for food-borne pathogens, focuses primarily on *Salmonella enteriditis* whose isolates are collected from animal, food and human sectors and data from on farm, veterinary diagnostic laboratory and human health data are compared with each other (BCISFP 2015). The agencies involved in integrated food chain surveillance include the BC Centre for Disease Control, BC Ministry of Agriculture, Public Health Agency Canada, Canadian Food Inspection Agency and the Centre for Coastal Health. Representatives of the agencies involved in integrated food chain surveillance meet on a quarterly basis.

France: In France an integrated food chain surveillance for *Salmonella* is being used that covers the whole food-chain from the breeding farms to the human cases (David et al 2013).

European Union (EU): In the EU integrated surveillance approaches for food borne events is applied mainly for investigation of zoonotic diseases using One Health approach as per the Directive 2003/99/EC (EFSA 2023a). EFSA monitors and analyses the situation on zoonoses, zoonotic microorganisms, antimicrobial resistance, microbiological contaminants and foodborne outbreaks across Europe (EFSA 2023b). Information from the surveillance of foodborne disease outbreaks are provided on an annual basis to the European Food Safety Authority (EFSA) for inclusion in the EU community (EFSA 2022). The Authority is assisted by the Network for Zoonoses Monitoring Data, a pan-European network of national representatives and international organisations that assist EFSA by gathering and sharing information on zoonoses in their respective countries.

Foodborne outbreaks are reported in accordance with Directive 2003/99/EC. Data on food borne disease prevalence in the EU is mainly sourced from the European Centre for Disease Prevention and Control (ECDC) and the World Health Organization (WHO) Regional Office in Europe that collate the data. Data on antimicrobial resistance (AMR) in zoonotic and indicator bacteria from humans, animals and food are collected annually by the EU Member States, jointly analysed by EFSA and ECDC and reported

in a yearly EU Summary Report. The annual monitoring of AMR in animals and food within the EU is targeted at selected animal species corresponding to the reporting year.

Important zoonotic food borne pathogens monitored include *Campylobacter*, *Salmonella*, *Listeria*, Shiga toxin-producing *Escherichia coli*, Tuberculosis due to Mycobacterium bovis and *Mycobacterium caprae*, Brucella, *Trichinella*, *Echinococcus*.

1.5.2 Description of the Core Elements in the Integrated Food Chain Surveillance System

Integrated food chain surveillance is a resource intensive programme and hence requires an in depth evaluation of available human and financial resources, and legislative mandates of all the relevant authorities collaborating in the surveillance programme. Thus, the key requirements include presence of a good governance framework that allows sharing of data through well-structured coordinated and communication mechanism, use of the data arising from the surveillance in risk analysis, and regular evaluation of the surveillance system (WHO 2017c).

The chief components and core elements in the integrated food chain surveillance system adapted from WHO Guidance Document (WHO 2017c) include the following:

1. **Presence of a multisector team comprising representatives/stakeholders from animal, food and human health sectors to integrate data from each of the sectors.**
2. **Presence of clear governance structure that allows data to be shared including a coordination and communication mechanism for sharing, storing and analysing integrated data.**
3. **Clear statement of the objectives of the integrated food chain surveillance.**
4. **Identification of pathogens detected routinely in all three sectors, present in high frequencies across the food chain and characterized.**
5. **Identification and prioritization of animal species and foods involved in outbreaks, food borne zoonosis and their pattern of consumption.**
6. **A centrally operated multisector database that contains data from food, animal and human health sectors. Existence of a well-established coordination system to link data from each sector and mechanisms for data collection, storage and transferring.**
7. **Multisector data analysis and interpretation including description of frequency of analysis and data transfer from each sector to central database, analysis of integrated data received from each sector and across the food chain to enable source attribution, data quality review and multi-sectoral interpretation.**
8. **Creating a surveillance bulletin to communicate food borne surveillance information to stakeholders including data collection and analysis methodology, data from each sector and results of integrated analysis.**
9. **Presence of a functional risk analysis operational framework consisting of food laws, policies, regulations and standards and capacity to carry out risk analysis. The food hazard risks across the food chain resulting from risk analysis of the integrated data should be communicated to all stakeholders and interested parties in the food chain.**
10. **Monitoring and evaluation including indicators capable of measuring the performance of the integrated food chain surveillance activities, to monitor each data source and the entire integrated system. Evaluation is required of each sector involved in the food chain surveillance to assess established governance framework and its impact on sharing or analysing data, human resources, time and financial resources and implementation of the food chain surveillance programme.**

CHAPTER 2

APPLICATION OF THE INTEGRATED FOOD CHAIN SURVEILLANCE SYSTEM IN THE INDIAN CONTEXT

The application of the integrated food chain surveillance in the Indian context has been studied based on the existing food hazard risks from microbial pathogens and the food borne surveillance programmes available for their investigation and control. This information served as a background to develop an activity/action plan for establishing integrated multisector food chain surveillance system in the Indian context based on the key requirements as entailed by the WHO (2017c).

2.1 Existing Food Safety Hazards/Risks from Microbial Pathogens in India

In India, the potential for occurrence of food safety risks throughout the food supply chain has been documented under different circumstances (Vasanthi and Bhat 2018). Frequent breakdowns of food safety controls, lack of capacity to handle/monitor/assess food safety issues, lack of efficient food traceability systems, climate change impacts and extreme weather conditions, etc. are often recognized as factors for the frequent occurrence of food safety hazards in the food chain.

The prevalence and public health impact of several food borne pathogens particularly *Campylobacte*r, *Salmonella*, *E.coli*, and *Listeria* in India have been reported through national surveillance programmes as well as independent studies (NCDC 2009, NCDC 2017). The National Academy of Agricultural Sciences (NAAS), India reported increasing food borne illness risk from food-borne zoonosis that was chiefly attributed to under-cooked poultry meat, water and raw milk, raw foods such as salads contaminated with *Campylobacter* spp, *E.coli* spp, and *Clostridium perfringens* as well as various food borne parasites (NAAS 2020). The occurrence of *Brucella* spp in the range of 4.35-55.6% was observed in cattle milk samples in India (NAAS 2020).

While the burden of food-borne diseases in Indian population is known to a limited extent, it is estimated that the number of food borne diseases may increase by 70% by 2030 (Kristkova et al 2017).

Food borne zoonosis burden in India represents about 100 million cases per year costing India about US$ 28 billion every year. The analysis of data from Integrated Disease Surveillance Programme (IDSP) under National Health Mission for the period 2011 to 2015 revealed that food-borne outbreaks together with acute diarrheal diseases constitute nearly half of all reported outbreaks (NAAS 2020). A review of the recorded food borne disease outbreaks in India from 1980 to 2016 revealed that *S. aureus*, *Vibrio* spp., *Salmonella* spp., *E. coli*, *Y. enterocolitica* and Norwalk-like virus are some important microbial pathogens responsible for food-borne illnesses (Bhat 2003; Vasanthi and Bhat 2018, Kohli and Garg 2015, NCDC 2017; Bisht et al 2020, Vardhan et al 2021). A total of 2,688 food-borne disease outbreaks, resulting in 153,745 illnesses, and 572 deaths were reported during 2009-2018 in India (Bisht et al 2020). Most frequently reported foods in these outbreaks include animal derived foods such as milk and milk products, meat, poultry, fish, fowl, seafood such as prawns, and also rice and vegetables.

Antimicrobial resistance (AMR) is an increasing problem in India which has one of the highest rates of resistance to antimicrobial agents used both in humans and food animals (Taneja and Sharma 2019). The use of antimicrobial agents in the animal food industry has been considerably high in India but limited data is available on the burden of AMR in livestock and food animals in India (MoHFW 2016).

2.2 Existing Surveillance Programmes in Food, Animal and Health Sectors in India

Surveillance programmes have been established in food, animal and human health sectors under different organizational frameworks for control of food borne disease outbreaks and food hazard risks across the food chain. The nature of the surveillance system, governance, human and financial resources, operational framework, interdisciplinary expertise, presence of early warning systems, laboratory testing infrastructure, information and communication system are briefly described below.

2.2.1 Food Safety Surveillance Programme under the FSSAI

The aim of the food safety surveillance programme under the FSSAI is to collect data regarding all types of contaminants in foods with the purpose of understanding the spectrum of food safety, timely identification of food safety hazards, and provide relevant data for food safety monitoring, risk assessment and standard setting (BOX 2 and 3) (FSSAI 2014, FSSAI 2017). The activities of surveillance include preparation of surveillance plan, collection of targeted samples, analysis of samples in designated laboratories, uploading report/results for analysis, interpretation, risk assessment and decision making.

States/UTs regularly conduct surveillance activities and intensive surveillance drives as per their surveillance plans. They also prepare annual surveillance plan taking into account certain factors like geographical location, availability of food items, active/specific surveillance drives during festivals or specific occasions, degree of risk associated with food commodities etc. and submit surveillance reports to FSSAI at defined time intervals (FSSAI 2017).

BOX 2. FSSAI Food Safety Surveillance and Monitoring Objectives (FSSAI 2017)

(a) Search, collect, collate, analyse and summarize relevant scientific and technical data particularly relating to

- **Food consumption and exposure of individuals to risks related to the consumption of food**
- **Incidence and prevalence of biological risk**
- **Contaminants in food**
- **Residues of various contaminants**
- **Identification of emerging risks**

(b) Promote, coordinate and issue guidelines for the development of risk assessment methodologies, monitor, conduct and forward messages on food safety risks to state governments and Commissioners of food safety

(c) Provide scientific and technical advice and assistance to State governments in implementation of risk management procedures with regard to food safety and to draw up a general surveillance plan for food safety management and work in close cooperation with the Central Government

Surveillance plans are discussed in various Central Advisory Committee meetings, Video Conferences, and other meetings with Food Safety Commissioners of States and UTs.

Food safety surveillance has been conducted and reports published for various foods such as milk and jaggery for contaminants including pesticide residues, veterinary drug residues, aflatoxins, melamine, heavy metals and microbiological hazards from *E.coli* and *Staphylococcus aureus* and detection of adulteration in khoya (MoHFW 2021, FSSAI 2017).

A detailed set of objectives for investigating and management of food borne diseases in India is provided by FSSAI (2021) (BOX 4). For surveillance of food borne diseases, the FSSAI has established the Food Safety Emergency Response (FSER) System (FSSAI 2020). The aim of this programme is to manage a potential or confirmed risk to public health arising from food through a timely and coordinated response so as to minimize any adverse impact on health and disruption to trade. It enables food safety authorities to focus on prevention and preparedness, besides response to individual events, and therefore has greater long-term sustainability. The FSER has developed guidelines for investigating and managing food-borne illness outbreaks in India. FSSAI has recently proposed to strengthen surveillance capabilities and epidemiological investigations to reduce foodborne illness through strengthening surveillance (FSSAI 2020). A total of 198 laboratories are utilized by FSSAI for food testing purposes such as enforcement, surveillance and testing imported foods, for risk assessment purposes.

BOX 3. Types of Food Safety Surveillance of FSSAI (2017)

(a) Active Surveillance: This is a system employing staff members to regularly contact health care providers/manufacturing units or the population to seek information about quality of food items procured, consumed and the different ingredients used in the manufacturing unit and the testing parameters involved.

Components of Active Surveillance: **This includes State specific, seasonal surveillance, surveillance during festivals/surveillance during disease or outbreak, commodity specific.**

(b) Passive Surveillance: This is a system by which regulatory authorities receives reports submitted by manufacturing or Public health units.

Components of Passive Surveillance: **This incorporates conducting surveys on regular basis covering various product categories; post approval market surveillance of new products; random food sampling from ports and domestic food markets based on the identified sampling plan; analysis of systemic outputs of food import clearance and food licensing and registration system; collect and collate data on food consumption, incidence and prevalence of biological risk, contaminants in foods through a risk management framework and introduction of rapid alert system.**

BOX 4. Objectives of Investigations and Management of Food Borne Diseases in India (FSSAI 2021)

- **To identify suspected food associated with the illness.**
- **To control the contributory cause and risk factors of outbreaks/diseases.**
- **To limit the spread of food borne disease outbreaks to other areas by removing or recalling unsafe foods/ingredients.**
- **To eliminate unsafe food handling processes that have contributed to the outbreaks occurrence (or allowed the outbreak to continue).**
- **To assess how preventive strategies can be further strengthened to reduce or eliminate the risk of such outbreaks in the future such as by enhancing the food safety management practices.**
- **To raise awareness on food borne diseases and risk factors and educate the stakeholders operating in the food supply chain on appropriate management of food safety risks to prevent the likelihood of re-occurrence.**
- **To collect information to guide further research in the prevention of outbreaks.**

2.2.2 ICMR's Foodborne Pathogens Surveillance Network (ICMR-Food Net)

ICMR-FoodNet is a sentinel surveillance network for pathogens causing food and water borne diseases initiated in by ICMR in 2020. It is an integrated task force that coordinates project-based activity campaigns, monitors foodborne enteric disease outbreaks and conducts intensified systematic laboratory-based surveillance in four North-East Indian states (Agartala, Sikkim, Arunachal Pradesh and Assam), in collaboration with research and medical institutions and food sectors (ICMR-FoodNet 2020). The apex centre is ICMR with a steering committee, expert panel, external quality assurance system and training, and data management system. The ICMR-FoodNet is equipped with SOPs, practical guidelines for the investigation of foodborne outbreak, questionnaire for outbreak investigation and guidelines of primary patient care prevention during a diarrhoeal disease outbreak.

The project includes estimation of illness burden, detection of specific pathogens responsible for outbreaks, documenting antimicrobial resistance patterns of enteric bacteria, while additionally acting as an external quality assurance system, maintaining a centralized databank and provides reference services.

2.2.3 Integrated Disease Surveillance Programme of the National Centre for Disease Control (NCDC)

The Integrated Disease Surveillance Programme (IDSP) coordinated by the National Centre for Disease Control (NCDC), is a decentralized State based surveillance system for epidemic prone diseases to detect the early warning signals, so that timely and effective public health actions can be initiated in response to health challenges in the country at the Districts, State and National level (IDSP 2023). The IDSP is the oldest among the existing surveillance programmes and has a comprehensive integrated surveillance system. Monitoring disease trends is carried out through Rapid Response Teams (RRTs). IDSP has a Central, State and District surveillance units. The key elements of IDSP include identification of an outbreak, its investigation, and control, followed by analysis and dissemination of results to develop a response strategy. A step-wise procedure for the investigation of food borne disease outbreaks is described in BOX 5 (NCDC 2009).

BOX 5. Steps for Identification of Food Borne Disease Outbreak (NCDC 2009)

1. Establishing the existence of an outbreak
   - Information about the person(s) reporting the potential outbreak
   - Number of persons suffering from the illness
   - Date and time of consumption of food and onset of illness for each ill person
   - Specific symptoms experienced
   - Presumptive diagnosis
   - Total number of persons exposed / not exposed, both ill and not ill
   - Location where food was prepared and eaten
   - Specific food item or drink consumed, including ice
   - Other commonalities, including other shared meals or activities
   - Number of stool samples collected for testing
   - Additional information, including specific activities and medications taken before the onset of illness
2. Coordination with key personnel: medical investigators, epidemiologists, food inspectors, microbiologists and healthcare providers.
3. Collection and transport of clinical specimens and food samples for laboratory testing
4. Implementation of control and preventive measures.
   - Removal of contaminated food
   - Exclusion and restriction of persons who are at high risk of spreading illness, including food handlers, day care attendees and providers, and persons involved with direct patient care.
   - Emphasizing hand hygiene.
   - Closing the food establishment, if implicated.
5. Definition of cases, population at risk and finding cases.
   - Clinical information and information related to time, place, and person.
6. Description of epidemiology (in time, place, and person).
7. Development of possible hypotheses.
8. Planning and conducting an epidemiological study to evaluate the hypotheses.
9. Analysis of the data collected and interpretation of results.

The occurrence of food borne diseases/outbreaks and description (causes, risk factors, location, population affected, etc.) are published in weekly and monthly reports of the IDSP by the district and state surveillance units. IDSP has developed surveillance reporting tools namely, Early Warning Signals/Outbreak reporting, Media Surveillance, Toll free number (1075) and Community Based Surveillance. Recently the IDSP established an Inter-sectoral Coordination for Prevention and Control of Zoonotic Diseases programme coordinated by NCDC for collection and collation of animal disease data and capacity building for effective prevention and control of zoonotic diseases.

IDSP has 315 functional District Public Health Laboratories. A referral lab network has been established in 9 States, through linking 65 functional labs in the medical colleges and various other major centers with adjoining districts for providing diagnostic services for epidemic prone diseases during outbreaks.

2.2.4 *Animal Disease Surveillance*

The animal disease surveillance is conducted through National Animal Disease Reporting System, which is a web-based information technology system for disease reporting from States and Union Territories (Kumar et al 2021). In addition, this network also has been linked to the animal disease diagnostic laboratories from the district level onwards. The aim of the surveillance is to record, monitor livestock disease situation and to initiate the preventive and curative action in a swift manner during disease emergencies. The reporting of animal diseases is governed by the Department of Animal Husbandry and Dairying (DAHD), Ministry of Fisheries, Animal Husbandry and Dairying.

The Indian Council of Agricultural Research with its various institutes such as Indian Veterinary Research Institute is involved in disease surveillance, diagnosis and research on livestock diseases. Surveillance programmes include investigations of all major zoonotic diseases and antimicrobial resistance. The Indian Network of Fisheries and Animal for AMR has been established by the ICAR with the cooperation of the FAO and USAID with the aim to detect the AMR in different production systems and identifying the spread of resistant bacterial strains, genes and trends through a structured surveillance programme (Rathore et al 2020).

CHAPTER 3

DEVELOPING AND ESTABLISHING INTEGRATED FOOD CHAIN SURVEILLANCE SYSTEM IN INDIAN CONTEXT: IDENTIFYING REQUIREMENTS AND DESIGNING A MODEL ACTIVITY/ACTION PLAN

The existing food borne, animal and human disease surveillance programmes in India have the basic infrastructure for investigating and respond to food borne events as outlined by WHO. However, several elements/components required for establishing integrated food chain surveillance framework are yet to be built in/enhanced in the existing systems mainly with respect to multisector linkages and data sharing mechanisms. Diverse information is required from multiple sectors for integrating surveillance data checked for quality and accuracy to the regulator/decision maker.

An attempt has been made to develop a model activity/action plan incorporating the critical components/elements required and a checklist of activities that need to be carried out to fulfil the requirements for establishing integrated food chain surveillance system. The WHO guidelines for setting up integrated food chain surveillance has been taken into consideration for evolving activity/action plan.

3.1 Model Activity / Action Plan

3.1.1 Preliminary Activity

1. Perform situational analysis of existing food safety/food borne disease and animal disease surveillance programmes. Identify strengths and gaps.

   Critical areas include: operational framework, multisector coordination and communication mechanisms, food borne pathogens and diseases prioritization, laboratory infrastructure, data collection, storage and transfer mechanisms, risk analysis framework, risk assessment capacity, data analysis and interpretation procedures/approaches, monitoring and evaluation plans.

2. Define requirements and design activity plan.

3.1.2 Key Components and Model Activity Plan

1. Formation of Multisector/Multidisciplinary Coordinating Working Group

Activity/Action Plan

i) Identify stakeholders from food, animal and human health sector for planning and establishing the integrated food chain surveillance programme. Incorporate appropriate stakeholders representing the food supply chain from production to consumption. Ministries, agencies and regulatory authorities responsible for each sector, funding agencies, national and subnational bodies, and other governmental or nongovernmental stakeholders, professionals engaged in decision-making and implementation of surveillance activities, laboratory testing personnel, emergency response/early warning system personnel, animal and human health epidemiologists, risk assessment experts, laboratory experts from government, industry and academia. Including experts/professionals from industry may be useful for obtaining data relevant to food chain safety from food industry. Identifying stakeholders at multiple levels and reviewing their interlinkages in the food chain are important.

Relevant stakeholders in the Indian context:

- Members in existing food safety and food borne disease surveillance programmes of FSSAI, ICMR and IDSP, professionals, governing body representatives, laboratory personnel.
- Ministries of Health and Family Welfare, Agriculture, Food and Civil supplies, Food processing, Fisheries, Animal Husbandry and Dairying, Environment and Forests, and various departments related to food under the above ministries, regulatory authorities FSSAI, and authorities from other departments. Research organizations namely ICMR, NCDC, ICAR, Veterinary research institutes, veterinary diagnostic laboratories, food testing laboratories.
- Food safety and disease specific (food borne, zoonotic, infections) experts, epidemiologists, statisticians, IT, laboratory and public health professionals.
- Private agencies relating to food production/processing, livestock production, food transport, storage and distribution.
- Consumer organizations .

ii) Assign roles and responsibilities to stakeholders and set up working groups (governing and coordination, testing, database functions, epidemiology, emergency response, communication).

iii) Create coordinated network of stakeholders.

2. Identify Core Functions of Surveillance Programme and Set Objectives

Activity/Action Plan

i) Core Functions

- To detect, control and prevent foodborne disease outbreaks.
- To establish governance structure and required legal framework for multisector coordination; operational framework (rules, laws, policies, standards, guidelines, SOPs).
- To set criteria for prioritizing food contaminants/food borne diseases using risk-based approaches.
- To establish central multisector coordinated database.
- To establish laboratory infrastructure.
- To evolve surveillance plans and guidelines for risk assessment methodologies.
- To monitor and evaluate integrated food chain surveillance.
- To set communication mechanisms.

ii) Objectives of Integrated Food Chain Surveillance

- Monitor occurrence of priority food contaminants/foodborne pathogens/zoonotic pathogens in food, food producing animals throughout the food chain.
- Identify trends (sources and pattern) of food borne diseases. Identify emerging risks.
- Monitor occurrence of antimicrobial resistance in bacteria isolated from food animals, food and human food chain.
- Investigate linkages between pathogens isolated from food and animal sources and human disease.
- Enable sharing of data on food, animal and human health surveillance, to identify, investigate and respond to health risks along the food chain.

- Develop partnership programmes through identification of existing strategic/ongoing plans and policies of each sector to aid data sharing mechanisms.
- Establish coordination and communication mechanisms between relevant stakeholders in the food chain.

3. Establish Governance Framework to Enable Coordinated Multisector Function

Activity/Action Plan

i) Evolve required legal frameworks for integrated multisector food chain surveillance programme (rules, policies, guidelines and regulations for coordinated surveillance and data sharing).

ii) Set up coordinating mechanism, surveillance implementation mechanisms: level of operation (national/state/district); stakeholders involved and roles and responsibilities.

iii) Define structural framework for data sharing that involves all the stakeholders in the multisector team for integration, analysis, and interpretation. Seek willingness of research groups, agencies and laboratories to share disease data freely and transparently. Data sharing may be across sectors, disciplines, decision-making/policy, and risk analysis.

iv) Evolve strategic plans applicable to multisector: vision, goals and objectives and governance.

v) Define surveillance types and plans, protocols, and standard operating procedures/guidelines, early warning systems.

vi) Describe financial outlay/distribution

4. Identify and Prioritize Pathogens and Determine the Animal Species and Foods to Include and Data Sources

Activity/Action Plan

i) Identification of Pathogens

- Identify common pathogens under surveillance in each sector, prioritize targeted pathogens based on data from food borne disease outbreaks, food contamination events, food producing animal diseases, and food borne infections/disease in humans.
- Routinely test pathogens occurring at high frequencies in the food chain such as *Salmonella*, *Campylobacte*r, and Shiga-toxin-producing *E.coli*.
- Set up/specify type of diagnostic and characterization tests i.e. :
  - *Tests used to characterize pathogens- culturing, sero-/phage-typing, PCR, whole genome sequencing, antibiotic susceptibility testing; and*
  - *Assess comparability of characterization tests between different sectors. Comparability of methods used to test pathogens in food with those used for testing isolates in animal and human clinical specimens should be examined.*

ii) Selection of Animal Species and Foods

- Include foods involved in outbreaks, from investigations on pathogen-food pairs; all types of animal derived foods that are consumed and their pattern of consumption, foods implicated as a source of infection from bacterial pathogens such as *Salmonella* and the risk factors involved for the infections to occur.

- Locations for sampling include farms, animal farms, storage areas, distribution centres, abattoirs, retail etc.

iii) Identify Data Sources, Frequency of Data Collection, Available Data Fields

(a) Data sources

- Food monitoring data: samples analysed from food supply/distribution chain (retail, packing, distribution and locally produced or imported food).
- Data from surveillance programmes (Notifiable disease surveillance programme).
- Animal sector- abattoirs, farm animals, sick or dead animals, carcasses at the slaughterhouse or the environment (animal living environments or animal feed).
- Data from ad-hoc studies (food borne disease outbreaks).

(b) Frequency of Data Collection

- On-going, during food borne disease outbreaks, specific seasons that are at risk for contamination/infection, etc.

(c) Data fields

- *Food sample:* Food product sampled, brand, place of purchase, date of sample collection, name of laboratory-confirmed pathogen, date of laboratory result.
- *Animal specimen:* Animal type, sample (e.g. carcass or swab), abattoir name, date of sample collection, name of laboratory-confirmed pathogen, date of laboratory result.
- *Human (clinical sample):* Date of birth, residence, Name of laboratory-confirmed pathogen, date of illness onset, date of specimen collection, date of notification of sporadic/outbreak case.

5. Set Up Central Multisector Integrated Database

Activity/Action Plan

i) Infrastructure

- Establish multisector integrated database at national and subnational level and data exchange and information sharing infrastructure and mechanisms for:
  - *Interface integrated database with existing databases in each sector to enable simultaneous extraction and integration of data from each sector.*
  - *System for data collection, storage and electronic transfer of data from each sector.*
- Prepare data dictionary (data elements and minimum data requirements).
- Evolve data transfer mechanisms.
  - *Define type of electronic transfer, frequency of data transmission, data fields to be transferred to integrated database.*

ii) Evolve Memorandum of Agreement (MoA) with each sector for willingness to share and transfer data.

iii) Identify data sources, define minimum core data sets, type of data shared and levels of data sharing (decision-makers, research groups, laboratories) between relevant sectors.

iv) Establish integrated surveillance log that documents any changes and modifications to the integrated data.

v) Set policy for maintaining confidentiality of data.

vi) Set procedures for data utilization- publications, newsletters, bulletins and accessibility.

6. Assess Laboratory Infrastructure and Surveillance Capacity

Activity/Action Plan

i) Assess laboratory surveillance, testing and reporting capacity in each sector
   - *Number of certified/reference laboratories and qualified testing personnel to perform testing, testing procedures in food, animal and human health sectors required as per the set objectives.*
   - *Number of qualified personnel/analysts for laboratory data analysis and interpretation of integrated data.*

ii) Assess extent of laboratory networking available at various levels (national, state, district)

iii) Compile sampling plans, SOPs for testing various pathogens in each sector. Ensure comparability of testing procedures for specific pathogens in each sector.

iv) Assess transport facilities for samples, supply chain of laboratory equipment and materials. Develop mechanisms for networking and linking laboratory supplies with each sector.

7. Set Up Mechanisms for Multisector Data Analysis and Interpretation

Activity/Action Plan

i) Determine frequency of data analysis.

ii) Assess frequency of data transmission from each sector to the integrated database.

iii) Ensure mechanisms for rapid collection, transmission and analysis of data during food borne disease outbreaks investigations.

iv) Set up data analysis plan for each sector and process for multisector data integration and analysis.

v) Explore source attribution approaches that can facilitate implementation of sound and timely control measures to reduce the occurrence of food borne events.

vi) Develop data quality review process.

8. Develop Risk Analysis Framework for Analysis and Interpretation of Integrated Surveillance Data

Activity/Action Plan

I) Assess capacity of each sector to undertake risk analysis: explore existing food laws, policies, regulations, standards established for risk analysis, identify gaps and develop framework for risk analysis for integrated food chain surveillance.

ii) Assess scientific capacity for performing risk assessments. Explore approaches for capacity building in risk assessment.

iii) Develop guidelines for risk analysis based on Codex Alimentarius Commission basic principles (CAC2007).

9. Establish Communication Mechanism

Activity/Action Plan

i) Assess type and extent of data to be communicated and frequency of communication to all stakeholders and interested parties in the food chain (decision- makers/regulators, integrated food chain surveillance working group, stakeholders in each sector).

ii) Evolve plans for periodic meetings and stakeholders to be informed.

iii) Establish integrated food chain surveillance bulletin, bring out weekly/monthly alerts newsletter and conduct workshops for publicising surveillance data.

10. Set Up Monitoring and Evaluation System

Activity/Action Plan

i) Set up monitoring and evaluation plan and objectives.

ii) Define sources of information, methods and frequency of data collection and analysis, and use of information.

iii) Assess availability and approaches for establishing of baseline data.

iv) Define performance indicators for infrastructure and operational framework and check on type of indicators used :

- *to evaluate performance and effectiveness of the surveillance: inputs (resources (trained manpower, finances, standards/guidelines, communication facilities), process (implementation of planned activities), outputs (reports), outcome and impact (achievement of set objectives); and*
- *to monitor and assess quality of data shared for ensuring completeness of data shared, timely reporting, accuracy at sharing point at local and national levels such as health care providers, surveillance team, decision makers, and laboratory team.*

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

Food contamination and foodborne diseases continue to represent a serious threat to the health of people globally. The upsurge in food chain contamination with microbial pathogens and occurrence of food borne zoonosis and antimicrobial resistance through new exposure routes are emerging concerns. Assessing the source of contamination and diverse transmission pathways of pathogens in the food chain is becoming a challenging task to the food control system. The integrated food chain surveillance is one such approach for assessing food borne risks throughout the food chain based on integrated surveillance data from food producing animals disease surveillance, human health surveillance and food safety surveillance activities. However the approach is very resource intensive and relies on diverse information sources from multiple sectors for integrating surveillance data that can pose challenges of generating and providing appropriate quality and accurate data to the regulator/decision maker. Because of these challenges the integrated food chain surveillance system has not reached full application in various countries.

The existing surveillance programmes for food borne events in India have the basic infrastructure for investigating and responding to food borne events. In order to adopt the integrated food chain surveillance system, several elements/components under the existing framework are yet to be built in/strengthened. The availability of adequate resources and a robust multisector coordinated surveillance and response framework together with appropriate data sharing mechanisms are critical requirements. It is imperative that the collaboration and partnerships between food, animal and human health sectors is initially strengthened/enhanced and core surveillance capacities identified. In this way existing resources can be utilized in an effective manner to address food safety challenges in a holistic way.

The following are some recommendations to strengthen food borne surveillance and response system with multisector coordination in the Indian context:

i) **Creation of a national integrated food safety and food borne disease surveillance programme for the whole of food chain on the model of integrated food chain approach is needed. The Ministry of Health can be the nodal ministry to set up the national food safety surveillance programme and FSSAI as the implementing authority. In this way, a full-fledged surveillance system devoted to food safety and food borne events can emerge.**

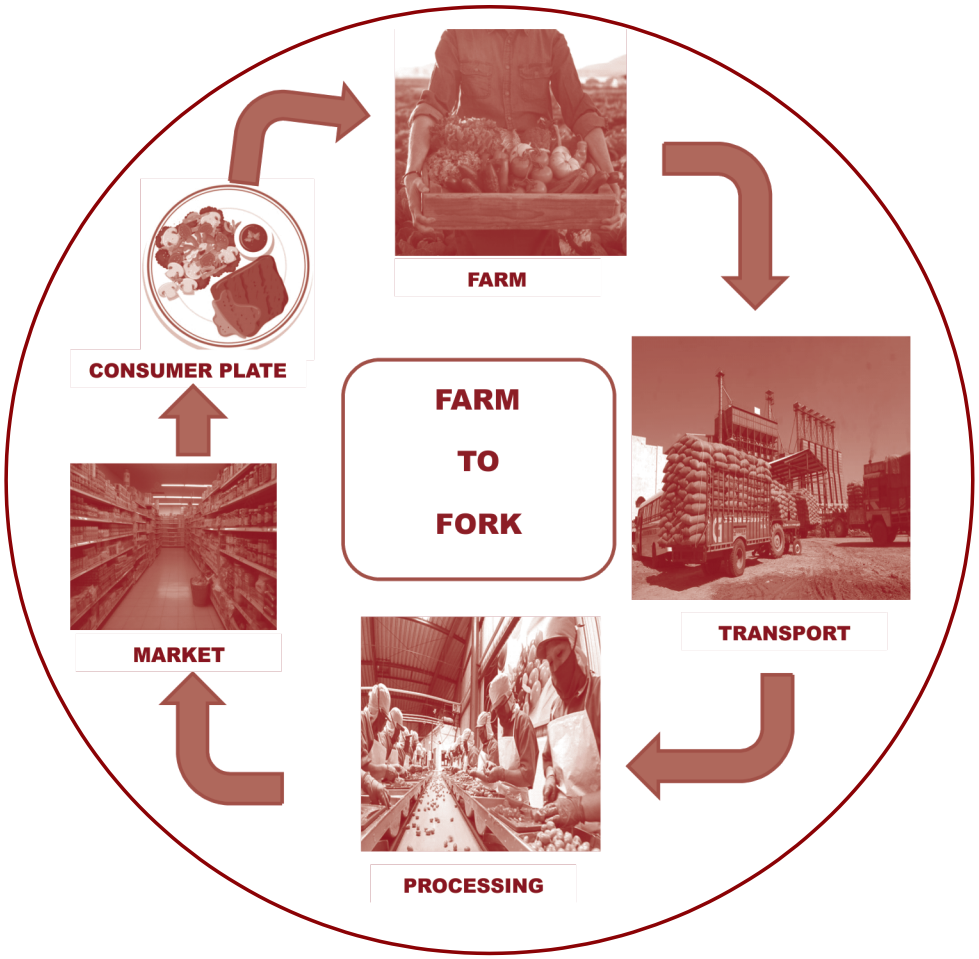
ii) **Strengthening/enhancing existing collaboration and partnerships between food, animal and human health sectors and identifying core surveillance capacities so that existing resources can be utilized in an effective manner to address food safety challenges in a holistic way.**

iii) **Prioritizing high risk food borne pathogens, foods including animal derived foods and fresh produce, food borne diseases that occur with high frequency, vulnerable population and geo-climatic locations susceptible to contamination/infection using risk-based approaches can aid in identifying scope and priorities of surveillance activities.**

iv) Strengthening database infrastructure / operational framework is an important pre-requisite for establishing data sharing mechanisms, defining surveillance activities, identifying gaps and developing mechanisms for gaining access to relevant evidence / information sources.

v) Identifying and prioritizing categories of data that need to be included (scientific data from monitoring food samples in the food chain), food control and enforcement data (regulatory compliance data from market surveillance, industry), clinical surveillance data (human and animal), environmental monitoring data, trends in food borne events (diseases, contamination incidents).

vi) Identifying capacity building areas/initiatives for enhancing expertise in data sourcing, analysis and interpretation needed to provide a holistic and comprehensive data for analysis and interpretation of the food hazard risks and vulnerable locations in the food chain.



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About Dr. Vasanthi Siruguri

Dr. Vasanthi Siruguri worked in the Food Safety division of the ICMR-National Institute of Nutrition, Department of Health Research, Ministry of Health and Family Welfare, Government of India for more than 3 decades. Her research areas include food safety risk assessment with focus on mycotoxins and genetically modified foods. Her specific contributions in the field of mycotoxin research include dietary exposure assessment of mycotoxins and setting regulatory limits for mycotoxins, surveillance and monitoring, development of analytical methods and evolving preventive strategies for mould and mycotoxin contamination. She was successful in initiating international collaborative research through MRC UK Global Health Nutrition Development Grant with the University of Aberdeen UK to study Mycotoxin exposure, intestinal inflammation and childhood stunting in India. With her expertise on mycotoxins she was identified as resource person for several training programs on mycotoxin health hazards and detection at national and international level. In the area of GM foods, Dr.Vasanthi Siruguri was instrumental in setting up the laboratory infrastructure for safety assessment of GM crops/foods for the premarket approval of the government of India. Dr.Vasanthi Siruguri was the recipient of several research fellowship awards for post-doctoral research in mycotoxins and GM foods in international research institutes in Germany, Netherlands and the USA. Significant among these were by the Federal Ministry for Education, Science, Research and Technology, Bonn, Germany, DBT International Overseas Associateship, and the USDA Norman E. Borlaug Fellowship in Agricultural Biotechnology and Food safety.

Dr Vasanthi Siruguri held various consultancy positions notable among these include National Consultant WHO Country Office for India for developing a white paper on aflatoxin M1 contamination of milk in India to inform strategic action for risk management and prevention, MRC UK GCRF funded project in collaboration with the University of Aberdeen entitled Mycotoxin exposure, intestinal inflammation and childhood stunting in India, and development of resource materials on climate change and its effect on nutrition and foodborne diseases under the National Programme on Climate Change and Human Health (NPCCHH).

The author has declared no conflict of interest.

ILSI India's Pioneering Work

ILSI India has had an interesting journey over the last 25 years. ILSI-India has been in the forefront of activities relating to food and water safety, nutrition, risk sciences and agricultural sustainability in India and other countries in the SAARC region. The high quality of the scientific information generated at its Workshops, Conferences, Research Programs and Publications have provided guidance to the scientists from Government, Industry and Academia on the actions to be undertaken in their areas of work. Capacity building activities conducted by national and international experts have imparted the necessary skills to the participants.

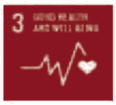
ILSI India's model of work as a tripartite organization working with national and international scientists and experts from public sector, private sector and academia has been unique and has enabled it to address some of the critical issues in area of food safety and nutrition in an efficient and effective manner benefiting public health. ILSI India is a non-profit scientific organization. It is not a lobbying organization. All its activities follow the Principles of Scientific Integrity.

Focus Areas of Scientific Work

- **Nutrition and Health for All.**
- **Lifestyle for improving Health and Environment.**
- **Improving Food and Water Safety.**
- **Building Agriculture Sustainability.**
- **Enhancing Food and Nutrition Security.**
- **Exploring new frontiers of science – Brain Health, Gut Microbiome, Nutritional Diagnostics, Personalized Nutrition, Food Processing Technologies, New Plant Breeding Technologies, Biotechnology, Nanotechnology.**
- **Climate Change and its impact on Food and Nutrition Security and Water Availability and Food Safety.**

ILSI India Meetings, Research Projects and Publications Contributed to the following United Nations Sustainable Development Goals:

GOAL 2: Zero Hunger



GOAL 3: Good Health and Well-being

GOAL 9: Industry, Innovation and Infrastructure

GOAL 12: Responsible Consumption and Production

GOAL 13: Climate Action

GOAL 17: Partnerships to achieve the Goal

The Contribution of Some of the Key Scientific Activities Pioneered by ILSI India are:

Nutrition

- Generating Evidence based scince for adopting Food Based Approaches including Micronutrient Fortification of Foods to Address the Challenge of Eliminating Micronutrient Malnutrition - Since 1999.
- Bringing Attention to Vitamin D Deficiency and Its Adverse Impact on Health and Role of Fortification in Dealing with this Problem – Since 2010.
- Addressing Lifestyle and Diet Related Issues including Metabolic Disorders for Different Segments of Population Including Children, Adolescents, Elderly, Pregnant and Lactating Mothers, Persons affected by HIV/AIDS on the One Hand and Sports Persons on the Other - Since 1997.
- Creating Awareness on Consumption Levels of Fat, Sugar and Salt by Indian Population and Exploring Suitable Strategies for Reducing their Consumption to Levels Recommended by ICMR – Since 1998.
- Examining the Role of Healthy Gut Microbiome in Promoting Health and Immunity and Role of Functional Foods including Probiotics and Prebiotics in Strengthening Gut Microbiome – Since 2009.
- Initiating Discussions on New and Innovative Approaches for Imroving Public Health such as Nutritional Diagnostics, Personalized Nutrition and Bioactive Molecules – Since 2022.

Food and Water Safety

- Preparation of Vision 2025 Document on Water Quality Management: South Asian Perspective – Since 2002.
- Addressing the Importance of Harmonization of Food Regulations in SAARC Countries – Since 1997.
- Drawing Attention towards Modernizing Food Control System in SAACR Countries and Establishing Need for Strong Infrastructure and Training of Manpower for Offering Safe Food to Consumers – Since 2000.
- Preparing the Blueprint for Surveillance and Monitoring System for Food Safety in India – 2007-08.
- Highlighting the importance of use of Packaging Materials to ensure that food is safe as also drawing Guidelines for ensuring that Safe Packaging Materials are used – Since 2006.
- Examining the need for using Food Additives and their Safety Protocols – Since 1997.
- Imparting Skills in Good Food Laboratory Practices – Since 2016 .
- Looking at Alternatives to Animal Testing for promoting Food Safety and revammending Way Forward – Since 2017.

Risk Assessment

- Improving Knowledge Base in Risk Assessment through Organization of Expert Consultations, Workshops and Training Programs on Nutrient Risk Assessment, Chemical and Microbiological Risk Assessment, GM Foods and Plants, Detection Methods for GM Foods and Plants and Pesticide Residues – Since 1999.

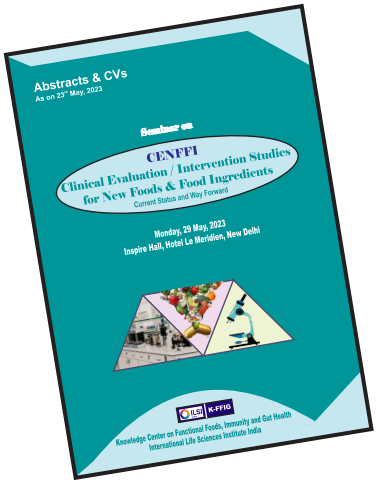
New Technologies for Food and Nutrition Security

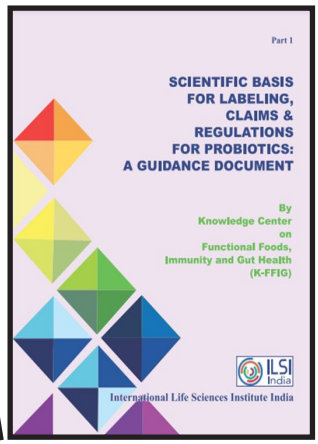
- Looking at Safety and Benefits of New Technologies which can improve Food Safety, contribute towards Agriculture Sustainability, improve Nutrient Delivery Mechanism, improve Food Processing and Packaging such as: New Plant Breeding Technologies, Biotechnology, Nanotechnology, High Pressure Processing etc. – Since 1999.

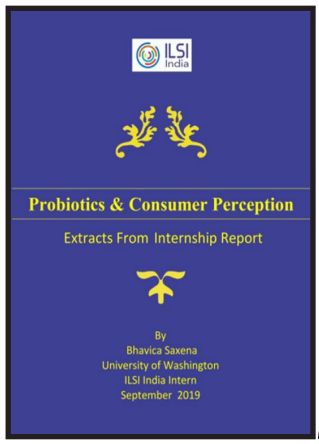
Climate Change and Impact on Food Safety and Nutrition Security

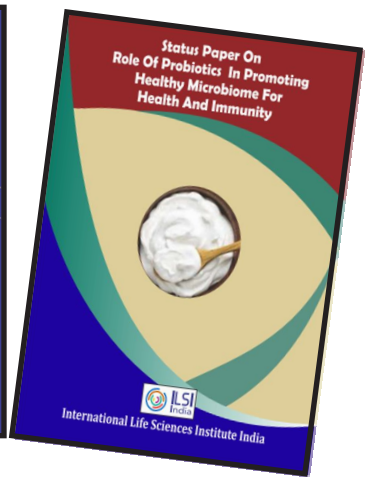
- Examining the impact of Climate Change on Water Availability, Agriculture Productivity, Food and Nutrition Security and drawing the Strategy for Mitigation and Remediation. Also identifying steps to bring Lifestyle Changes to reduce Carbon Footprints. Examining the use of innovative technologies for developing new varieties of Food Crops, Vegetables and Fruits which require less of land and water and encourging development of eco-freindly Packaging Materials – Since 2013.

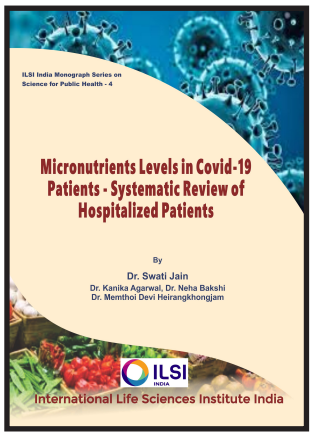
Latest Publications

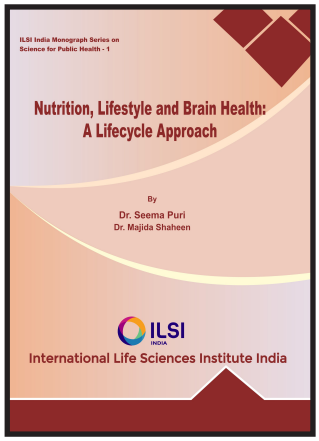


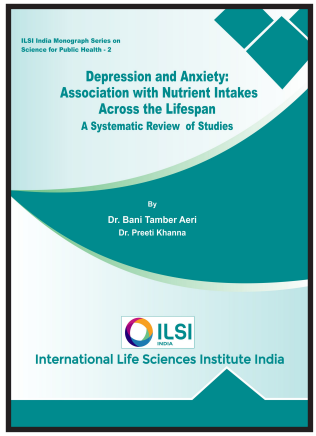


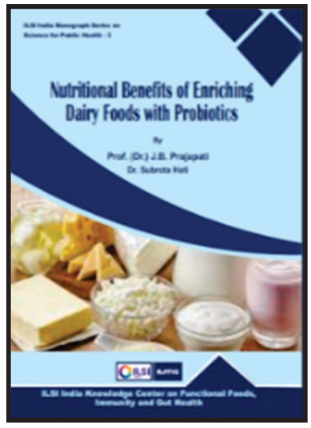


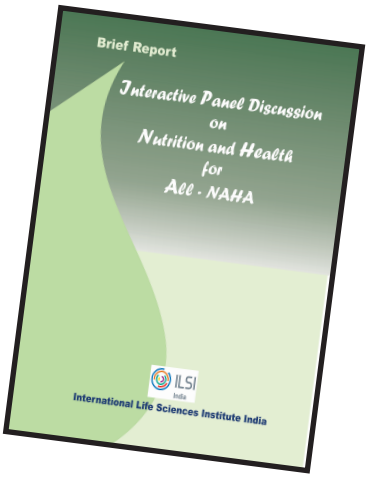


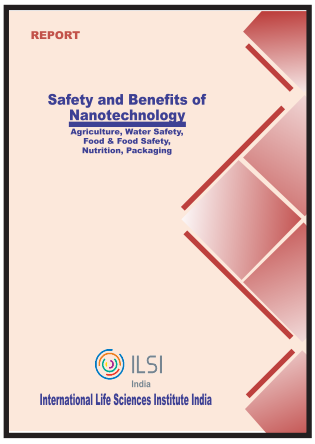


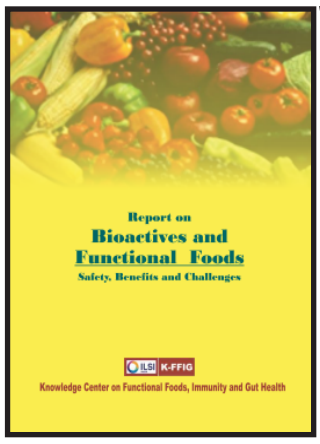


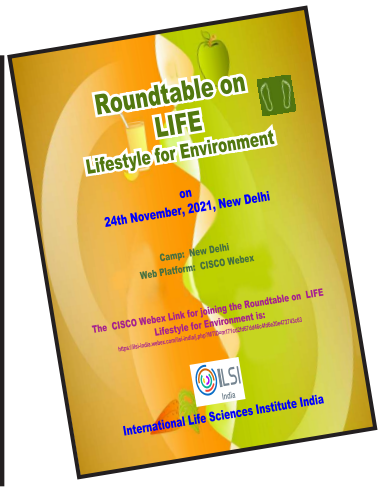












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