CD Alert

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FOOD-BORNE DISEASES AND FOOD SAFETY IN INDIA

INTRODUCTION

Food-borne diseases, including food-borne intoxications and food-borne infections, are terms applied to illnesses acquired through consumption of contaminated food, and are also frequently referred to as food poisoning.

Worldwide, food-borne diseases are a major health burden leading to high morbidity and mortality. The global burden of infectious diarrhoea involves 3-5 billion cases and nearly 1.5 million deaths annually, mainly in young children, due to diarrhoeal disease caused by contaminated food and water.

Annual burden of foodborne diseases in the WHO South-East Asia Region includes more than

- 150 million illness
- 175 000 deaths
- 12 million DALYs

Source: FERG Report 2010

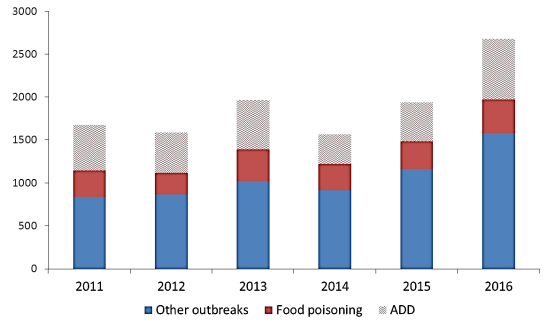
The WHO South East Asia Region has a quarter of the world's population, diarrhoeal diseases continue to be one of the top three leading causes of DALY losses. It has the second highest burden of food-borne diseases per population among WHO regions.

While many food-borne diseases may be self-limiting, some can be very serious and can lead to death particularly in children, pregnant women and older persons. The WHO South East Asia Region contributes to one third of the global deaths due to diarrhoea in children under five years of age.

FOOD-BORNE DISEASES IN INDIA

In India, the burden of food-borne disease is not known. Most food-borne diseases go unreported, only few are reported by the media, usually those with high morbidity and/or occurring in urban areas.

The Integrated Disease Surveillance Programme (IDSP) network was launched in India in 2004. Aggregate analysis of IDSP data from 2011-15 shows food-borne outbreaks together with acute diarrhoeal diseases constitute nearly half of all reported outbreaks under IDSP for the period 2011-16 (figure below)



However, for food-borne illnesses, passive surveillance systems only represent the tip of the iceberg because:

(1) Most patients have mild symptoms of short duration and do not seek medical care;
(2) Many of those that do access clinical care will not have the laboratory test performed to determine a specific etiology; and
(3) Of those who seek medical care in whom an etiologic diagnosis is confirmed, not all will be reported to the surveillance system(s)

Food-borne disease outbreaks are defined as the occurrence of 2 or more cases of a similar illness resulting from ingestion of a common food or observed number of cases of a particular disease exceeds the expected number. These can be confirmed (when at least one causal agent is identified) or suspected (based on clinical and epidemiological information). Although most cases are sporadic, these diseases draw attention to themselves due to outbreaks, thorough investigation of which can help in identifying control measures.

It is estimated by the WHO that food-borne diseases are notified in only 10% of cases in developed countries and 1% in developing countries.[1]

Food borne illness of infectious origin

The pathogenic organisms transmitted through contaminated foods are bacteria, viruses, protozoa and helminths. Foods that are contaminated may not look, taste or smell any different from foods that are safe to eat. A review of recorded foodborne disease outbreaks in India from 1980 to 2016 shows *Staphylococcus aureus, Vibrio sp, Salmonella sp, E. coli, Yersinia enteroclitica* and Norwalk-like virus are some important microbial pathogens responsible for foodborne illnesses. *Salmonella* is the most common cause of foodborne illnesses. *Listeria monocytogenes* can even grow inside the refrigerator in ready-to-eat food. *Staphylococcus aureus* bacteria grow in food and produce toxins that cause staphylococcal food poisoning. Cholera, although primarily a waterborne disease, may have a food source if contaminated water is used.

Different foods implicated in foodborne outbreaks in India are milk and milk products such as dahi, khoa, butter milk, sweets, kheer; meat, poultry, fish, fowl, sea food such as prawns; cooked and uncooked rice; samosa, batatawada, tamarind, and cooked as well as uncooked vegetables. A survey of eggshells, egg trays and egg contents in Coimbatore showed, 7.7% eggs and 7.5% egg trays were contaminated with *Salmonella*. The most common serotype was *Salmonella enteritidis.*

The total count of bacteria per gram of food is an indicator of hygiene and temperature abuse in the preparation of food. The microbial population of different Indian foods varies from 0-400X10^6 organisms/ gm.[17] The percentage of contamination of different foodborne pathogens in Indian foods varies from 1-75% [17].

Worldwide, foodborne illness figure prominently among emerging and re- emerging diseases discovered in the last few decades. They include *campylobacteriosis, Cyclosporidium, Cryptosporidiosis, enterohaemorrhagic E. coli infections, listeriosis and yersiniosis* [22-24]. These microbes have animal reservoirs and are associated with consumption of foods of animal origin, contact with contaminated soil and infected animals. In addition, there are new strains of *Vibrio cholerae* and drug resistant strains of enteric pathogens such as *Salmonella* and possibly *Helicobacter pylori*. Viral agents being host specific, their transmission to humans through food of animal origin is rare. Cases of Nipah virus infection have been hypothesized due to consumption of date palm juice contaminated with virus from infected bats in Bangladesh [25].

Review of literature shows some of the emerging pathogens such as *Listeria monocytogenes, Yersinia enterocolitica, Campylobacter jejuni, E.coli (STEC) 0157:H7* and *S sonnei* have been isolated from humans, animals and food in India.[23,26,27,28,29,30,31,32]

Some of these organisms have developed high level of drug resistance. One hundred and sixty six *Campylobacter jejuni* strains isolated from paediatric diarrhoea cases (children < 5 years) at a Children's hospital in Kolkata, India from 2010-2012 were tested for macrolide resistance. About 4% of the isolates were macrolide resistant by disc diffusion.[33] *S. dysenteriae* and S. flexneri have been predominant *Shigella* sp in India responsible for causing foodborne illness. During 2002-2003, *S. dysenteriae* type 1 with an altered antimicrobial resistence pattern (100% fluoroquinolone resistant) was reported to have caused severe dysentery outbreaks in West Bengal.[34] The severity of symptoms associated with *S. dysenteriae* type 1 is thought to be related to production of Shiga toxin type 1. *S. sonnei* is most common in industrialized countries and the disease is less severe, although it is less common in India. However, two foodborne outbreaks of *S. sonnei* have been reported in India in 2009-2010 from Kerala and Maharashtra.[35]

Food borne outbreak due to chemical contamination

Chemical contamination of food may result from various sources. Industrial or agricultural practices such as use of pesticides, fertilizers lead to entry of heavy metals such as cadmium, lead and mercury into the food chain. India's production of pesticides was 85,000 metric tonnes in 2004, and rampant use of these chemicals has led to several short-term and long-term effects. Many marine toxins produced by dinoflagellates occurring secondarily in molluscs and mussels can lead to food poisoning in humans. They accumulate in fish when they feed on the algae or other fish that have fed on the algae. IDSP reported two cases of shellfish poisoning in 2015 from coastal parts of India.

Mycotoxins are a group of naturally occurring chemicals produced by certain moulds and fungi. They can grow on a variety of different crops and foodstuffs including cereals, nuts, spices and dried fruits. Mycotoxins are produced by several fungi in foodstuffs and these feed during production, storage and transportation, often under warm and humid conditions. Mycotoxins such as aflatoxins, ochratoxin A, fumonisins, trichothecenes, ergot alkaloids and zeralenone are of public health importance. In India, mouldy maize, sorghum and wheat flour are associated with outbreaks of mycotoxicosis.

Food poisoning from consumption of poisonous wild mushrooms has been reported frequently

particularly in the monsoon season. The majority of fatal mushroom poisoning occurs due to ingestion of Amanita phalloides - the death cap due to its high content of Amatoxin, a potent cytotoxin.[36,37] In India, atropine food poisoning from accidental consumption of Atropa acuminata plant leaf has also been reported from a military garrison.[38]

Classification of food-borne illnesses

- **Food-borne infections** – caused by consuming foods or liquids contaminated with bacteria, viruses, or parasites. These pathogens cause infection by:
  - Invading and multiplying in the lining of the intestines and/or other tissues
  - Invading and multiplying in the intestinal tract and releasing a toxin (bacteria only)
- **Food-borne intoxications** – caused by consuming foods or beverages already contaminated with a toxin. Sources of toxins are as follows:
  - Certain bacteria (pre-formed toxins)
  - Poisonous chemicals
  - Natural toxins found in animals, plants, and fungi

Chemical food poisoning can also occur through adulteration of food by adding prohibited substances to partly or wholly substitute healthy ingredients or to artificially create the impression of freshness in stale food. Adulterants may be in solid form, chemicals or liquids and made up of colouring substances.

Poisonous colouring agents such as metanil yellow, ponceau 4R, auromine, rhodomine b, malachite green and sudan red are applied on food items for colouring, brightness and freshness. These can lead to tissue hypoxia, functional anaemia, kidney and liver damage. A large informal food production and distribution system makes regulation of this sector difficult and open to widespread exploitation. According to the FSSAI Act in India, any cooked food item cannot be prepared using a colouring agent. Only items such as cakes, ice-creams and sweets can be prepared using colouring, that too within permissible limits. Food colours that are permissible for use in India is covered under the category 'Colouring Matter' in the Food Safety and Standards (Food Products Standards and Food Additives) Regulations, 2011.

Inorganic forms of arsenic predominate in rice and spices, and are a real threat to human health. Adulteration of edible oil with *Argemone mexicana* (Mexican poppy) oil is a common practice to increase the profit margins. Many outbreaks of dropsy have been from India since 1877, when the first case was reported besides occasional sporadic cases. Noticeably a large outbreak of food poisoning due to epidemic dropsy occurred in Delhi in 1998 in which 60 persons lost their lives and more than 3000 victims were hospitalized.[39]

Infections versus Intoxications*

	INFECTIONS	INTOXICATIONS
Cause	Bacteria / Viruses / Parasites	Toxin
Mechanism	Invade and / or multiply within the lining of the intestines	No invasion or multiplication
Incubation period	Hours to days	Minutes to hours
Symptoms	Diarrhoea Nausea / Vomiting Abdominal cramps ± Fever	Vomiting, Nausea, Diarrhoea Double vision Weakness Respiratory failure Numbness Sensory and motor dysfunction
Transmission	Can be spread from person-to-person via the faeco-oral route	Not communicable
Factors related to food contamination	Inadequate cooking Cross-contamination Poor personal hygiene Bare hand contact	Inadequate cooking Improper holding temperatures

* WHO, 2016. Burden of foodborne diseases in the South-East Asia Region.

Reported food-borne outbreaks due to bacteria in India during 1980-2016 [2-21]

Place	Incidences	Number of affected persons	Microorganism	Food item identified
Party	3	98	*Salmonella Paratyphi A Var Durazoo;* *S.aureus;* *V. parahaemolyticus*	Veg food Coconut balls Fish and meat sandwiches
Mess	1	76	*E. coli serotype* 020	Dinner
Home	2	5	*Salmonella enterica* serovar Weltevreden *(S. Weltevreden)* *Salmonella bornum*	Stale rice Chicken
Feast	2	303	*Yersinia enterocolitica* *Salmonella weltevreden and Vibrio fluvialis*	Butter milk Mutton- ghogni
Religious ceremony	2	164	*Vibrio fluviatilis* *Shigella sonnei*	Bread and vegetable curry Food item not identified
Military establishment	2	78+43	*Salmonella enteritidis* Non typhoidal Salmonella sp	Frozen food Potato bitter gourd vegetable contaminated by rodents
Marriage party	2	800	*Vibrio vulnificus* *Shigella sonnei*	Fish Food item not identified
School	2	135	*E coli* *Staph aureus*	Soyabean milk Bhalla
Hostel	2	184	*Salmonella weltevreden* *Salmonella weltevreden*	Fish Not identified
Educational institution	1	150	*Salmonella enteritidis*	Kheer
Hospital	10	10	*Salmonella wein*	Poultry products
Slum area	1	103	*Salmonella typhi*	Yogurt and sweets
Tea Garden	1	72	Salmonella weltevreden	Contaminated drinking water
Funeral reception	1	44	Vibrio parahaemolyticus	Not identified

Link between food and noncommunicable diseases

Food systems including cultivation and processing have undergone dramatic changes in past decades. This has influenced the nutritional quality of foods that are available, affordable and acceptable to consumers. This nutritional transition is characterized by increase intake of processed food with calories obtained from meat, sugars and oils and fat and decline in intake of fibre-rich foods such as whole grains, pulses and roots. Populations around the world are increasingly exposed to foods and diets that influence the risk of developing non-communicable diseases. India is in the midst of an epidemiological transition. While communicable diseases continue to pose a sizeable challenge in India, non-communicable diseases are estimated to account for 60% of total deaths in India in 2014. The NFHS 4 shows that the prevalence of obesity is on the rise. According to the survey, 20% males and 18% females are obese in India. The food safety and standards authority of India has taken several steps to contain the rise of non-communicable diseases including suitable labelling of food items for class title, saturated fats, trans fats; downward revision of trans fat level in partially hydrogenated vegetable oils (from 10% to 5%); prohibition of sale of junk foods in school premises.

PATHOGENESIS

Food-borne illness is typically caused by micro-organisms or their toxins, and most often manifests with gastro-intestinal symptoms, which can vary in severity and duration. In addition to food-borne pathogens (bacteria, viruses and parasites), food-borne disease may also be caused by contaminants like heavy metals, chemicals, pesticides and toxic substances present naturally in food like toxic mushrooms, plants, fish or shellfish.

The food-borne diseases due to infectious causes form the majority of cases, and are largely dependent on the inoculum size or the infective dose of the pathogen. This may be as small as 10 to 100 bacteria or cysts for *Shigella, Entero-Haemorrhagic E. coli (EHEC), Giardia lamblia and Entamoeba histolytica*, requiring minor lapses in hygiene for the faeco-oral transmission. The infective dose for *Vibrio cholerae* on the other hand is usually 10^5 – 10^8, and may be variable for *Salmonella species*.

Food-borne transmission of pathogens and toxins

Food may become contaminated during food production and processing or during food preparation and handling, or during storage.

Food production and processing

Foods, such as fruits and vegetables, may be contaminated if washed or irrigated with water that is contaminated with pathogens from animal or human faeces. Animals naturally harbour many food-borne bacteria in their intestines that can cause illness in humans, but often do not cause illness in the animals. During slaughter, meat and poultry carcasses can become contaminated if they are exposed to small amounts of intestinal contents.

Food preparation and handling

- *Infected individuals* – most food-borne pathogens are shed in the faeces of infected persons and these pathogens may be transferred to others through food via the faecal-oral route. Bacteria present in infected lesions and normal nasal flora may also be transmitted from an infected food-handler to ready-to-eat foods.
- *Cross-contamination* – pathogens naturally present in one food may be transferred to other foods during food preparation if same cooking equipment and utensils are used without washing and disinfecting in between, especially in case of ready-to-eat foods.
- *Inadequate cooking temperature* – with insufficient cooking bacteria can multiply and produce toxins within the food. Many bacterial toxins are heat stable and may not be destroyed by cooking.

Improper storage

Food being held or stored at warm (10-50ºC) temperature allows multiplication of pathogens and is an important cause of food-borne outbreaks.

It is essential to have a high index of suspicion for food-borne illnesses for better evaluation and management of these cases. During the initial assessment of patients with suspected food-borne illness, the clinical history is very important. The time of onset (incubation period), duration of illness, clinical symptoms, history of recent travel, or antibiotic use, as well as presence of blood or mucus in the stool, recent meals (including type of food, especially raw or uncooked food, unpasteurised milk or food products), cooking and refrigeration as well as details of others affected by similar symptoms can provide valuable clues to the aetiology.

During the clinical examination, special attention should be focussed on vital signs, degree of dehydration and abdominal examination. In an Indian study of diarrhoeal deaths in children, patients with moderate or severe dehydration or Shigellosis had a significantly higher chance of having a fatal outcome. Presence of fever, systemic symptoms, and bloody diarrhoea suggests invasive diarrhoeal illness.

Types of bacterial food poisoning*

Mechanism	Location	Illness	Stool M/E	Examples
Non-inflammatory (enterotoxin)	Proximal small intestine	Watery diarrhoea	No faecal leukocytes	*Vibrio cholerae, ETEC, EAggEC, Cl. perfringens, Bacillus cereus, Staph aureus, rotavirus, norovirus, enteric adenoviruses, Giardia lamblia, Cryptosporidium, Cyclospora, Microsporidia*
Inflammatory (invasion / cytotoxin)	Colon / distal small intestine	Dysentery / inflammatory diarrhoea	PMN faecal leukocytes	*Shigella, Salmonella, C. jejuni, EHEC, EIEC, Y. enterocolitica, Vibrio parahaemolyticus, Cl. difficile, E. histolytica*
Penetrating	Distal small intestine	Enteric fever	Mono-nuclear faecal leukocytes	*Salmonella typhi, Y. enterocolitica, Campylobacter fetus*

Bacterial food poisoning*

Incubation Period	Cause	Symptoms	Common foods
1-6 hours	*Staph aureus*	Nausea, Vomiting, Diarrhoea	Ham, poultry, potato / egg salad, mayonnaise, cream pastries
	Bacillus cereus	Nausea, Vomiting, Diarrhoea	Fried rice
8-16 hours	*Cl. perfringens*	Abdominal cramps, diarrhoea (vomiting rare)	Beef, poultry, legumes, gravies
	B. cereus		Meats, vegetables, dried beans, cereals
>16 hours	*Vibrio cholerae*	Watery diarrhoea	Shell-fish
	ETEC	Watery diarrhoea	Salad, cheese, meats, water
	EHEC	Bloody diarrhoea	Beef, salami, raw milk / vegetables, apple juice
	Salmonella sp	Inflammatory diarrhoea	Beef, poultry, eggs, diary products
	Campylobacter jejuni	Inflammatory diarrhoea	Poultry, raw milk
	Shigella sp	Dysentery	Potato / egg salad, lettuce, raw eggs
	V. parahaemolyticus	Dysentery	Sea food - Molluscs, crustaceans

Some important food-borne pathogens*

Bacteria			
Aeromonas hydrophila	Enterotoxigenic *E. coli* (ETEC)	Salmonella (non Typhi) sps	*Bacillus cereus*
Brucella spp	Enteropathogenic *E. coli* (EPEC)	Shigella spp	*Staphylococcus aureus*
Campylobacter spp	Entero-Haemorrhagic *E. coli* (EHEC)	*Vibrio cholerae* O1 and O139	*Clostridium botulinum*
Salmonella typhi			*S. paratyphi*
Clostridium perfringens	Entero-Invasive *E. coli* (EIEC)	*Vibrio parahaemolyticus*	*Yersinia enterocolitica*
Escherichia coli spp	*Listeria monocytogenes*	*Vibrio vulnificus*	
Viruses			
Hepatitis A virus	Norovirus	Rotavirus	Hepatitis E virus
Poliovirus			
Protozoa			
Cryptosporidium spp	*Entamoeba histolytica*	*Toxoplasma gondii*	*Cyclospora cayetanensis*
Giardia lamblia			
Trematodes			
Clonorchis sinensis	*Fasciolopsis buski*	*Opisthorchis viverrin*	*Fasciola hepatica*
Opisthorchis felineus	*Paragonimus westermani*		
Cestodes			
Diphyllobothrium spp	Echinococcus spp	*Hymenolepis nana*	*Taenia solium / saginata*
Nematodes			
Anisakis spp	*Ascaris lumbricoides*	*Trichinella spiralis*	*Trichuris trichiura*

** WHO, 2016. Burden of foodborne diseases in the South-East Asia Region.*

Some important food-borne toxins and chemicals*			
Toxins			
Marine biotoxins	Tetrodotoxin (pufferfish)	Pyrrolizidine alka	Ciguatera poisoning
Mushroom toxins	Phytohaemagglutinin (red kidney bean poisoning)	Shellfish toxins (paralytic, neurotoxic, diarrhoeal, amnesic)	Mycotoxins (e.g. aflatoxins)
Grayanotoxin (honey	Scombroid poisoning/histamine		Plant toxicants
Chemicals			
Toxic metals (cadmium, copper, lead, mercury, tin)	Pesticides (organophosphates,	Nitrites (food preservatives)	Polychlorinated biphenyls
	Radionuclides		Monosodium glutamate
	Fluoride	Sodium hydroxide	Zinc

Major Food-borne Hazards: Clinical Features & Samples* (WHO. Foodborne disease outbreaks: guidelines for investigation and control. Geneva; 2008)			
Time to onset of symptoms	**Predominant symptoms**	**Associated organism or toxin**	**Samples from cases (and food-handlers)**
Upper gastrointestinal tract symptoms (nausea, vomiting) occur first or predominate			
<1 hour	Nausea, vomiting, unusual taste, burning of mouth.	Metallic salts	Vomit, urine, blood, stool
1–2 hours	Nausea, vomiting, cyanosis, headache, dizziness, dyspnoea, trembling, weakness, loss of consciousness	Nitrites	Blood
1–6 (mean 2–4) hours	Nausea, vomiting, retching, diarrhoea, abdominal pain, prostration	*Staphylococcus aureus and its enterotoxins*	Stool, vomit, (swabs from nostril, skin lesions)
8–16 hours (2–4 hours if emesis predominant)	Vomiting, abdominal cramps, diarrhoea, nausea	*Bacillus cereus*	Rectal swab, stool
6–24 hours	Nausea, vomiting, diarrhoea, thirst, dilation of pupils, collapse, coma	Mycotoxins (Amanita sp. Fungi)	Urine, blood (SGOT, SGPT), vomit
12–48 (median 36 hours)	Nausea, vomiting, watery non-bloody diarrhoea, dehydration	Norovirus	Stool
Lower gastrointestinal tract symptoms (abdominal cramps, diarrhoea) occur first or predominate			
2–36 (mean 6–12) hours	Abdominal cramps, diarrhoea (putrefactive diarrhoea - *Clostridium perfringens)*, sometimes nausea and vomiting	*Clostridium perfringens, Bacillus cereus*	Rectal swabs, stool
6–96 hours (usually 1–3 days)	Fever, abdominal cramps, diarrhoea, vomiting, headache	*Salmonella spp, Shigella, Aeromonas, Entero-Pathogenic E. coli*	Rectal swabs, stool
6 hours to 5 days	Abdominal cramps, diarrhoea, vomiting, fever, malaise, nausea, headache, dehydration (sometimes bloody or mucoid diarrhoea, cutaneous lesions associated with *Vibrio vulnificus)*	*Vibrio cholerae (O1 and non-O1), V. vulnificus, V. fluvialis, V. parahaemolyticus*	Stool
1-10 (median 3-4) days	Diarrhoea (often bloody), abdominal pain, nausea, vomiting, malaise, fever (uncommon with *E. coli* O157)	*Entero-Haemorrhagic E. coli (including E. coli O157), Campylobacter*	Stool, rectal swabs
3-5 days	Fever, vomiting, watery non-inflammatory diarrhoea	*Rotavirus, astrovirus, enteric adenoviruses*	Stool, vomit
3-7 days	Fever, diarrhoea, abdominal pain (can mimic acute appendicitis)	*Yersinia enterocolitica*	Stool
1-6 weeks	Mucoid diarrhoea (fatty stools) abdominal pain, flatulence, weight loss	*Giardia lamblia*	Stool
1 to several weeks	Abdominal pain, diarrhoea, constipation, headache, drowsiness, ulcers, variable – often asymptomatic	*Entamoeba histolytica*	Stool
3-6 months	Nervousness, insomnia, hunger pains, anorexia, weight loss, abdominal pain, sometimes gastroenteritis	*Taenia saginata, T. solium*	Stool, rectal swab

** WHO, 2016. Burden of foodborne diseases in the South-East Asia Region.*

Major Food-borne Hazards: Clinical Features & Samples

(WHO. Foodborne disease outbreaks: guidelines for investigation and control. Geneva; 2008)

Time to onset of symptoms	Predominant symptoms	Associated organism or toxin	Samples from cases (and food-handlers)
	Neurological symptoms (visual disturbances, vertigo, tingling, paralysis)		
Less than 1 hour	Neurological and/or gastrointestinal symptoms	Shellfish toxin	Gastric washing
	Gastroenteritis, nervousness, blurred vision, chest pain, cyanosis, twitching, convulsions	Organic phosphate	Blood, urine, fat biopsy
	Excessive salivation, perspiration, gastroenteritis, irregular pulse, pupils constricted, asthmatic breathing	Muscaria-type mushrooms	Vomit
1–6 hours	Tingling, numbness, gastroenteritis (GE), temperature reversal, dizziness, dry mouth, muscular aches, dilated pupils, blurred vision, paralysis	Ciguatera toxin	
	Nausea, vomiting, tingling, dizziness, weakness, anorexia, weight loss, confusion	Chlorinated hydrocarbons (insecticides, pesticides)	Blood, urine, stool, gastric washing
2 hours to 6 days, usually 12–36 hours	Vertigo, double / blurred vision, loss of light reflex, difficulty in swallowing, speaking & breathing, dry mouth, weakness - descending, bilateral flaccid paralysis (respiratory paralysis), with preserved sensorium	*Clostridium botulinum* and its neurotoxins	Blood, stool, gastric washing
> 72 hours	Numbness, weakness of legs, spastic paralysis, impairment of vision, blindness, coma	Organic mercury	Urine, blood, hair
	Allergic symptoms (facial flushing, itching)		
Less than 1 hour	Headache, dizziness, nausea, vomiting, peppery taste in mouth, burning of throat, facial swelling / flushing, stomach pain, itching	Histamine (scombroid)	Vomit
	Peri-oral numbness, tingling sensation, flushing, dizziness, headache, nausea	Monosodium glutamate	
	Flushing, itching, abdominal pain, puffing of face and knees	Nicotinic acid (additive / preservative)	
	Generalized infection symptoms (fever, chills, malaise, prostration, aches, swollen lymph nodes)		
4–28 (mean 9) days	Gastroenteritis, fever, oedema around eyes, perspiration, muscular pain, chills, prostration, laboured breathing	*Trichinella spiralis*	Serum, muscle tissue (biopsy)
7–28 (mean 14) days	Malaise, headache, fever, cough, nausea, vomiting, constipation, abdominal pain, chills, rose spots, bloody stools	*Salmonella typhi*	Rectal swab, stool
Varying periods (depends on specific illness)	Fever, chills, headache, arthralgia, prostration, malaise, swollen lymph nodes, etc	*C. jejuni, B. anthracis, Brucella sp, C. burnetii, Fr. tularensis, L. monocytogenes, P. multocida*	

** WHO, 2016. Burden of foodborne diseases in the South-East Asia Region.*

INVESTIGATION

The investigation and control of food-borne disease outbreaks require multi-disciplinary skills in the areas of clinical medicine, epidemiology, laboratory medicine, food microbiology and chemistry, food safety and food control, and risk communication and management.

STEPS OF OUTBREAK INVESTIGATION

1. Establish existence of an outbreak

Detailed baseline epidemiological information should be collected as soon as possible, which includes, but is not limited to, the following:

- 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

A successful investigation requires a teamwork approach and collaboration among, but not limited to medical investigators, epidemiologists, food inspectors, microbiologists and healthcare providers.

3. Collection and transport of clinical specimens and food samples for laboratory testing

For most food-borne disease outbreaks, food and stool samples have to be collected from persons experiencing diarrhoea to identify or confirm the pathogen. Blood cultures or serological testing are recommended for systemic infections, such as Enteric fever, Listeriosis or viral hepatitis, although, serology has a limited role for most other food-borne illnesses.

Stool collection should be encouraged whenever a person is experiencing or has recently experienced a diarrhoeal illness. If possible, requests for stool samples should begin during the initial food-borne illness report, and may continue during the outbreak investigation.

- Testing of all ill individuals is neither useful nor recommended for optimal utilization of resources. Collection of at least five stool specimens is usually sufficient to confirm the diagnosis.
- Laboratory testing may still be beneficial even after symptoms have ceased. For many food-borne illnesses, an ill person may continue to shed the pathogen in their stool even a few days after symptoms have disappeared and stool appears normal.
- Even in the absence of any laboratory confirmation, positive results, or definitive diagnosis, pathogens may still be implicated and public health measures may be implemented solely based on clinical and epidemiological information collected during the outbreak investigation.
- Stool specimens are most useful for microbiological diagnosis if collected soon after onset of diarrhoea (for viruses < 48 hours and for bacteria < 4 days), and preferably before the initiation of antibiotic therapy.
- Stool is the preferred specimen for culture of bacterial, viral and parasitic diarrhoeal pathogens.
- Rectal swabs showing faeces may be collected from infants (where collection of stool sample may not be possible). They are not recommended for the diagnosis of viruses.
- IDSP has identified 107 state referral labs in 24 states with capacity for stool examination for identification of selected pathogens. Each referral lab is inturn linked to selected districts.

4. Implementation of control and preventive measures

Usually most of these outbreaks are self-limiting. Precautions and prevention are aimed at preventing future outbreaks.

Investigators should respond and implement appropriate public health action as soon as possible including, but should not be limited to, the following:

- 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

Preliminary information obtained during the early stages of an outbreak investigation can be organized using a line list.

The case definition in the setting of an outbreak investigation usually includes four criteria: clinical information and information related to time, place, and person.

A case definition should be developed for every outbreak to ensure that ill persons are classified appropriately. Good case definitions often include simple and objective clinical criteria (e.g. diarrhoea [defined as three or more loose stools in a 24-hour period] with vomiting or nausea). The population at risk provides the denominator based on which various attack rates can be calculated.

6. Description of epidemiology (in time, place, and person)

Tools that may be used to organize and depict the outbreak by time, place, and person include epidemic curves, maps and frequency tables.

7. Development of possible hypotheses

Develop a hypothesis as an educated guess about the cause of the outbreak and the factors that may have contributed to the illness.

8. Planning and conducting an epidemiological study to evaluate the hypotheses

The questionnaire and the study design are important tools used to further analyse the outbreak and make comparisons between those affected and not affected by the outbreak.

9. Analysis of the data collected and interpretation of results

Important tasks that should be performed to finalize the data include the following:

- Re-evaluate the case definition and ensure all cases meet the case definition
- Update previously plotted epidemic curves
- Calculate frequencies and percentages
- Compute the median and ranges for the incubation period and recovery period
- In a retrospective cohort study, calculate the attack rate, food-specific attack rates and relative risk ratios
- If the study design was a case-control study, calculate the odds ratios
- Determine if results obtained are statistically significant (e.g., 95% confidence intervals)

10. Reporting the findings of the outbreak investigation

Documentation is extremely important as a written record of the public health rationale for the activities as well as the findings of the investigation. A written report provides a record of performance, provides an account of the outbreak for potential medico-legal issues, and can improve the quality of future investigations.

- Prepare and write the report following a scientific format - introduction, background, methods, results, discussion, recommendations and supporting documents.
- A preliminary or summary report should be prepared and disseminated until the final report is completed.

LABORATORY DIASGNOSIS OF FOOD-BORNE ILLNESS

The main objectives of laboratory analysis during food-borne outbreak investigations are to

(1) Confirm the clinical diagnosis by isolation of causative agent from human specimens
(2) Ensure proper identification of the disease, and
(3) Determine if the same causative agent is present in implicated food sources, using relevant epidemiological markers like biotyping, serotyping, antimicrobial susceptibility profile, phage typing, plasmid profile, pulsed field gel electrophoresis, PCR, etc.

Most food-borne infections are diagnosed through the identification of the pathogen in stool collected from infected persons. Vomitus has also been used to detect certain organisms and confirm the aetiology. Blood samples are recommended for cases with systemic involvement.

Stool Specimens: Stool samples should be collected in Clean, dry, leak-proof screw cap container and tape Proper collection and transport of stool specimens requires the appropriate transport medium (modified Cary-Blair medium), and encouraging ill persons to submit a stool specimen.

Method of collecting a rectal swab from infants/debilitated patients

- Label the specimen tube/container containing the appropriate transport medium.
- Moisten a swab in sterile saline.
- Insert the swab tip just past the anal sphincter and rotate gently.
- Withdraw the swab and examine to ensure that the cotton tip is stained with faeces.
- Place the swab in the labelled sterile tube/container containing the appropriate transport medium.
- Break off the top part of the stick without touching the tube and tighten the screw cap firmly.
- Place in a sealed bag and send to laboratory immediately.

Handling and transport

- Stool specimens should be transported at 4-8°C. Bacterial yields may fall significantly if specimens are not processed within 48hrs of collection. Shigella are particularly sensitive to elevated temperatures.

Vomitus / gastric aspirate can also be tested for organisms and toxins, and should be collected as soon as possible after onset of illness. Instruct the patient to vomit directly into a sterile specimen container, such as a screw-capped bottle (or a urine specimen container). If this is not possible, ask the patient to vomit in a clean container, bowl or plastic bag and transfer the vomitus to the screw-capped container with a clean spoon. Place the cap securely on the container and seal the lid with tape.

Food specimens: Microbiological analysis of food supports the epidemiological investigation of a food-borne disease outbreak. The purpose of testing is to isolate and identify pathogenic micro-organisms in food samples, which have been implicated in the outbreak. Samples collected as part of the investigation should be treated as official samples and should be collected in a manner that reflects the food as it was prepared, served, or used in preparation of the suspected meal. Food samples are collected by food safety officer or other authorized personnel under clause (c) of subsection (1) of section 47 of the FSS Act. Formal enforcement action may result if an adverse report is received following examination or analysis.

Food samples must be collected using aseptic techniques and appropriate containers. Samples must be refrigerated during storage and transport and must arrive at the food microbiology laboratory within three days of collection. Samples collected frozen should be stored and transported frozen on dry ice.

- Whenever possible, food samples should be submitted in the original container as contamination of a sample may occur during manipulation.
- Samples that cannot be shipped in their original container should be collected aseptically using sterile and leak-proof collection containers.
    - Representative sample of the solid food item should be taken from the geometric centre as well as several other locations in the food item.
    - Stir or shake the liquid food item and pour or ladle the sample into the sterile leak-proof container.
- Collection of an adequate amount of the food sample (500 gms as per section 47 FSSA act).
- Containers should be filled not more than 75% and sealed.
- Food samples should be placed in Styrofoam coolers with ice packs.
- Sample labelling should include the following - name and type of product, brand of product, product manufacturer and code or lot number, collected by, date, time, and place of collection, and establishment name.

Labelled specimen containers should be placed in a zip-lock bag and sealed. Cold chain should be maintained by using solid CO2 during transport, avoiding freezing. Investigation forms should be filled for each specimen obtained along with relevant clinical details.

TREATMENT

Initial treatment of patients with food-poisoning should focus on assessment and reversal of dehydration, either through oral rehydration therapy (ORT) especially in children, or through IV fluids in seriously dehydrated cases.

Specific treatment in case of pesticide poisoning with chelating agents may be done based on epidemiological and clinical features, under medical supervision.

The earlier standard Oral Rehydration Salts (ORS) provided a solution containing 90 mEq/l of sodium with a total osmolarity of 311 mOsm/l. In 2003, the **"improved" ORS having lower osmolarity** was formulated by reducing the solution's glucose and salt concentrations. Because of the improved effectiveness of reduced osmolarity ORS solution, especially for children with acute, non-cholera diarrhoea, WHO and UNICEF now recommend that countries use and manufacture the following formulation in place of the previously recommended ORS solution.

Reduced Osmolarity ORS Formulation

Formula	Grams /litre	Constituents	Mmol /litre	Acceptable Range
Sodium chloride	2.6	Sodium	75	60-90
Glucose, anhydrous	13.5	Chloride	65	50-80
Potassium chloride	1.5	Glucose, anhydrous	75	= Na but ≤111 mmol/l
Trisodium citrate, dihydrate	2.9	Potassium	20	15-25
		Citrate	10	8-12
		Total Osmolarity	245	200-310 mmol/l

PREVENTION

Food safety is an area of public health action to protect consumers from the risks of food poisoning and foodborne diseases, acute or chronic (WHO Toolkit on food safety, 2015). Food safety is a continuum with its scope extending from farm to plate. The globalization of food trade has increased the potential to rapidly spread foodborne hazards around the world. Food production today is more complex -from its raw state through processing and shipping to consumption by the consumer- food can get contaminated at any stage. An error by a food producer in one country can affect the health of consumers on the other side of the planet. In our globalised world, foods travel far and fast. The health risks impact the whole food supply chain, starting from input supply to the farm to the consumer table.

Key strategies to ensure food safety include having a clear food safety policy and regulations which can be uniformly enforced in an uncomplicated manner; effective surveillance system for foodborne diseases linked to a food safety database information system; food control and inspection systems with analytic capacity and adoption of quality assurance systems by the food business operators and food industry such as HACCP which is recognized by the Codex Alimentarius Commission as the most cost effective approach for food safety at all stages of the food supply system.

Hazard Analysis and Critical Control Point (HACCP) is a systematic preventive approach to food safety that addresses physical, chemical, and biological hazards as a means of prevention rather than finished product inspection. HACCP is used in the food industry to identify potential food safety hazards, so that key actions can be taken at these Critical Control Points (CCPs). The system is used in the food industry at all stages of food production and preparation processes including packaging, distribution, etc. HACCP is an effective approach to food safety and protecting public health.

Apart from food contamination, transmission of infection occurs by direct contact, favoured by the habits and customs of people. Improper storage and handling of cooked food is equally responsible for food-borne illnesses, as during storage at especially at ambient temperatures (28-38 degree C) there is higher risk of multiplication of pathogenic organisms. Food safety education is a critical pre-requisite to prevent food-borne outbreaks by education of food-handlers and the community about proper practices in cooking and storage of food, and personal hygiene. Handwashing is one of the key interventions, not just by food handlers, but also by the community at large. Environmental measures include discouraging sewage farming for growing vegetables and fruits.

Food Supply Chain: Potential Sources of Food Safety Hazards

Agricultural input	Farming	Storage/ Transport	Processing	Retailing	Consumer
Use of banned or restricted pesticides. Seed borne and animal borne diseases. Improper waste water management. Industrial pollution (heavy metals).	Contaminated water and soils. Improper pesticide application. Improper animal health practice.	Improper storage, drying and pest control. Poor waste management. Industrial pollution. Unhygienic handling and transport. Use of prohibited chemical as preservatives.	Use of banned substances/ food additives. Cross-contamination. Poor waste management. Industrial pollution (heavy metals). Contaminated water.	Improper storage. Unhygienic transport. Improper handling and packaging.	Unsafe raw material/ water. Cross-contamination. Improper storage. Poor sanitation.

Principles of Hazard Analysis and Critical Control Point (HACCP)*

1. **Analyse hazards -** Potential hazards associated with a food and measures to control those hazards (biological, e.g. a microbe; chemical, e.g. a toxin; or physical, e.g. ground glass or metal fragments) are identified.
2. **Identify critical control points -** These are points in a food's production - from its raw state through processing and shipping to consumption by the consumer - at which the potential hazard can be controlled or eliminated. Examples are cooking, cooling, packaging, and metal detection.
3. **Establish preventive measures with critical limits for each control point** - For a cooked food, for example, this might include setting the minimum cooking temperature and time required to ensure the elimination of any harmful microbes.
4. **Establish procedures to monitor the critical control points -** Such procedures include determining how and who should monitor the cooking time and temperature.
5. **Establish corrective actions when monitoring shows that a critical limit has not been met** - For example, reprocessing or disposing of food if the minimum cooking temperature is not met.
6. **Establish procedures to verify that the system is working properly** - For example, testing time-and-temperature recording devices to verify that a cooking unit is working properly.
7. **Establish effective record keeping for documentation -** This would include records of hazards and their control methods, monitoring of safety requirements and action taken to correct potential problems.

Five Keys to Safer Food*

1. **Keep Clean**
   - Wash your hands before handling food and often during food preparation
   - Wash your hands after going to the toilet
   - Wash and sanitize all surfaces and equipment used for food preparation
   - Protect kitchen areas and food from insects, pests and other animals
2. **Separate raw and cooked food**
   - Separate raw meat, poultry and seafood from other foods
   - Use separate utensils such as knives and cutting boards for handling raw foods
   - Store food in containers to avoid contact between raw and prepared foods
3. **Cook thoroughly**
   - Cook food thoroughly, especially meat, poultry, eggs and seafood
   - Bring foods like soups and stews to boiling to make sure that they have reached 70°C
   - Reheat cooked food thoroughly
4. **Keep food at safe temperatures**
   - Do not leave cooked food at room temperature for more than 2 hours
   - Refrigerate promptly all cooked and perishable food (preferably below 5°C)
   - Keep cooked food piping hot (more than 60°C) prior to serving
   - Do not store food too long even in the refrigerator
   - Do not thaw frozen food at room temperature
5. **Use safe water and raw materials**
   - Use safe water or treat it to make it safe
   - Select fresh and wholesome foods
   - Choose foods processed for safety, such as pasteurized milk
   - Wash fruits and vegetables, especially if eaten raw
   - Do not use food beyond its expiry date

** WHO, 2016. Burden of foodborne diseases in the South-East Asia Region.*

FOOD SAFETY REGULATIONS IN INDIA

India is a signatory to World Trade Organization (WTO) on food trade and therefore has to abide by guidelines of Codex Alimentarius, a collection of international food standards, guidelines and codes of practice covering all the main foods tailored to the Indian context and known as codex India. Prior to 2006 in India, food-related issues were managed by various departments and ministries through a number of central acts. These included the Prevention of Food Adulteration Act 1954, Fruit Products Order 1955, Meat Food Products Order 1973, Vegetable Oil Products (Control) Order 1947, and the Edible Oils Packaging (Regulation) Order 1988, among others. In 2006, these orders were consolidated and brought under one overarching act, the Food Safety and Standards (FSS) Act, 2006.

The Food Safety and Standards Authority of India (FSSAI) is an autonomous statutory body created for defining science-based standards for articles of food, and regulating the manufacture, storage, distribution, sale and import of food items to ensure the availability of safe and wholesome food for human consumption. The Ministry of Health & Family Welfare, Government of India is the Administrative Ministry for the implementation of FSS Act. Enforcement and execution of the act is done at the central level by the Food authority and at the state level by Food Safety Commissioners. At the local level Food Safety Officers are the licensing authority and municipal corporations and gram panchayats are the registering authority.

CONCLUSIONS

Various evolving influences have broadened the scope of foodborne illness and food safety in 21st century.

Apart from contamination of food by known pathogens (bacterial, viral and parasitic), new foodborne diseases due to emerging and reemerging pathogens have been identified. Increasingly, foodborne illnesses have also been identified with social and behavioural factors, environmental hazards, scientific and technological progress and demographic changes. Lack of epidemiological data on food borne illnesses is as a major deterrent to framing appropriate policies related to food safety in India.

Efforts to enhance foodborne disease and ADD surveillance complementing existing communicable disease surveillance, should be rolled out. Robust foodborne disease surveillance combined with rapid quality outbreak investigations are essential to strengthening food safety as they provide essential data to understand the etiologies of foodborne illness (microbial/ toxic chemical etc.), the types of food vehicles that are responsible for such illness, as well as the sources and routes of food contamination, including gaps in food production, distribution, preparation, and storage practices. A better understanding of each of these issues is key to the development of evidence-based technical standards for food, and is equally essential to effectively promote general awareness about food safety and food standards.

Food safety is a cross cutting issue with prominent stakeholders in non-health areas such as the food industry, agriculture, standardization/regulation authorities, food distributors and the general public. The establishment of the overarching FSS Act 2006 has paved the way for easier access to and utility of food safety regulations by the food and agricultural industry as well as health officials. Further strengthening of food safety policies and its effective enforcement is needed. Additional efforts to enhance inter-sectoral public health approaches will be essential to further strengthen food safety in India.

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