Creation of CBRNE protection system for large area shopping malls

BEST PRACTICES

FOR PREVENTION OF FOOD CBRN INCIDENTS

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MALL-CBRN CONSORTIUM

University of Lodz, PL (coordinator)
www.uni.lodz.pl

Military Institute of Chemistry and Radiometry, PL
www.wichir.waw.pl

International Security and Emergency Management Institute, SK
www.isemi.sk

National Institute of Aerospace Technology, ES
www.inta.es

Hellenberg International, FI
www.hellenberg.org

ATRIUM Promenada, PL
www.warszawa.promenada.com/en

Military Institute of Hygiene and Epidemiology, PL
www.wihe.waw.pl

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Abbreviations

BWA – The Biological Weapons Convention (The Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction)
CBRN – Chemical, Biological, Radiological and Nuclear materials
CCP – Critical Control Points
CCTV – Closed-Circuit Television
CWA – Chemical Warfare Agent
CWC – The Chemical Weapons Convention (The Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction)
FPD – Flame Photometric Detector
FM – Facility Management
FTIR – Fourier Transformation Infra-Red
GC – Gas Chromatography
GCMS – Gas Chromatography Mass Spectrometry
GHP – Good Hygienic Practice
GMP – Good Manufacturing Practice
HACCP – Hazard Analysis and Critical Control Points
IMS – Ion Mobility Spectrometry
IR – Infra-red
PPE – Personal Protective Equipment
SM – Shopping Mall
TIC – Toxic Industrial Chemical
TIM – Toxic Industrial Material
UAV – Unmanned Aerial Vehicle

1. Introduction

The issue of food safety goes back to the 1920's, when it was realized that a lot of kitchens were in varying states of cleanliness. Back then, refrigeration was poor or not existing and food handling was done in an improper way. Considering the deadly effects that contaminated food can have, there were obvious needs to control this aspect of societal life. This concern continues today in restaurant inspections, food inspections, as well as inspections of meat packing plants. Consumption of foods, including beverages that contain hazards, can cause a "food-borne disease". Examples are Salmonella infections (biological hazard) and poisoning by mushrooms (chemical hazard). Hundreds of food hazards exist and can cause an equal number of diseases. Microbial contaminations are by far the most common cause of food-borne illnesses. The spectrum of common food-borne diseases in the Europe has changed considerably during the last hundred years, from typhoid, tuberculosis and cholera to illness caused by bacteria like Campylobacter, Salmonella, and Escherichia coli.

The "old" food-borne diseases are, however, still a problem in the developing world. A relatively new problem is the Norwalk virus. Infections with the parasite Giardia lamblia are usually caused by contaminated water, but when this water is used to wash foods they may cause a food-borne disease. Detection of the agent causing the infection can be a problem. Several steps can be taken if it is assumed that the illness of a person is food-borne. One method is to analyze samples of the food that a sick person has eaten in an effort to find the agent that caused the illness in one of them. Sometimes many people show the same symptoms of disease at the same time. If there is such a cluster of cases of the illness, questioning the affected patients to identify a consumed food item that all have in common may be sufficient to detect the source of the illness. Common places that have such food-disease outbreaks include potlucks, picnics, family reunions, restaurants. In these places and events there is usually a totally unregulated and uncontrolled access to food, which increases the risk for food-borne diseases. Transmission via food may be inferred because the illness affects the digestive tract, but this clue may not always be available. Individual persons might have no digestive tract symptoms yet have the infection and sometimes the infectious agent may cause primarily other symptoms like fever or dizziness. Finally, certain diseases and symptoms are known for having a food connection. It is therefore natural to start the search into the cause of the disease with an inspection of the food items that were consumed recently.

Food is the primary source of nutrients for human. Regulation (EC) No 178/2002 of the European Parliament and the Council of 28 January 2002 states that food „is any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by humans"[1].

In recent years, the development of terrorism is favored by such factors as: globalization, freedom of movement (of people and goods), lack of stability in many countries (both political

[1] Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety (Official Journal EC L 31 of 01.02.2002).

and economic) e.g. Middle Eastern countries, religious conflicts[2]. These facts influenced on the situation that, the food became the object of CBRN terrorism.

Food terrorism can be defined as the deliberate contamination or pollution of food (or foodstuffs) using agents such as biological, chemical and radioactive[3].

[2] Wiśniewska M. 2012. „Food terrorism and the food defense shield". Food Industry 7: 41–43.
[3] Dzwolak W. 2009 A. "Food terrorism – threat factors". Przemysł Spożywczy 9: 41–45.

2. History of CBRN incidents in food chain

CBRN agents pose a daily threat to humans, animals, and plants in Europe and elsewhere. The history of usage CBRN agents are dated on ancient times. However, usage of food as a carrier for CBRN agents is dated later. The first mentions in dated on 15 century. In 1495, the Spanish Armed Forces contaminated the wine with leprosy patients' blood against French during the war in Sothern part of Italy[4]. In 1978, five Dutch children were suffered after eating the mercury contaminated oranges originated from Israel. The Palestine Liberation Organization was responsible for this action. They tried to influence on Israel economy by targeting their export[5].

In 1984, over 700 residents of the Dalles Wasco County in Oregon, USA suffered from food poisoning caused by Salmonellae enteritidis. Over 40 of them were hospitalized. There was no death case caused by this outbreak. The incident was caused by local members of the Rajneeshee religious cult. They contaminated 10 salad bars in the county by Salmonellae enteritidis. The intention was to prevent the residents from voting and thereby affecting the local elections in Wasco County at which they wanted to gain political control. Two members of this group were convicted for 29 months in prison. As a source of the strain, which was used, is believed that was obtained from commercial sources. Besides of victims, nine of the restaurants went out of business. This attack clearly pointing on the fact of relative easiness of executing this kind of attack and pointing out on particularly vulnerable part of the food chain[6].

In 2003, over 90 people got sick after eating ground beef that had been intentionally contaminated with a nicotine-containing pesticide at a Michigan supermarket. A person employed by the store was charged of putting banned Black Leaf 40 into meat[7].

In the UK in 2005, Sudan I (dye used as food colorants, azo compounds, carcinogenic – banned in 2005 by EU) was detected in a Worcester sauce, which was used to make a wide variety of foods. As a result, close to 500 food products were recalled, making it the largest recall in the UK history[8].

In 2009 also in UK, the incident of contamination of food and wine by feces mix with urine in Tesco resulted in loss over 700 million of pounds due to the destruction of products[9].

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[4] Jeffery K. Smart. History of Chemical and Biological Warfare: An American Perspective. Chapter 2 History of Chemical and Biological Warfare: An American Perspective.

[5] Phil Gurski. Borealis Threat & Risk Consulting.

[6] Carl Abbott. Utopia and Bureaucracy: The Fall of Rajneeshpuram, Oregon. Pacific Historical Review Vol. 59, No. 1 (Feb., 1990), pp. 77-103.

[7] Nicotine poisoning after ingestion of contaminated ground beef--Michigan, 2003. MMWR Morb Mortal Wkly Rep. 2003 May 9;52(18):413-6.

[8] Susie Genualdi, Shaun MacMahon, Katherine Robbins, Samantha Farris, Nicole Shyong, and Lowri DeJager. Method development and survey of Sudan I–IV in palm oil and chilli spices in the Washington, DC, area. Food Addit Contam Part A Chem Anal Control Expo Risk Assess. 2016 Apr; 33(4): 583–591.

[9] Man sprayed urine on Tesco food. Metrowebukmetro Tuesday 14 Apr 2009.

3. The most common bacterial food borne pathogens

3.1 Bacillus cereus

Bacillus cereus is a bacteria occurring naturally in the environment (dust, soil, etc.). It can forming spores and producing toxins, which can survive high temperature in cooking or boiling process. Starchy foods like potato, pasta, rice and cereals, and pre-cooked mixed dishes (especially spiced dishes) are products at highest risk of contamination. *B. cereus* can cause two types of illness – emetic and diarrheal. Symptoms of poisoning starts between 1 and 16 hours after consumption of contaminated food. Most common symptoms are vomiting, nausea and watery diarrhea. Symptoms usually are mild and recovery occurs within 24h without any specific treatment. The high risk for pregnant women, young children, elderly people (as they are susceptible to dehydration) or patients with weak immune system.

Risk reduction of contamination and poisoning is possible by: thoroughly cooking and serving food immediately, keeping cooked food hot (60°C or higher) before serving, quickly cooling and storing cooked food in 5°C (or lower) if will be used later, not eating cooked food older than 3-4 days, washing your hands with soap and drying them before preparing and eating food, keeping your kitchen and equipment clean[10].

3.2 Bacillus anthracis (gastrointestinal form)

Bacillus anthracis - bacteria naturally occurring in the environment (dust, soil, wild animals, etc.). It can forming spores and producing toxins, which can survive high temperature in cooking or boiling process. Food products with highest risk are: undercooked or raw meat and milk (from infected animals), water and other products contaminated by spores. The gastrointestinal form of anthrax has an incubation period of 1 to 7 days. Symptoms include severe gastrointestinal disorders and fever. Symptoms may occur in the esophagus area (tongue base, sore throat, fever, enlarged lymph nodes) or mainly in the intestines (nausea, loss of appetite, vomiting and fever, followed by abdominal pain, bloody vomiting and diarrhea). Mortality ranges from 25 to 60%.

Risk reduction: not eating meat or milk from unauthorized sources, thorough cooking and serving food immediately, keeping cooked food hot (60°C or higher) before serving, quickly cooling and storing cooked food in 5°C (or lower) if will be used later, not eating cooked food older than 3-4 days, washing your hands with soap or disinfectant and drying them before preparing and eating food, keeping your kitchen and equipment clean[11].

[10] Richard Dietrich, Nadja Jessberger, Monika Ehling-Schulz, Erwin Märtlbauer, Per Einar Granum. The Food Poisoning Toxins of *Bacillus cereus*. Toxins (Basel) . 2021 Jan 28;13(2):98. doi: 10.3390/toxins13020098.

[11] Ghodratollah Maddah, Abbas Abdollahi, Mehrdad Katebi. Gastrointestinal anthrax: clinical experience in 5 cases. Caspian J Intern Med. 2013 Spring; 4(2): 672–676.

3.3 Campylobacter

Campylobacter is a type of bacteria that can be found naturally in the intestines of pets (cats, dogs), livestock (poultry, swine, cattle), rodents and wild birds. Contamination of food and water usually follow from the faeces or cross-contamination in technological process. *Campylobacter* can cause a severe type of gastro disorders called campylobacteriosis. *Campylobacter* is the most common bacterial cause of diarrheal illness. Virtually all cases occur as isolated, sporadic events, not as a part of large outbreaks. Over 10,000 cases are reported each year (6 cases per 100,000). Many more cases go undiagnosed or unreported, and campylobacteriosis is estimated to affect over 2 million persons every year, or 1% of the population. *Campylobacter* is found in seafood and chicken. Some reports claim that all chicken have *Campylobacter*. If the chicken is well cooked the *Campylobacter* bacteria are killed off. *Campylobacter* is the bacterium implicated with the highest numbers of diarrheal diseases and the most common reason for food-borne illness, although most cases are sporadic and large outbreaks are not common. Symptoms of campylobacteriosis starts at 2 to 5 days after eating contaminated food, and usually involved fever, diarrhea (often bloody and watery), abdominal pain, nausea, vomiting and tiredness. The illness duration up to ten days, and most people recover without any treatment in two weeks.

Protection steps: cook food thoroughly, especially poultry meat and liver, store cooked food separately from raw foods, thoroughly reheat cooked food (to 75°C), drink only treated or boiled water, wash fruit and vegetables with clean running water, avoid consuming unpasteurized milk and raw seafood, wash and dry your hands before handling and eating food, keep your kitchen and equipment clean (counters, cutting boards, knives and other utensils), use separate cutting boards and knives for raw poultry and ready-to-eat food, keep your pets away from food storage and preparation areas[12].

3.4 Clostridium botulinum

Clostridium botulinum is a type of anaerobic bacteria which will be found in soil, water, on plants and in intestines of animals, including fish and birds. *C. botulinum* bacteria similar to B. cereus and *B. anthracis* can forming spores and produce heat resistant toxin. Eaten toxin can cause very serious illness called botulism, in case very young children (under 12 months old) after eaten spores can cause the infant botulism. Transmitted by improperly canned foods, garlic in oil, vacuum-packed and tightly wrapped food. Symptoms: toxin affects the nervous system. Symptoms usually appear within 18 to 36 hours; double vision, droopy eyelids, trouble speaking and swallowing, and difficulty breathing. Fatal in 3 to 10 days, if not treated. Three main kinds of botulism. Food-borne botulism is caused by eating foods that contain the botulism toxin. Infant botulism is caused by consuming the spores of the botulinum bacterium, which then grow in the intestine and release the toxin. Honey can contain spores of *C. botulinum* and has been a source of infection for infants. Wound botulism is caused by toxin produced from a wound infected with *Clostridium botulinum*. 110 cases of botulism are

[12] Sharon V. R. Epps, Roger B. Harvey, Michael E. Hume, Timothy D. Phillips, Robin C. Anderson, David J. Nisbet. Foodborne Campylobacter: Infections, Metabolism, Pathogenesis and Reservoirs. Int J Environ Res Public Health. 2013 Dec; 10(12): 6292–6304. doi: 10.3390/ijerph10126292.

reported each year – 72% infant, 25% food-borne. *C. botulinum* found often in improperly canned food - a warning sign for possible botulinum contamination in canned food is when the can is bulging. This bulge is from the gas produced by the microbe via anaerobic respiration. This toxin affects the nervous system, beginning with double vision and droopy eyelids. Then it starts migrating through the body, eventually hitting the lungs and the diaphragm, shutting them down and asphyxiating the person. There are three mechanisms to be poisoned by botulinum toxin: the toxin is in the food that is eaten, the bacterium is ingested and produces the toxin in the gut, and the toxin is produced in an infected wound. This latter form was common during WWI and a major cause for morbidity and mortality.

Preventing steps: to producing home-canned and bottled food use only new sterilized bottles and jars, making sure that food products are keeping in correct temperature, don't eat food from damage, bulging or leaking cans, baked or cooked food keep hot until served or refrigerate promptly, don't give honey to infants under 1 year, wash your hands and kitchen equipment thoroughly before food preparing and eating[13].

3.5 Clostridium perfringens

Clostridium perfringens is a spore forming bacteria widespread in the environment, they are found in soil, dust, sewage, and human and animal intestines. The spores and toxin of *C. perfringens* are resistant to high temperature, it can survive at the boiling temperature up to one hour. Transmission: "the cafeteria germ" because many outbreaks result from food left for long periods in steam tables or at room temperature (*Clostridium* enterotoxin is heat sensitive 75°C!). Symptoms – diarrhea and gas pains may appear 8 to 24 hours after eating; usually last about 1 day, but less severe symptoms for 1 to 2 weeks. In many cases symptoms are mild and subside within a 24h or less, in rare it can last for up to two weeks. Common symptoms include abdominal pain, stomach cramps, loss of appetite, fatigue, nausea, vomiting, watery diarrhea and fever. *Clostridium perfringens* is destroyed by heat, but the spores are relatively heat resistant and can survive and germinate once the food is cooling down. Thus *Clostridium perfringens* enterotoxin food poisoning occurs where there is improper holding temperatures in food, especially in items like gravy. *Clostridium*-based food poisoning is a classic problem in military bases if the cafeteria lines are not handled well enough. The identified source of poisoning are food products which are high in starch or proteins (cooked meat products, cooked beans, thick gravy or soups).

Reduce the risk of poisoning: thoroughly food cooking and serving immediately or keeping in 60°C or hotter before serving, refrigerate quickly cooked food if it will be stored and used later, divide large amounts of food to cooling faster, keep food in fridge in 5°C or lower, cooked food from fridge should be eaten within 3-4 days, cooked food reheat quickly to minimum 75°C, wash your hands and kitchen equipment thoroughly before preparing and eating food[14].

[13] Yiman Lin, Yixiang Jiang, Zelong Gong, Yanli Wang, Min Jiang, Qiongcheng Chen, Chunlian Li, Qinghua Hu, Xiaolu Shi. Investigation and Identification of Food Poisoning Caused by *Clostridium botulinum* Type B1 in Shenzhen, China. Foodborne Pathogens and DiseaseVol. 19, No. 3. doi.org/10.1089/fpd.2021.0060.

[14] Bhattacharya A, Shantikumar S, Beaufoy D, Allman A, Fenelon D, Reynolds K, Normington A, Afza M, Todkill D (2020). Outbreak of *Clostridium perfringens* food poisoning linked to leeks in cheese sauce: an unusual source. Epidemiology and Infection 148, e43, 1–7. https://doi.org/10.1017/ S095026882000031X.

3.6 Escherichia coli

Escherichia coli is a bacteria naturally found in intestines of people and other mammals, it also widespread in environment in soil and water, where they go with secretions and faeces. Most *E. coli* strains are harmless and are a part of the normal intestines microbiota. Some strains of *E. coli* are beneficial by producing vitamins B and K or preventing intestines before colonization by pathogenic bacteria. Pathogenic E. coli strains are grouped to six pathotypes: Shiga toxin-producing *E. coli* (STEC, VTEC, EHEC), Enterotoxigenic *E. coli* (ETEC), Enteropathogenic *E. coli* (EPEC), Enteroaggregative *E. coli* (EAEC), Enteroinvasive *E. coli* (EIEC), and Diffusely adherent *E. coli* (DAEC).

3.6.1 Enterohemorrhagic *E. coli* (EHEC)

EHEC is a strains with the ability to produce Shiga toxin (or verotoxin). EHEC are the major causes of foodborne illness. Symptoms of illness begins in 2 to 10 days after exposure. EHEC are resistant for stomach acids and colonize of human large intestine cause gastroenteritis, enterocolitis, and bloody diarrhea, in some cases a severe complication called hemolytic-uremic syndrome (HUS). The general symptoms include bloody diarrhea, nausea, vomiting and cramping stomach pain. The natural reservoirs of EHEC are cattle and other livestock animals, as well as pets (cats, dogs) and wild animals. EHEC is also found in environment contaminated by faeces of infected animals (soil, water, plants). People get infected by eating raw or undercooked beef meat, raw milk or dairy products, unwashed fresh fruits and vegetables, contaminated ready-to-eat food with fresh fruits or vegetables. *E. coli* 0157:H7 is one of the strains of the bacteria *E. coli* that cause illness in humans. It causes an estimated 60 deaths and 73,000 illnesses annually. Most reported outbreaks are due to contaminated food or water, however, direct transmission of *E. coli* 0157 H7 from animals and their environment to humans is a growing concern. *E. coli* 0157:H7 can be found on most dairies, in water troughs, wet feeds, and flush alleys especially during warmer months, however, the bacteria presents an insignificant disease problem of cattle and only a few animals shed the bacteria in their manure at any one time. Healthy cattle are the main recognized animal reservoir and may harbor the organism as part of the bowel flora. It is most easily found in weaned calves, but market cattle can shed significant amounts in their feces which can lead to the contamination of beef during slaughter. Most infections of *E. coli* 0157:H7 come from eating undercooked, contaminated ground beef often from spent dairy cows, or those animals that have surpassed their prime producing years and sent to slaughter. Meat becomes contaminated in the slaughterhouse, and the bacteria are easily spread when meat are ground in the processing plant. The bacteria cause human disease by producing toxins and some of the clinical signs include diarrhea, cramping, vomiting, urinary problems, and is currently the most significant cause of kidney disease in children (Hemolytic Uremic Syndrome). Can begin 2 to 5 days after food is eaten, lasting about 8 days. *E. coli* 0157:H7 can survive in the environment for months and thus pose an ongoing source of infection in humans. It is estimated 10,000 to 20,000 cases

of infection occur each year. First recognized as a cause of illness in 1982 during an outbreak of severe bloody diarrhea. The outbreak was traced to contaminated hamburgers[15].

3.6.2 Enterotoxigenic *E. coli* (ETEC)

ETEC strains are able to produce two toxins: heat-stable (ST toxin) and heat-labile (LT toxin). Different strains can produce one or both of these toxins, but the illness is similar. The symptoms of infection begin in 12-72 hours after eating or drinking contaminated food products and include profuse, watery diarrhea with no blood and cramping abdominal pain. Other symptoms, like fever, nausea, vomiting, headache and muscles pain can also occur. The disease is usually self-limiting and diarrhea lasts in 3 days[16].

3.6.3 Enteropathogenic *E. coli* (EPEC)

EPEC strains are not able to produce toxins, but possess a many other virulence factors which are similar to Shigella. EPEC colonize the small intestine and change a cell structure due to "attachment and effacement". Natural reservoirs are humans and wild, livestock and pets (rabbits, dogs, cats and horses). People get sick after eating food products or drinking water contaminated by faeces of infected humans or animals. Symptoms usually begins in 1-2 days and include watery diarrhea with mucus (without blood), fever, vomiting and dehydration. The disease is usually self-limiting and diarrhea lasts in 5 to 15 days[17].

3.6.4 Enteroinvasive *E. coli* (EIEC)

EIEC strains producing no toxins. To colonize small intestine bacteria are using the adhesion proteins, like an EPEC strains. The infection syndrome are very similar to shigellosis. The natural host are only human intestine, and people get sick within 12-72 hours after ingestion food or water contaminated by faeces of infected humans. The initial symptoms include watery secretory diarrhea from the small intestine, then severe colitis develops. Symptoms of colitis include fever, abdominal pain, painful tenesmus and frequent passing of scanty stools with mucus, blood and pus[18].

Prevention steps in Escherichia coli infections: cook thoroughly raw minced meat (burgers, sausages etc.), wash thoroughly raw fruit and vegetables under running water, wash your hands with soap and running water before preparing or eating food and after using bathroom,

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[15] Kashima, K., Sato, M., Osaka, Y., Sakakida, N., Kando, S., Ohtsuka, K., . . . Honda, A. (2021). An outbreak of food poisoning due to Escherichia coli serotype O7:H4 carrying astA for enteroaggregative E. coli heat-stable enterotoxin1 (EAST1). Epidemiology & Infection, 149, E244. doi:10.1017/S0950268821002338.

[16] James M. Fleckenstein and F. Matthew Kuhlmann. Enterotoxigenic Escherichia coli Infections. Curr Infect Dis Rep. 2019 Mar 4; 21(3): 9. doi: 10.1007/s11908-019-0665.

[17] Min-A Lim, Ji-Yeong Kim, Dilaram Acharya, Bishnu Bahadur Bajgain, Ji-Hyuk Park, Seok-Ju Yoo, and Kwan Lee3. A Diarrhoeagenic Enteropathogenic Escherichia coli (EPEC) Infection Outbreak That Occurred among Elementary School Children in Gyeongsangbuk-Do Province of South Korea Was Associated with Consumption of Water-Contaminated Food Items. Int J Environ Res Public Health. 2020 May; 17(9): 3149. doi: 10.3390/ijerph17093149

[18] Sophie Newitt, Vanessa MacGregor, Vivienne Robbins, Laura Bayliss, Marie Anne Chattaway, Tim Dallman, Derren Ready, Heather Aird, Richard Puleston, and Jeremy Hawker. Two Linked Enteroinvasive Escherichia coli Outbreaks, Nottingham, UK, June 2014. Emerg Infect Dis. 2016 Jul; 22(7): 1178–1184. doi: 10.3201/eid2207.152080.

use separate knives and cutting boards for raw meat and ready-to-eat food, store raw meats and ready-to-eat food separately in the fridge, avoid unpasteurized milk and dairy products.

3.7 Listeria monocytogenes

Listeria is found throughout nature – animals and water are just a few sources of the bacterium. Infected soil from cattle manure used as fertilizer can contaminate crops with the bacteria. Dairy cattle may become infected with *Listeria* from sources in their environment. The literature suggests *Listeria monocytogenes* in dairy cattle may originate from consumption of poorly fermented silages and/or by inadequate cleaning of animal areas and milking equipment. *Listeria monocytogenes* is one of the causes of circling disease in cattle. Infected cattle often display generalized illness with abnormal behavior and posture. A common sources of human infections are raw milk, soft cheeses or meats as well as foods contaminated during processing or food preparation. In humans, this bacteria causes flu-like illness including nausea, vomiting, and diarrhea and in severe cases, neurological signs and abortions. While less widely known than other human food borne pathogens like *Salmonella* or *E. coli,* it is far deadlier. Listeria is fatal in nearly 20 percent of all cases. It is estimated, 2,500 people become seriously ill from Listeria each year with infections often leading to blood poisoning or meningitis. Most at risk from this pathogen are pregnant women, new-born children, and people with weakened immune systems. In the past, Listeriosis in cheese has caused dozens of deaths. As a precaution, pregnant women are warned not to consume unpasteurized soft cheeses, particularly from Latin America. A major public health concern for the pathogen Listeria monocytogenes is that it can survive and continue to multiply in post pasteurizing processing environments and may lead to the recontamination of dairy products such as milk and cheese. The bacteria readily grow at refrigerator temperatures therefore a small amount of contamination may become an infective dose as the food is stored in the refrigerator. Literature suggests the development of drug resistance in *Listeria* from antibiotic use in farm animals is less of concern that in other food and water borne pathogens. It is believed that the population of Listeria found in the intestines of food animals are often not the same that ultimately contaminates ready to eat foods. In addition, Listeria is a poor competitor against other human pathogens such as *E. coli* or *Campylobacter*.

The symptoms can start as early as 3 days, but in severe cases may appear up to 70 days after exposure. Early symptoms include fever, head and muscle aches, constipation, cramps, nausea, vomiting, diarrhea. Severe listeriosis symptoms include confusion, loss of balance, stiff neck, sepsis, meningitis, encephalitis, corneal ulcer, pneumonia, myocarditis, and in pregnant women intrauterine or cervical infections, which may cause spontaneous abortion (second to third trimester), prematurely or stillbirth. Mortality ranges may reach over 70%, from sepsis 50%, and from perinatal/neonatal infections greater than 80%[19].

Good practices to prevent infection: avoid pre-prepared ready-to-eat foods, don't eat foods over their date to use, cook and/or reheat food thoroughly and eat it immediately (*Listeria* died in high temperature), refrigerated food should be eaten within 3-4 days, cooked food

[19] J M Farber and P I Peterkin. Listeria monocytogenes, a food-borne pathogen. Microbiol Rev. 1991 Sep; 55(3): 476–511. doi: 10.1128/mr.55.3.476-511.1991.

should be stored at 5°C or lower, separately from raw foods, wash raw fruit and vegetables thoroughly under clean running water, use separate cutting boards and knives for raw and ready-to-eat food, wash your hands and kitchen equipment before preparing food and eating.

3.8 Salmonella spp.

Salmonella bacteria are ubiquitous in nature and are found in the gastrointestinal tracts of animals and humans. There are over 2000 serotypes of *Salmonella*, most of which do not cause illness in humans. There are three types of Salmonellosis: gastroenteritis, typhoid fever, and bacteremia (bacteria in the blood), which are most commonly caused by consumption of contaminated food and water tainted with animal faeces. Studies show that there is an estimated 1,412,498 human illnesses, 16,430 hospitalizations, and 582 deaths annually caused by food producing animals such as cattle who are the main reservoir of non-typhi serotypes of *Salmonella enterica*. Salmonella can be found on dairy farms especially in flush alleys and on milking equipment. The bacteria presents significant disease of cattle with symptoms of diarrhea, decreased milk production, abortion and sometimes death. Cows infected with *Salmonella* can spread the bacteria in their manure wherever they go on the dairy farm, especially during time of stress, like calving. As a result, dairy cattle destined for culling may readily bring it into the slaughter house. The literature suggests animal feed may serve as a vehicle to infect cattle with *Salmonella*. The conducted surveys of food ingredients and animal feed were executed. In a particular survey where 101 animal protein based samples were taken, contamination with *S. enterica* was detected in over 50 percent of the samples. Although this was only one study, it supported that animal protein-based animal feed could be contaminated with the pathogen. As a result; the contaminated animal feed can cause infection or colonization of food animals which may lead to human food-borne illness. In humans, *Salmonellae* can cause a broad range of infections, including gastroenteritis, enteric fever, bacteremia, endovascular infections, and focal infections such as osteomyelitis and abscesses. An infective dose can vary, with as few as 1 to 15 cells causing illness, depending on the age and health status of the recipient. The health care community is concerned about the emergence of drug – resistant strains of *Salmonella*. There have been high rates of drug-resistance including multi resistant bacteria documented in meat destined for human consumption. It has the transmission potential of drug resistant pathogens from animals to people. A particular strain of *Salmonella*, is now resistant to five important antibiotics used in human medicine. In recent years *Salmonella* contamination in the food supply has dropped but the prevalence of multidrug-resistant isolates has increased from less than 1 percent in 1980 to 34 percent in 1996[20].

3.8.1 Salmonella enteritidis

Salmonella enteritidis can be found in intestinal tract and faeces of animals. *Salmonella enteritidis* is mostly presence in raw eggs. Is transmitted by consumption of raw or undercooked eggs, poultry, and meat; raw milk and dairy products; seafood and by food handlers. The symptoms: stomach pain, diarrhea, nausea, chills, fever, and headache usually

[20] Olugbenga Ehuwa, Amit K. Jaiswal and Swarna Jaiswal. Salmonella, Food Safety and Food Handling Practices. Foods 2021, 10(5), 907; https://doi.org/10.3390/foods10050907.

appear 8 to 72 hours after eating; may last 1 to 2 days; may produce arthritic conditions 3-4 weeks after acute symptoms appeared[21].

Reduce risk infection and contamination of food: cook thoroughly poultry meat and eggs, don't eat dirty or cracked eggs, wash your hands and kitchen equipment before preparing and eating food, especially after handling raw poultry meat and eggs, never wash raw chicken, wash thoroughly raw vegetables and fruits in clean running water, use separate cutting boards and knives for raw chicken and other food products, store separately cooked food from raw foods, keep raw or cooked food in fridge (temperature 5°C or lower), before serving keep cooked food hot (60°C or hotter), store food follow storage instructions.

3.9 Shigella spp.

Shigella is another bacterium that may cause food-borne disease. *Shigella* is usually found in the human intestinal tract. It is the cause of bacillary dysentery. Poor personal hygiene of people handling food is a major reason for contaminations. *Shigella*-induced diarrhea typically contains blood. *Shigella* can also produce a toxin (an *E. coli* type of toxin).

Shigella is a pathogenic bacteria which can be found in the intestines of humans and animals. The four pathogenic species of *Shigella* are known - *Shigella sonnei, Shigella flexneri, Shigella boydii, and Shigella dysenteriae.* Infection by *Shigella dysenteriae* type 1 can be deadly. Food can become contaminated by: infected people, contact with contaminated surfaces or water, vectors (e.g. flies) which can spread *Shigella* germs from faeces to uncovered food. Food products at higher risk include unpasteurized milk, raw oysters and shellfish, raw unwashed fruits and vegetables, ready-to-eat sandwiches and salads with raw vegetables or fruits. *Shigella* infection is called shigellosis, which symptoms start usually 1-2 days after exposure and last approx. 7 days. Symptoms of shigellosis include diarrhoea (sometimes bloody and prolonged), fever, nausea, vomiting, stomach pain and abdominal cramping. Group of people at higher risk of severe infection are young children (under 5 years old), elder (over 60 years old) and people with weakness immune systems. Shigella spread very easily, disease can be cause by small number of bacteria. People infected by Shigella can shed the bacteria germs for up 2 weeks after the symptoms finished[22].

Steps to avoid contamination food and infection: carefully wash hands with soap and clean running water, especially before preparing and eating food, or after going to the bathroom, drink only bottled water, avoid preparing food with using untreated water.

[21] Surendran Deepanjali, Mandal Jharna, Bammigatti Chanaveerappa, Dhandapani Sarumathi, Pallam Gopichand, and Kaliyappan Anupriya. An outbreak of Salmonella Enteritidis food poisoning following consumption of chicken shawarma: A brief epidemiological investigation. F1000Res. 2021; 10: 851. doi: 10.12688/f1000research.54410.4

[22] Shuai Zhi, Brendon D. Parsons, Jonas Szelewicki, Yue T. K. Yuen, Patrick Fach, Sabine Delannoy, Vincent Li, Christina Ferrato, Stephen B. Freedman, Bonita E. Lee, Xiao-Li Pang and Linda Chui. Identification of Shiga-Toxin-Producing Shigella Infections in Travel and Non-Travel Related Cases in Alberta, Canada. Toxins 2021, 13(11), 755; https://doi.org/10.3390/toxins13110755.

3.10 Staphylococcus aureus

Staphylococcus food poisoning. *Staphylococcus aureus* (micrococcus) found on humans: skin, infected cuts, noses, and throats. Transmitted by people to food through improper food handling. Multiply rapidly at room temperature to produce a toxin that causes illness (>1 µg endotoxin in food sufficient!). *Staphylococcus* can be found on the skin of humans. When it infects a cut, it causes a skin sore. When it is ingested, it causes food-related symptoms that start very rapidly and are due to staphylococcal enterotoxin, not due to the bacterium itself, i.e. it's a food poisoning, not foodborne infection. *Staphylococcus aureus* is a bacteria commonly occurring on skin and in the upper respiratory tract of people and animals. In healthy people it does not cause any illness. Bacteria produce a toxin (staphylococcal enterotoxin B, SEB) which is heat resistant and can cause the food poisoning. The gastrointestinal illness, called as Staph food poisoning, is caused by eating foods or drinking water contaminated with SEB. The severe illness is very rare, usually symptoms like vomiting, nausea, stomach cramps and diarrhea starts after 30 minutes to 8 hours after eating or drinking contaminated food products. The symptoms last no longer than 1-2 days. Foods products at higher risk of contamination with toxins include sliced meats, meat dishes, milk and milk products, creams, puddings, halves, ice creams, pastries and ready-to-eat salads and sandwiches, especially foods which are not cooked after handling. Enterotoxin present in the food products usually does not change their taste or smell and foods not look spoiled[23].

The best way to avoid food poisoning caused by *Staphylococcus*: prevent ready-to-eat food from storing in unsafe temperature (between 5°C and 60°C) for more than 2 hours, thoroughly cooking foods, keep hot foods hot (60°C or hotter) and cold foods cold (5°C or colder) before serving, put cooked food in fridge within 2 hours (or 1 hour if it's hotter than 30°C outside), wash your hands carefully with soap and clean running water before preparing and eating food, keep your kitchen and equipment clean (counters, cutting boards, knives and other utensils), avoid preparing food if you are ill with diarrhea or vomiting, wear gloves if you have skin wounds or infections on your hands.

3.11 Vibrio spp.

Vibrio cholerae is a bacteria naturally occurring in brackish and marine water, on the surfaces of chitin shells of crabs, shrimps and other shellfish. Diarrhoeal illness is called cholera, and cause by toxigenic strains of *V. cholerae* serogroups O1 or O139. Non-toxigenic strains (non-O1 and non-O139) may cause the illness named "cholera-like illness". People get the *V. cholerae* by drinking contaminated water or eating undercooked or raw shellfish. In epidemic areas the source of infection is water contaminated by faeces of sick people. Symptoms of infection appear in few hours to 5 days after ingestions (usually 2-3 days) and in many cases are mild or not occur at all. In rare cases (approx. 1 in 10 people) severe symptoms will develop and include watery diarrhoea, vomiting, and legs cramps. In these people rapid

[23] María Ángeles Argudín, María Carmen Mendoza, and María Rosario Rodicio. Food Poisoning and *Staphylococcus aureus* Enterotoxins. Toxins (Basel). 2010 Jul; 2(7): 1751–1773. doi: 10.3390/toxins2071751.

loss of body fluids leads to severe dehydration, shock and without treatment to death within hours[24].

Preventive actions: drink only bottled, boiled or treated water and bottled or canned drinks - make sure the seal has not been broken, carbonated drinks are safer than non-carbonated, wash your hands carefully using soap and clean running water (if not available, use minimum 60% alcohol sanitation solution) before preparing and eating food or after using the bathroom, eat packaged ready-to-eat foods or foods freshly cooked and served hot, not eat raw or undercooked fruits, vegetables, meats and seafood, clean kitchen surfaces, equipment and dishes under clean running water and using chemical cleaning supplies.

3.12 Cronobacter sakazakii

Cronobacter sakazakii is a bacteria widely present in the natural environment in water, soil and sewage, it is resistant to dry conditions of live. They also appear in a wide range of food products, which consuming are the general source of infection in people. *Cronobacter* may also produce the heat resistant enterotoxin (stable in 90°C by 30 minutes) and proteolysis enzymes. Groups of people at high risk of severe illness are infants (less than 2 months old and born prematurely), elder people (over 65 years old) and people with weakness of immune systems.

Products at higher risk of contamination include: milk (raw and powdered), powdered infant formula, cheese, vegetables, meat, sausages, fish, rice, tea and various spices. *Cronobacter* illness in healthy people are very rare, but in people from risk group may be severe and deadly. In infants and new born babies it can cause meningitis, sepsis and severe intestinal infection with necrosis of enterocolitis[25].

3.13 Yersinia enterocolitica

Yersinia enterocolitica is a bacteria widespread in nature, it can be found in intestinal of pets (cats, dogs), livestock (mammals and birds) and wild animals (rodents). *Y. enterocolitica* was also isolated from water, soil and food contaminated by faeces of infected animals and people. Strains of *Y. enterocolitica* was classified into 6 biotypes and over than 57 serogroups. However only some of these serogroups are pathogenic for humans and animals, isolates from environment are avirulent. Pathogenic for humans strains was generally isolated from pigs, sheep, dogs, cats and wild rodents. People get sick for yersiniosis usually after eaten raw or undercooked pork, the rare sources of infection are also unpasteurized milk, raw fruits and vegetables and untreated water. Symptoms of yersiniosis depend on the age of infected person and starts typically 4 to 7 days after exposure and last in 1-3 weeks. In young children symptoms include fever, watery or bloody diarrhoea and abdominal pain, in older children

[24] Dipanjan Dutta, Anupam Kaushik, Dhirendra Kumar, and Satyabrata Bag. Foodborne Pathogenic Vibrios: Antimicrobial Resistance. Front Microbiol. 2021; 12: 638331. doi: 10.3389/fmicb.2021.638331.

[25] Wei Yong, Baofu Guo, Xiaochao Shi, Tingting Cheng, Mingming Chen, Xiao Jiang, Yanhua Ye, Junning Wang, Guoxiang Xie, and Jie Ding. An Investigation of an Acute Gastroenteritis Outbreak: *Cronobacter sakazakii*, a Potential Cause of Food-Borne Illness. Front Microbiol. 2018; 9: 2549. doi: 10.3389/fmicb.2018.02549.

and adults the predominant symptoms are fever and right-side abdominal pain which can be confused with appendicitis. In some cases the joint pain and rashes occur[26].

Prevention of yersiniosis: carefully hand washing with soap and clean running water before preparing an eating foods or after using bathroom, thoroughly cooking or baking pork before eating, washing fruits and vegetables under running water, storing meat in fridge in temperature 5°C or lower, separately from ready-to-eat food, using separate knives and cutting boards for raw pork and other food products and keeping kitchen clean.

[26] Md. Latiful Bari, M. Anwar Hossain, Kenji Isshiki, and Dike Ukuku. Behavior of *Yersinia enterocolitica* in Foods. J Pathog. 2011; 2011: 420732. doi: 10.4061/2011/420732.

4.The most common food borne parasites

4.1 Toxoplasmosis (Toxoplasma gondii)

Toxoplasma gondii is a species of pathogenic protozoan which can cause an illness named toxoplasmosis in warm-blooded animals, especially cats but also pigs, sheep, boars and rodents. People get infected toxoplasmosis by eating raw or undercooked meat (pork, lamb, venison) or shellfish (oysters, mussels, etc.), accidentally by eating fruits and vegetables or drinking water contaminated by faeces of infected animals. In many cases people infected *Toxoplasma gondii* have no symptoms, very rare symptoms include swollen lymph glands or muscle pains which last for weeks to month. Severe toxoplasmosis can develop from acute infection or reactivation of earlier no-symptoms infection, and cause damage of brain, eyes or other organs. Ocular toxoplasmosis symptoms include reduced and blurred vision, redness of the eye, pain with bright light, and sometimes tearing[27].

Prevention steps: cook or bake meat thoroughly, do not eat raw or undercooked meat or shellfish, rinse fruits and vegetables under running water before eating, keep kitchen surfaces and equipment clean, and wash it in hot water with cleaning products before and after using, if you have cat, clean the litter box daily

4.2 Cryptosporidium

Cryptosporidium is a genus of microscopic protozoan which can cause humans and animals gastrointestinal illness named cryptosporidiosis. A number of *Cryptosporidium* species are pathogenic for mammals, in humans cryptosporidiosis is cause by *C. parvum* and *C. hominis*, but also *C. canis, C. felis, C. meleagridis,* and *C. muris* can cause disease. *Cryptosporidium* can be found in soil, food, water, or other surfaces contaminated by faeces of infected humans or animals. Crypto is high tolerance to chlorine, from this reason it can survive for long time in chlorinated drinking and swimming pool water. Infection dose is very low and swallowing approx. Ten *Cryptosporidium* germs (oocysts) can cause illness. People get infected by swallowing contaminated recreational water (swimming pool, fountain, lake, river), drinking untreated water, eating uncooked food or drinking unpasteurized milk or raw juice. Symptoms of infections start general 2 to 10 days after eaten germs and last about 1-2 weeks. They include watery diarrhea, cramping stomach pain, nausea, vomiting, dehydration, weight loss, fatigue and in some cases low-grade fever[28].

Spread and infection prevention: good hygiene practices, washing thoroughly hands with soap and running water before preparing and eating food or after using bathroom, hand sanitizers based on alcohol solution are not enough effective for *Cryptosporidium*, rinse fruits

[27] Malik A. Hussain, Victoria Stitt, Elizabeth A. Szabo, and Bruce Nelan. Toxoplasma gondii in the Food Supply. Pathogens. 2017 Jun; 6(2): 21. doi: 10.3390/pathogens6020021.

[28] Damien Costa, Romy Razakandrainibe, Stéphane Valot, Margot Vannier, Marc Sautour, Louise Basmaciyan, Gilles Gargala, Venceslas Viller, Denis Lemeteil, Jean-Jacques Ballet, French National Network on Surveillance of Human Cryptosporidiosis,Frédéric Dalle and Loïc Favennec. Epidemiology of Cryptosporidiosis in France from 2017 to 2019. Microorganisms 2020, 8(9), 1358; https://doi.org/10.3390/microorganisms8091358.

and vegetables under running water before eating, pasteurizing raw milk and juice, not drink untreated water or use untreated ice.

4.3 Giardia

Giardia duodenalis is a microscopic parasite causing one of the most common parasitic diarrheal diseases in humans, dogs and cats named giardiasis. It can also infecting other mammals species include sheep, cattle and goats. *Giardia* cysts can survive outside the body for weeks or even month and over one hour in chlorinated water. Giardiasis can be spread by drinking untreated water or eating undercooked food products contaminated by faeces infected people or animals. Symptoms begin 1 to 2 weeks after exposure and last in healthy people to 2-6 weeks. Symptoms generally start by having 2 to 5 loose stools per day and include diarrhea, cramping stomach pain, nausea, vomiting, progressively increasing fatigue, dehydration, weight loss, avitaminosis (vit A and B12)[29].

Spread and infection prevention: washing thoroughly hands with soap and running water before preparing and eating food or after using bathroom, avoid eating undercooked food or drinking untreated water, rinse properly raw fruits and vegetables before eating.

4.4 Entamoeba histolytica

Entamoeba histolytica is an anaerobic parasite, causing disease in human and other primates called amoebiasis. The infection can occur after ingestion food or water contaminated by faeces of infected people. The cysts (eggs) of *Entamoeba* are readily killed high (cooked, boiled) and low (freezing) temperatures, under moist conditions cysts can survive outside of the hosts for a few months. The trophozoite (active stage) of Entamoeba can exists only in the host or in fresh loose faeces. The amoeba can get into the intestinal wall and reach to the blood stream. From there, it can reach to the other vital organs of the human body (liver, lungs, brain or spleen). Infection can be asymptomatic or mild (e.g. occasional loose stools, abdominal cramps, abdominal distension, loss of appetite and weight loss). In some cases it can lead to severe amoebic dysentery or amoebic liver abscess. Then symptoms can include bloody diarrhea, weight loss, fatigue, abdominal pain, amoebic abscesses on liver (single or multiple), and ameboma (colon carcinoma-like lesion)[30].

Safety rules: drinking only bottled, filtrated, boiled or after chemical treated water, eating only cooked food, rinse carefully fresh fruits or vegetables under clean running water, avoid unpasteurized milk and dairy products.

[29] Özlem Orunç Kılınç, Adnan Ayan, Burçak Aslan Çelik, Özgür Yaşar Çelik, Nazmi Yüksek, Gürkan Akyıldız and Fatma Ertaş Oğuz. The Investigation of Giardiasis (Foodborne and Waterborne Diseases) in Buffaloes in Van Region, Türkiye: First Molecular Report of *Giardia duodenalis* Assemblage B from Buffaloes. Pathogens 2023, 12(1), 106; https://doi.org/10.3390/pathogens12010106.

[30] Andrea Servián, Elisa Helman, María del Rosario Iglesias, Jesús Alonso Panti-May, María Lorena Zonta and Graciela Teresa Navone. Prevalence of Human Intestinal *Entamoeba spp*. in the Americas: A Systematic Review and Meta-Analysis, 1990–2022. Pathogens 2022, 11(11), 1365; https://doi.org/10.3390/pathogens11111365.

4.5 Cyclospora cayetanensis

Cyclospora cayetanensis is a microscopic parasite, that cause an acute or chronic diarrheal disease in humans and other primates called cyclosporiasis. People get sick after consuming food or water contaminated by faeces of infected humans. Direct transmission from human to human is unlikely due to the fact that oocysts excreted in the faeces need time for sporulation in the external environment, outside the host (one to several weeks). The incubation period is typically around a 7 days after ingestion mature oocysts and illness can self-limiting in 6 weeks. Infection can be asymptomatic, or mild symptoms can include chronic watery diarrhea without blood and mucus, loss of appetite, weight loss, fatigue, cramping abdominal pain, increased flatulence, nausea, and low-grade fever[31].

Safe recommendations: washing hands with soap and warm, clean, running water before preparing and eating food, washing fresh fruits and vegetables that will not be cooked before eating under warm water, using separate knives, cutting boards and dishes for meat and fruits and vegetables, storing fruits and vegetables separately than raw meat, poultry or seafood.

4.6 Sarcocystis

Sarcocystis is a genus of protozoan parasites including over 130 species infecting mammals, reptiles and birds. Only *S. hominis* and *S. suihominis* use humans as definitive hosts and cause intestinal sarcocystosis in human. After the accidental swallowing oocysts of non-human *Sarcocystis spp.,* people may also become end hosts. In cases of intestinal sarcocystosis, infections are often asymptomatic and clear spontaneously. Sometimes, low to mild fever, chills, diarrhea, nausea, vomiting and respiratory problems may occur. When humans are the dead-end host, the infection take muscular form. In these cases symptoms may occur myalgia, muscle weakness and transitory edema. Symptoms begins in 3-6 hours (intestinal form) or weeks to month (muscular form) and lasting in 36 hours (intestinal) or months to years in muscular[32].

Prevention: cooking thoroughly cattle or pork meat before eating, freezing the cattle or pork meat at −5°C for several days.

4.7 Trichinella spiralis

Trichinella spiralis is a species of parasitic nematode. It is one of the most dangerous human parasites - it causes the disease called trichinosis. Trichinosis is cause by eating raw or undercooked meat of pigs, horses or wild boars. Intestinal, initial symptoms can begin in 1–2 days after infection and include abdominal discomfort, diarrhea, nausea, vomiting, fatigue and fever. Further symptoms, like headache, high fever, cough, chills, swelling of the face and eyes, muscles and joints pains, itchy skin, diarrhea, or constipation, occur in 2-8 weeks. Intensity of

[31] Agni Hadjilouka and Dimitris Tsaltas. *Cyclospora Cayetanensis*—Major Outbreaks from Ready to Eat Fresh Fruits and Vegetables. Foods 2020, 9(11), 1703; https://doi.org/10.3390/foods9111703.

[32] Lisa Guardone, Andrea Armani, Francesca Mancianti and Ezio Ferroglio. A Review on Alaria alata, *Toxoplasma gondii* and *Sarcocystis spp*. in Mammalian Game Meat Consumed in Europe: Epidemiology, Risk Management and Future Directions. Animals 2022, 12(3), 263; https://doi.org/10.3390/ani12030263.

symptoms (from very mild to severe) are relate to the number ingested parasites. In mild to moderate cases most symptoms last few months, muscles and joints pain, weakness and fatigue may last for many months. In severe infection, patients may have hearth and breathing problems and difficulty with movements coordination. In very severe cases infection can be fatal[33].

Prevention: cooking pork and venison thoroughly, salting, drying or smoking not kill parasites, for preparing meat dishes use only examined meat from trusted sources, cleaning carefully all kitchen equipment (knives, cutting boards and especially meat grinders) after using.

[33] Olimpia Iacob, Ciprian Chiruță and Mihai Mareș. *Trichinella spiralis* and *T. britovi* in North-Eastern Romania: A Six-Year Retrospective Multicentric Survey. Vet. Sci. 2022, 9(9), 509; https://doi.org/10.3390/vetsci9090509.

5.The most common food borne viruses

Virus Facts:

- Their ability to withstand heat and cold
- Do not increase in number while they are in food
- Do not require potentially hazardous foods to survive
- Food and food-contact surfaces serve only to transport viruses, which reproduce once in a human host
- Outbreaks are almost always due to poor personal hygiene or a contaminated water supply
- Viruses cannot grow on their own, so they cannot begin to colonize in food
- They require being inside a “host” (such as us) to multiply
- Other characteristics include their ability to withstand heat or cold, and they do not require potentially hazardous foods to survive
- They are much more difficult to control, so the prevention focuses more on hygiene and surface decontamination versus time or temperature, as with bacteria

5.1 Hepatitis A

Hepatitis A virus (HAV) is pathogenic virus, which can be found in intestines and blood of people and environment (soil, water) contaminated by faeces of infected humans. After ingestion even very small amount of viruses, HAV cause an infection of intestines and liver called hepatitis A or food jaundice. The infection is always contagious and can transmitted from person to person thought direct contact ("dirty hands" disease). Hepatitis A is usually a short-term infection and does not cause chronic liver disease. In most cases symptoms are mild and include fever, nausea, diarrhoea, loss of appetite and weight, weakness, joint and muscles pain, stomach pain, dark colour of urine and yellowing skin or whites of eyes. Symptoms usually become in 2-4 weeks after exposure and generally last for 1-2 weeks (sometimes can continue for few months). In cases of elder people or patients with weakened immune systems, hepatitis may have severe symptoms and cause acute liver failure, which is often fatal. Children under 6 years can have no noticeable symptoms of infection. People get infected by eating contaminated food (raw shellfish and oysters, fresh salads, fruits, vegetables, or any others foods prepared by infected people) or drinking untreated water[34].

Prevention steps: vaccination, thoroughly washing hands with soap and clean water before preparing and eating food, or after using the bathroom, avoid eating raw or undercooked seafood, rinse carefully fresh fruits and vegetables before eating, drinking only bottled or chemically treated water.

[34] Yoonjeong Yoo, Miseon Sung, Jeongeun Hwang, Daseul Yeo, Ziwei Zhao, Changsun Choi, and Yohan Yoon. Quantitative Risk Assessment of Hepatitis a Virus Infection Arising from the Consumption of Fermented Clams in South Korea. Foods 2023, 12(4), 796; https://doi.org/10.3390/foods12040796.

5.2 Hepatitis E

Hepatitis E virus (HEV) can be found in intestines of people. HEV cause the hepatitis type E, the infection of intestines and liver. In many cases infection HEV is mild and self-limited, not cause long-term liver complications, young children may have no noticeable symptoms. Severe illness is possible in vulnerable people like pregnant women, elder people and people with other liver diseases or weakness immune systems. First symptoms of infection become in 5 to 6 weeks after exposure and include mild fever, nausea, vomiting, reduced appetite, stomach pain, joint pain, jaundice, rash, dark coloured urine and pale stools, in some cases hepatomegaly (enlarged and tender liver). Symptoms usually go away in 1 to 6 weeks without liver damage. Pregnant women shows a more severe infection than other patients, liver failure can be fatal in 20% to 25%. HEV can also break the placenta barrier and infect fetus, in effect may cause preterm delivery, stillbirth or neonatal death. People get infection generally through drinking contaminated, untreated water and poor hygiene standards ("dirty hands" disease), as well as eating raw or undercooked pork, venison or seafood[35].

Preventing steps: thoroughly washing hands with soap and clean water before preparing and eating food, or after using the bathroom, thoroughly cooking meat, especially pork and venison products, avoid eating raw or undercooked seafood, drinking only bottled or chemically treated water.

5.3 Rotaviruses

Rotaviruses are the genus of viruses causes severe diarrhoeal intestines infections. Genus include 9 species named from "A" to "J", but only "A", "B" and "C" species can cause human diseases. Infection of Rotaviruses are highly contagious (infection dose less than 100 virus particles) and can be transmitted through faecal-oral or respiratory route and direct or indirect contact with infected people (hands, surfaces or objects). Viruses are stable in external environment and can survive 9 to 19 days outside the host. Rotaviral intestines infection is a mild to severe disease. Symptoms often start in 2 days after exposure and include nausea, vomiting, watery diarrhoea and mild-range fever. In some cases it can provide to severe dehydration.

Rotavirus A infections can occur throughout life, because vaccine or natural infection not provide full immunity. The first infection usually produces symptoms and may be severe, but next are typically mild or asymptomatic. The most severe symptoms may occur in young children (from 6 months to 2 years of age), the elderly, and patients with immunodeficiency. Most healthy adults are not susceptible to rotavirus[36].

[35] Owada, K.; Sarkar, J.; Rahman, M.K.; Khan, S.A.; Islam, A.; Hassan, M.M.; Soares Magalhães, R.J. Epidemiological Profile of a Human Hepatitis E Virus Outbreak in 2018, Chattogram, Bangladesh. Trop. Med. Infect. Dis. 2022, 7, 170. https:// doi.org/10.3390/tropicalmed7080170.

[36] Serhii O. Soloviov, Tetiana S. Todosiichuk, Olena V. Kovaliuk, Gabriel M. Filippelli, Olena P. Trokhymenko, Iryna V. Dziublyk and Zachary A. Rodd. Rotaviruses and Noroviruses as Etiological Agents of Acute Intestinal Diseases of Ukrainian Children. Int. J. Environ. Res. Public Health 2022, 19(8), 4660; https://doi.org/10.3390/ijerph19084660.

Preventing steps: vaccination, thoroughly washing hands with soap and clean water before preparing and eating food, or after using the bathroom, thoroughly cleaning the surfaces and objects (especially toilets) with disinfectants contains sodium hypochlorite.

5.4 Astroviruses

Astroviruses are the type of pathogenic for human and animals viruses. It include over 8 identified serotypes cause gastroenteritis diseases in human. Astroviruses are associated with approx. 10% of the gastroenteritis diseases in young children, but humans of all ages are susceptible. The incubation period is approx. 3 to 4 days. The main symptoms of infection are diarrhoea, followed by nausea, vomiting, mild fever, weakness and stomach pain. Dehydration is very rare, and in most cases the symptoms will reduce by themselves after 2 to 4 days. In group of high risk patients (very young children, elder and people with immunodeficiency or malnutrition) Astroviruses can cause severe dehydration which could require hospital care. The Astroviruses are transmitted via oral-faecal route, the main mode of transmission is eating or drinking contaminated food products[37].

Prevention: compliance of good food handling practices, compliance of good hygiene practices, disinfection of surfaces and objects.

5.5 Noroviruses – formerly Norwalk virus

It was named after Norwalk, Ohio where it was first isolated in 1968. It often contaminates ice, a common event in the Philippines and in other places. It can be a significant problem in developing countries without proper water treatment. This is also the virus that commonly affects cruise ships. Noroviruses are a group of pathogenic viruses that cause acute stomach and/ or intestines inflammation. Noroviruses group include 10 genogroups and 48 genotypes. Infection of Rotaviruses are highly contagious (infection dose is 10-100 virus particles) and can be transmitted through faecal-oral or respiratory route and direct or indirect contact with infected people (hands, surfaces or objects). Symptoms become usually in 1-2 days after exposure (eating contaminated food, touching contaminated surfaces or objects), and include frequent vomiting, nausea, muscles and head pain, moderate watery diarrhoea, low-range fever. In case of very young children, elder and immunodeficiency people vomiting and diarrhoea can cause severe dehydration. In healthy people the main symptoms reduce by themselves in 1 to 3 days. Noroviruses are stable outside the host, heat resistant (inactivation in 30 minutes in 60°C), and for alcohol based disinfectant[38].

Prevention steps: thoroughly washing hands with soap and clean water before preparing and eating food, or after using the bathroom, thoroughly cleaning the surfaces and objects (especially toilets) with disinfectants contains sodium hypochlorite, rinse carefully fresh fruits and vegetables before eating, avoid eating raw or undercooked seafood.

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[37] Diem-Lan Vu, Albert Bosch, Rosa M. Pintó and Susana Guix. Epidemiology of Classic and Novel Human Astrovirus: Gastroenteritis and Beyond. Viruses 2017, 9(2), 33; https://doi.org/10.3390/v9020033.

[38] Elias P. Papapanagiotou. Foodborne Norovirus State of Affairs in the EU Rapid Alert System for Food and Feed. Vet. Sci. 2017, 4(4), 61; https://doi.org/10.3390/vetsci4040061.

6.The most common food borne - prions

6.1 Prions

Bovine Spongiform Encephalopathy (BSE). Better known as “Mad Cow Disease”. Also known as wasting disease of cows. Variant Creutzfeldt-Jakob Disease (CJD) a form of CJD in mostly young humans. BSE and CJD are diseases that are associated with the accumulation of abnormal protein in the brain (prions). Mad cow disease is not viral. It is caused by so called “prions”, misfolded proteins found in the brain of infected animals. In humans a disease called Creutzfeldt-Jacob disease produces similar symptoms and brain pathology. During the last decades this typically old-age disease was also observed in young patients, most of them living in Great Britain, and called variant Creutzfeld-Jakob (vCJD). The disease could be traced back to eating cow meat from animals with mad cow disease. Previously populations with strange dietary habits like cannibalism in Papua New Guinea or eating of monkey brains in the far east were also associated with cCJD. Extremely resistant to heat, UV light, ionizing radiation, sterilizing processes, disinfectants -DNAse/ RNAse -Phenols.

Prions are misshaped proteins. Their 3 dimensional conformation is crucial to infectivity. Typically phenols are used to denature proteins, but phenols do not denature prions. Surprisingly, ozone may have some efficacy against prions, but further studies are needed. So far only very high temperatures were shown to effectively destroy prions.

The possible pathways of transmission of prions. It is believed that feed containing carcass material from sheep with scrapie were the original source for the mad cow disease. Once a cow is infected, it may transmit the disease to other cows.

Humans can get infected by eating meat from diseased cows. It cannot be excluded that prions can be transmitted through cosmetics or food additives that contain bovine material. Transmission from human to human through blood and tissue transplants was also proven[39].

[39] Edgar Holznagel, Barbara Yutzy, Carina Kruip, Par Bierke, Walter Schulz-Schaeffer, Johannes Löwer. Foodborne-Transmitted Prions From the Brain of Cows With Bovine Spongiform Encephalopathy Ascend in Afferent Neurons to the Simian Central Nervous System and Spread to Tonsils and Spleen at a Late Stage of the Incubation Period. J Infect Dis 2015 Nov 1;212(9):1459-68. doi: 10.1093/infdis/jiv232. Epub 2015 Apr 20.

7.The most common food borne toxins

7.1 Ricin

Ricin toxin is a natural poison found in castor beans. It can be acquired from whole beans or from the waste material arise in technological processing of castor beans. Toxin can be in different forms - powder, pellet, mist and also it can be dissolved in water or weak acid dilution. Under normal condition ricin toxin is stable, inactivation occurs in temperature 80 °C or higher. After ricin ingestion, initial symptoms occur in less than 6 -12 hours (depend on amount ingested). Initial symptoms affect the gastrointestinal system and include stomach pain, nausea and vomiting, often bloody. In result, after next 12 hours, severe dehydration and problems with kidney, liver and blood pressure become. Late symptoms may include low blood pressure, seizures and blood in urine. After several days the liver, kidneys and spleen might stop working and victim of poisoning can die. For ricin no antidote exists. In treatment, the most important is quickly getting off the toxin from organism, but do not induce vomiting. Supportive medical care in case of ingestion poisoning, include giving intravenous fluids (not to drink), activated charcoal or stomach flushing (only in few hours after ingestion)[40].

Prevention: no antidote, vaccine, or effective treatment is available. Best practices for prevention of ricin are still under the development.

7.2 Botulinum toxin

Botulinum toxin is a neurotoxin produced by Clostridium botulinum bacteria strains. Botulinum toxin is one of the most poisonous biological substances, a lethal dose in humans is 1.3–2.1 ng/kg body weight. It is resistant to gastrointestinal tract enzymes, but will be inactivated after 15-20 minutes at 100°C temperature (pasteurisation, boiling). Foodborne botulism can happen after consuming food contaminated by botulinum toxin. Foods at high risk are improperly homemade canned, pasteurised or fermented foods. Symptoms of foodborne usually starts in 18-36 hours, but can also become in several days after ingestion the toxin (depends on amount of ingested toxin). Typically symptoms include blurred and double vision, nausea, vomiting, muscles weakness, trouble in breathing and swallowing, reduce or absent nerve reaction. In treatment antitoxin is available and reducing the harm and mortality, but not healing done damages[41].

Prevention: Do not try canned food to check if they are still good. Discard any cans, which bulging, leaking, or appear damaged. Make certain, that all foods, which are served are well-cooked. Retain oils infused with e.g. garlic or herbs in refrigerator. Separate raw and cooked food. Store food at safe temperatures. The potatoes that have been baked should be kept in foil hot until eaten. Do not give honey or corn syrup to infants under 1 year old.

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[40] Jennifer Audi, Martin Belson, Manish Patel, MSc; Joshua Schier, John Osterloh. Ricin Poisoning A Comprehensive Review. JAMA. 2005;294(18):2342-2351. doi:10.1001/jama.294.18.2342.

[41] Davide Lonati, Azzurra Schicchi, Marta Crevani, Eleonora Buscaglia, Giulia Scaravaggi, Francesca Maida, Marco Cirronis, Valeria Margherita Petrolini and Carlo Alessandro Locatelli. Foodborne Botulism: Clinical Diagnosis and Medical Treatment. Toxins 2020, 12(8), 509; https://doi.org/10.3390/toxins12080509.

7.3 Staphylococcal Enterotoxin type B (SEB)

Staphylococcal Enterotoxin type B (SEB) is a toxin produced by Staphylococcus aureus bacteria strains. SEB is resistant to proteolysis enzymes in gastrointestinal tract (pepsin, trypsin), and high temperature. The dose that causes symptoms of poisoning in humans is from 20 to 100 ng/kg. The symptoms of poisoning develop quickly, approx. 30 minutes after consuming foods contaminated by toxin and last in 1-2 days. Food products at high risk of contamination are sliced meats, raw milk and dairy products. Staphylococcal Enterotoxin B not change food taste or smell. In treatment the most important is drinking plenty fluids or in severe case giving medicines decreasing vomiting and intravenous fluids. Antibiotics therapy not giving any results in treatment of SEB poisoning[42].

Prevention: Avoid consuming unrefrigerated meats, dairy, and bakery products. SEB can be destroyed by heating food and water to 100°C for couple minutes. For the purpose of decontamination soap and water is recommended. Foods contaminated by SEB should be discarded.

7.4 Algal toxins (seafood toxins)

Algal toxin are produced by diatoms and dinoflagellates in salt water of sea, oceans and bays. Harmful algal bloom toxins include: brevetoxin, saxitoxin, azaspiracid, dinophysistoxin, ciguatoxin, domoic and okadaic acids. Algal toxins are accumulate in many species of shellfish or sea fish during filter-feeding. People get sick after eating seafood containing toxins, or drinking contaminated water, because the toxins are not destroyed by high or low temperatures. Food products at higher risk are clams, crabs, coral fish, oysters, scallops, tuna, marlin, anchovy and sardines. Symptoms occur usually in 30 minutes to 6 hours after ingested toxin. Symptoms depend on the type of consumed toxin, but generally include stomach pain, nausea, vomiting, diarrhoea, shortness of breath, headache and weakness. In healthy person, the symptoms of not severe poisoning disappear within a few days, without any dedicated treatment (only supportive care). In severe cases it can cause coma, paralysis, memory loss, disorientation, irregular heartbeat, respiratory failure and finally can be fatal[43].

Prevention: Shellfish products should be purchased only from reputable and licensed seafood brokers or stores. In any one meal, eat a smaller amount of shellfish. Avoid eating the viscera, gonad and roe. Toxins are heat-stable. They cannot be destroyed through cooking process. However, cooking at 100^0C until their shells open, hence boiling for an additional 5 minutes will reduce the risk caused by contamination.

[42] Irina V. Pinchuk, Ellen J. Beswick, and Victor E. Reyes. Staphylococcal Enterotoxins. Toxins (Basel). 2010 Aug; 2(8): 2177–2197. doi: 10.3390/toxins2082177.

[43] Stephanie L Hinder, Graeme C Hays, Caroline J Brooks, Angharad P Davies, Martin Edwards, Anthony W Walne & Mike B Gravenor. Toxic marine microalgae and shellfish poisoning in the British isles: history, review of epidemiology, and future implications. Environmental Health volume 10, Article number: 54 (2011).

7.5 Mycotoxins

Mycotoxin is a group of toxic metabolites produced by some genus of fungi (*Aspergillus, Penicillium, Rhizoctonia, Fusarium, Claviceps*). It can cause rare diseases in human and animals. Major groups of mycotoxin include aflatoxins (produced by *Aspergillus flavus* and *parasiticus*), ochratoxins (*Penicillium* and *Aspergillus species*), citrinin (*Penicillium citrinum* and other *Penicillium* and *Aspergillus* species), ergot alkaloids (*Claviceps* species), patulin (*Penicillium expansum* and other *Aspergillus, Penicillium,* and *Paecilomyces* species) and fusarium toxins (*Fusarium species*). People can get poisoning after directly eaten contaminated food products. Mycotoxins can contaminated food as a result of fungal infection of crops or livestock feeding products. The food products at high risk of contamination by mycotoxins are dry spices (red chili, ginger, pepper, etc.), beverages (beer, wine, juice), cereals (wheat, rye, barley, oats, rice and corn), food colored with Monascus pigment.

Prevention methods include using chemical and biological fungicide in crops, control of temperature and humidity conditions during storage of cereals grains, irradiation and photodynamic treatment. Mycotoxins can cause acute and chronic poisoning called mycotoxicosis. The symptoms depend on type, amount and time of exposure of mycotoxin, but generally they cause gastrointestinal complaints (nausea, diarrhea, vomiting), and sometimes also severe liver damage, euphoria, hallucinations, skin inflammation, neurological disorders (e.g. convulsions), bleeding and even miscarriages. Severe poisoning can be fatal[44].

Prevention: The grains and nuts should be consumed as fresh as possible. Store food products properly. Food products should be protected from insects and stored in dry not too warm environment. Do not keep food products for extended periods of time before using.

7.5.1 Aflatoxins

Aflatoxins are a one of the type of mycotoxins, produced by *Aspergillus* species (*flavus* and *parasiticus* mainly). Fungal species produced aflatoxins were found in rotting plants, fruits and soil. Fungal spores are dispersed by insects and wind and in results they attack agricultural crops. Infection can occur during the growth of the plant, as well as during processing, storage or transport. Major types of aflatoxins are B1, B2, G1, G2, M1 and M2, the most harmful for humans is aflatoxin B1. Aflatoxins can cause acute and chronic poisoning, allergies, as well as serious diseases of the liver, respiratory, digestive and immune systems. They are also classified as mutagenic and highly carcinogenic substances. They cause primary liver cancer and also stomach, esophageal, soft tissue and leukemia cancers. The symptoms depend on amount of ingested toxins and time of exposure. Initial symptoms include allergic signs (rhinitis, conjunctivitis, laryngitis, headaches and skin changes). Symptoms of acute aflatoxin poisoning include pulmonary edema, cough, shortness of breath, internal bleeding, abdominal pain, nausea, vomiting, fever, jaundice, convulsions, and coma. Chronic poisoning can lead to: cirrhosis of the liver, kidney damage, severe skin and respiratory allergies, growth disorders in children, mental disorders, swelling of the limbs. Aflatoxins can be found in incorrect stored food imported from tropical countries (peanuts, almonds, raisins, dates, figs, cereal grains -

[44] Jagoda Kępińska-Pacelik and Wioletta Biel. Mycotoxins—Prevention, Detection, Impact on Animal Health. Processes 2021, 9(11), 2035; https://doi.org/10.3390/pr9112035.

especially in rice and corn), spices, vegetable oils, and even meat and dairy products from animals feeding contaminated feed[45].

Prevention: The nuts and nut butters should be purchased only from major commercial brands. The nuts, which look moldy, discolored, shrivelled should be discarded. Enforcing strict food safety standards.

[45] Solomon Abrehame, Valsa Remony Manoj, Merry Hailu, Yu-Yi Chen, Yu-Chun Lin and Yen-Po Chen. Aflatoxins: Source, Detection, Clinical Features and Prevention. Processes 2023, 11(1), 204; https://doi.org/10.3390/pr11010204

8.The most common food borne - chemicals

8.1 Lead

Lead has been used by humans since pre-historic times and still is used in industry and crafts. Lead was used in water pipes and can therefore be a problem in older houses and neighborhoods. Lead is still used in lead glazed pottery and lead-soldered cans. If these items come in contact with acidic foods, lead can easily leach out and contaminate the food item. Thanks to increased awareness about the negative health effects of lead, various laws were issues that resulted in a strong reduction of lead in our environment and food. It is estimated that the daily average intake of lead from food is around 20 µg/day, down from 400-500 µg/day in the 1940s. This intake can be considerably higher under certain circumstances, i.e. old lead water-pipes, lead-glazed dishes, and uptake of lead from paint chips and house dust in old houses by babies and little children.

Lead is neurotoxic. Exposure of children to lead causing a blood lead level of 10 µg/dL. Lead lowers the IQ by about 4-7 points. For a population a downshift of the average IQ by only 5 points results in a decrease of highly gifted individuals and an increase of mentally retarded once by about 57%[46]. Such a shift would not easily be recognized, but the consequences for the society and the individual are enormous.

Exposure and uptake. Food decreased dietary intake from 400-500 µg/day (1940s) to < 20 µg/day now. Environment - paint, lead dust in households. Drinking water (about 10 µg/day, seldom 20 µg)[47].

8.2 Mercury

Mercury is a natural component in the earth crust. Mercury use in the chemical industry and metal processing and release during coal burning and waste incineration has increased the atmospheric mercury level considerably. This is a problem, since mercury is highly persistent and biomagnifies in ecosystems. A major source of human mercury exposure, especially of the highly toxic methylmercury, is through fish consumption. Mercury has the potential to cause severe health damage, affecting multiple organs, but especially the CNS (Central Nervous System).

8.2.1 Minamata Disease

In early fifties of twenty century, new mysterious neurological disease in Minamata Bay, Japan was observed. In 1953 many people in a fishing village in Japan started to suffer from a mysterious disease. It took years before the cause of this suffering was discovered: mercury in the fish and shellfish of the bay. Until then thousands of people had been poisoned, many

[46] J Schwartz. Low-level lead exposure and children's IQ: a meta-analysis and search for a threshold. Environ Res . 1994 Apr;65(1):42-55. doi: 10.1006/enrs.1994.1020.

[47] Marcella Malavolti, Susan J Fairweather-Tait, Carlotta Malagoli, Luciano Vescovi, Marco Vinceti, Tommaso Filippini. Lead exposure in an Italian population: Food content, dietary intake and risk assessment. Food Res Int . 2020 Nov;137:109370. doi: 10.1016/j.foodres.2020.109370. Epub 2020 Jun 2.

died, others had their health destroyed forever. In 1959 methylmercury identified as toxin. Mercuric sulphate and chloride from plastic factory discharged with wastewater into bay. Bacteria converted inorganic mercury to organomercury (mostly alkyl-) – Methylmercury accumulated in fish and shellfish – Fishermen and their families eat fish Î mercury poisoning – Minamata disease becomes synonym for methylmercury poisoning.

Recommendations for young women and children:

- Do not eat shark, swordfish, king mackerel, or tilefish because they contain high levels of mercury
- Eat up to 350 gram (2 average meals) a week of a variety of fish and shellfish that are lower in mercury

Five of the most commonly eaten fish that are low in mercury are shrimp, canned light tuna, salmon, pollock, and catfish. Another commonly eaten fish, albacore ("white") tuna has more mercury than canned light tuna. So, when choosing your two meals of fish and shellfish, you may eat up to 175 gram (one average meal) of albacore tuna per week.

If no advice is available, eat up to 175 gram (one average meal) per week of fish from local waters, but don't consume any other fish during that week[48].

Mercury is very toxic and increasing in our environment and our food supply, especially fish. It was decided, that the situation was so serious that young women should be warned to reduce their fish intake to no more than 2 meals per week and to avoid certain kinds of fish, which are known to contain high mercury levels, completely.

8.3 Persistent Organic Pollutants (POPs)

POPs are persistent, lasting for years or decades before degrading. Often highly toxic, damaging the CNS, endocrine system, reproduction and others. Evaporate and travel long distances; since this depends on the temperature, POPs travel from warm to cold climates. Accumulate in fatty tissue; this leads to “bioaccumulation” and “biomagnification”. Unlike metals which are natural compounds, POPs are manmade and a problem of the “chemical revolution” of the 20th century. This large group of compounds has several characteristics in common. They are persistent, because they don’t degrade easily in the environment. They are often highly toxic to specific or all species. They evaporate and can travel long distances in the air, thus reaching regions of the world where they have never been produced or used, like mountain lakes in the Himalayas and the Arctic. They accumulate in fatty tissue due to their lipophilicity, which results in bioaccumulation and biomagnification[49].

[48] Tatiana Kimáková, Lucia Kuzmová, Zuzana Nevolná, Vladimír Bencko. Fish and fish products as risk factors of mercury exposure. Ann Agric Environ Med. 2018;25(3):488–493. DOI: https://doi.org/10.26444/aaem/84934

[49] Hing Man Chan, Kavita Singh, Malek Batal, Lesya Marushka, Constantine Tikhonov, Tonio Sadik, Harold Schwartz, Amy Ing, and Karen Fediuk. Levels of metals and persistent organic pollutants in traditional foods consumed by First Nations living on-reserve in Canada. Can J Public Health. 2021 Jun; 112(Suppl 1): 81–96. doi: 10.17269/s41997-021-00495-7.

8.3.1 Terminology

Biomagnification - the incremental increase in concentration of a contaminant at each level of a food chain. Describes the increase of a compound in an organism over time.

Bioaccumulation - is the process by which organisms (including humans) can take up contaminants more rapidly than their bodies can eliminate them. Describes the increase in the contamination level within the food chain.

Humans are at the end of the food chain, so biomagnification is of great concern for us. DDT: chronic low dose effects altered metabolism of hormones, drugs, etc. (cytochrome P450 induction). Hypertrophy of hepatocytes. Altered estrogen imbalance in birds – change in calcium metabolism – egg shell thinning. Carcinogenic (leukemia, lung, brain). Reduced testicular size. Problems initiating and/or maintaining pregnancy. Impairment of some cognitive skills, poor self-esteem, depression. DDT use was banned in most of the countries in 1970 ties.

8.4 The Dirty Dozen

The Stockholm convention identified the 12 most important compounds that should be dealt with, calling them the “Dirty Dozen”. When you look at the list you can see that 9 of them are pesticides. The convention allows the use for several of them, recognizing the continuing need for these pesticides in certain situations, but recommends or requires a strong reduction of use to the absolute minimum necessary. The remaining three members of the Dirty dozen are actually all groups of compounds with very similar chemical structures. One of them, the dioxins, are a byproduct of chemical production of certain pesticides (Agent Orange) or of incomplete combustion for example in municipal waste incinerators. Dioxins have never had a practical use for humans, but they are highly toxic.

The Dirty Dozen: aldrin, chlordane (exempted for some specific production & uses), diedrin (Convention exempts some specific uses), endrin, heptachlor (Convention exempts some specific uses), toxaphene z DDT (use should be restricted), hexachlorobenzene (HCB), mirex (Convention exempts some specific production & uses), dioxins (TCDD), furans, PCBs (Convention exempts some specific uses)[50].

8.4.1 Dioxins

Dioxins and dioxin-like compounds (DLCs) are a group of highly poisonous chemical compounds that are persistent organic pollutants in the environment, belonging to the type of chlorinated aromatic hydrocarbons. Group includes over 400 compounds that are released into the environment as a result of human activity (wastes burning, accidental and wild fires, metal smelting and refining). Dioxins accumulate in environment and can be released to food products, like fish and seafood, fat meat, milk and dairy products and drinking water. Acute dioxin poisonings are reported extremely rare and are associated with direct exposure to high doses, the symptoms include chloracne, skin discoloration, rash, and moderate liver damage.

[50] Tri Thanh Nguyen, Carmen Rosello, Richard Bélanger and Cristina Ratti. Fate of Residual Pesticides in Fruit and Vegetable Waste (FVW) Processing. Foods 2020, 9(10), 1468; https://doi.org/10.3390/foods9101468.

Symptoms of long-term exposition for small doses and accumulation in organism include disorders of the central and peripheral nervous system, chronic skin allergies, increased susceptibility to infections, hormonal disorders, lung and liver cancer, infertility, fetal damage, increased risk of cardiovascular diseases and diabetes, lower bone strength.
One of the effects of dioxin – chloracne - can be seen observing the face of Viktor Yushchenko in 2004[51]. The tests have confirmed that Mr. Yushchenko was poisoned with TCDD, the most toxic one in the group of dioxins.

8.4.2 Polychlorinated biphenyls (PCBs)

Another group of compounds that made the list of the Dirty Dozen are the PCBs. They were and still are used in capacitors and transformers, but their production was banned in the many countries in the 1070s. Released into the environment they are highly persistent, bioaccumulate in fatty tissue, and biomagnified in the food chain. Our major route of exposure is through the consumption of contaminated food, especially fish, but we may also inhale PCBs from indoor and outdoor air around destruction and waste sides and contaminated buildings (PCBs were used in sealants around windows and other applications). PCBs also pass the placenta and are excreted with the mother's milk, which makes this a major route for women to reduce their body burden of this contaminant, which unfortunately results in potentially high levels of PCBs in breast-fed children[52].

8.5 Heavy and toxic metals

8.5.1 Arsenic

Arsenic is a chemical heavy and toxic metal, found in water, air, food and soil as a naturally occurring substance or due to contamination from human activity. The sources of contamination are herbicides, defoliants, dyes (tanning), glass (pigments), batteries, accumulators, pollution by smelters (copper and other metals) and coal mine. From the contaminated environment, arsenic gets into food products: fish (seafood, tuna, salmon, sardines, mackerel), poultry, plants (rice and its products), mushrooms, beer and wine. Arsenic oxide is used in terrorist attacks. The toxic dose for humans ranges from 10 to 50 mg, a single dose of 70 to 200 mg causes instant death.

Symptoms due to dose and time of exposure. Acute symptoms become from 1 to 30 hours after exposure on higher dose: severe vomiting, diarrhea, headaches, drop in blood pressure, loss of consciousness, toxic liver damage, cerebral hemorrhage, shock and finally death. Late symptoms occurring after several years (exposure to low doses over a long period of time: kidney, skin, lung, liver, bladder cancer, dermatitis (keratosis, hyperpigmentation), chronic diarrhea and vomiting, mucosal and conjunctivitis, sensory and movement neuropathies.

Arsenic is a natural component in soil and water. Some areas have higher arsenic levels than others, like certain parts in Texas and New England in the USA or Chile and Bangladesh. Arsenic

[51] Arnold Schecter, Linda S Birnbaum, John Jake Ryan, John D Constable. Dioxins: An overview. Environmental Research 101(3):419-28. DOI: 10.1016/j.envres.2005.12.003.
[52] Panithi Saktrakulkla, Tuo Lan, Jason Hua, Rachel F Marek, Peter S Thorne and Keri C Hornbuckle. PCBs in Food. Environ Sci Technol. 2020 Sep 15; 54(18): 11443–11452. doi: 10.1021/acs.est.0c03632.

is the primary cause of black foot disease, the first sign of arsenic poisoning that was observed in Bangladesh after new wells delivered arsenic-laden water from high arsenic soil strata to the population. Arsenic has several useful applications. The major use of arsenic nowadays is in pesticides, but it is also used in some forms in medicine and the electronic industry. Occurrence and use: natural soil and ground water component. Pesticides (80% of use), medicine (tryphanosomiasis, chemotherapy), computer chips, semiconductors, glassware, paints. Uptake: food (~10 µg/day, other sources estimate 1mg/day), water (~10 µg/day, assuming 5 µg/L water). The allowance reduced since 1/2006 to 10 µg/L. Arsenic is a carcinogen and teratogen[53].

Prevention: safe drinking water is a priority.

8.5.2 Tin metal

Tin is a metallic compound founded naturally in environment. Sources of food contaminations are mainly preserved food cans, organotin pesticides, plastic packaging where tin compounds are used as stabilizers. Inorganic tin compounds cause various types of anaemia by disrupting heme formation. Organic compounds are much more dangerous, they are almost as toxic as cyanide, they cause damage to the nervous and digestive systems (bile ducts), they damage the thymus gland.

Symptoms: lack of appetite, diarrhoea, vomiting, muscle weakness, convulsions, photophobia, balance disorders, toxic liver damage, cholangitis, porphyria, kidney damage, nervous system damage, increased intracranial pressure, brain damage. It causes anaemia, respiratory system disorders, erythematous skin lesions and difficult to heal wounds[54].

Prevention: Do not use canned food in incorrectly manufactured tins (especially canned tomatoes).

9. Acrylamide

Acrylamides are a chemicals that can form during cooking or processing certain starchy foods. Acrylamides can cause a skin, gastrointestinal and lung cancer or nervous system damages. Acrylamides were detected in many food products including coffee, tea, fried or roasted potato products (chips, frites), cereal-based products (sweet biscuits or toasted bread)[55].

Protection: avoid fried and roasted potato products, do not store the potatoes in refrigerator or on lighting places, follow a balanced diet, processing food by boiling, steaming or microwaving.

[53] https://pmj.bmj.com/content/79/933/391.

[54] Anirban Goutam Mukherjee, Kaviyarasi Renu, Abilash Valsala Gopalakrishnan, Vishnu Priya Veeraraghavan, Sathishkumar Vinayagam, Soraya Paz-Montelongo, Abhijit Dey, Balachandar Vellingiri, Alex George, Harishkumar Madhyastha, and Raja Ganesan. Heavy Metal and Metalloid Contamination in Food and Emerging Technologies for Its Detection. Sustainability 2023, 15(2), 1195; https://doi.org/10.3390/su15021195.

[55] Health Implications of Acrylamide in Food. https://apps.who.int/iris/bitstream/handle/10665/42563/9241562188.pdf;jsessionid=A6231C2DD7663E46474DB8F3E2B81C1A?sequence=1.

10. Cyanide

Cyanide is a very strong poison, fast and violent acting. The most common cause of poisoning is hydrogen cyanide - a volatile gas with the characteristic smell of bitter almonds. In food products it can be found as a result of intentional adding in powdered form (potassium cyanide salt crystals), causing death after a few hours, as a terroristic act. The lethal dose for humans is 150-500 milligrams (95% lethality).

Symptoms of poisoning include: headache, tinnitus, shortness of breath with tightness in the chest, vomiting, faster and weaker pulse, drop in blood pressure, coma, pink colour of the skin. Less specific symptoms include: irritation of the mucous membranes, feeling of scratching in the throat, burning tongue, conjunctivitis, cardiac arrhythmia, states of agitation, mydriasis[56].

Protection: Cooking, in most cases eliminates the cyanide compounds, store food products in sealed glass or metal container, wash the outside of the container before using, avoid using the food products, if smells, tastes, or looks unusual.

11. Cadmium

Cadmium was first discovered in 1817 and unlike many other metals is only a trace element. Nevertheless it is a health concern, because cadmium bioaccumulates (uptake higher than excretion) and the likelihood of exposure has increased significantly during the last decades, since the usefulness of cadmium was discovered and industrial use increased. Cadmium is not corroding, a characteristic that makes this metal highly desirable for many industries. Cadmium is taken-up and accumulated at very different degrees in different plants. Unfortunately some major food plants like wheat and rice and also tobacco have a high uptake rate for cadmium. If these plants are grown in soil that is contaminated with cadmium, due to run-off from a factory or use of cadmium-containing sewage sludge for example, the levels of cadmium can be very high. Other foods that can contain high levels of cadmium are shellfish and organ meats (e.g. kidney, liver). Cadmium has a half-life (the time during which half of the incorporated compound is excreted) of about 10-30 years. Adverse health effects are expected when the lifetime uptake has reached 2000mg. The average uptake through food, water and air is estimated as 10 – 40 ug/day, but that is an estimated average, and individual uptakes may be much higher. Major health effects of cadmium are nephrotoxicity (affects the kidney) and in older women bone weakening (itai-itai disease), due to high accumulation in these organs, but cadmium was also shown to induce cancer, systolic hypertension and lung damage. Occurrence and use: byproduct of Zn and Pb mining and smelting. Released by coal burning. Industrial use increasing since last 50 years, continues to increase. Electroplating, galvanizing, Ni-Cd batteries, color pigment. Exposure: food - plant uptake of Cd from soil,

[56] Tara B. Hendry-Hofer, Patrick C. Ng, Alyssa E. Witeof, Sari B. Mahon, Matthew Brenner, Gerry R. Boss, and Vikhyat S. Bebarta. A Review on Ingested Cyanide: Risks, Clinical Presentation, Diagnostics, and Treatment Challenges. J Med Toxicol. 2019 Apr; 15(2): 128–133. doi: 10.1007/s13181-018-0688-y.

sewage sludge, fertilizers, air deposition. High accumulation of Cd by rice, wheat, tobacco. High levels in shellfish (100-1000ug/kg). Meats, especially kidney and liver. Daily intake estimated 10-40 µg/day. Half-life 10-30 years. Bioaccumulates to nephrotoxic levels. Accumulates in bone.

The major sources of cadmium in food are: rice, cereal grains, potatoes, vegetables, meats (mainly liver and kidneys)[57], so the prevention steps are: use above mentioned products only from verified sources.

12. Nicotine

Nicotine is a very toxic, natural alkaloid that has an addictive effect. Found in tobacco root and leaves. It can be in volatile or liquid form - a colorless or pale yellow liquid with a sharp, burning taste (pure nicotine solution is colorless and almost odorless). It is a component of pesticides and insecticides. The toxic dose is 4-8 mg of nicotine taken at one time. The lethal dose is 40-60 mg for an adult.

The first symptoms of acute poisoning appear from 1 to 4 hours after exposure. Tachypnoea, headache, dizziness, nausea, pallor, diarrhoea, sweating, drooling, tachycardia and an increase in blood pressure are observed. After the gradual disappearance of these symptoms, there is a period of weakness. After high doses of nicotine, there is a burning sensation in the mouth, throat, stomach and the above-mentioned symptoms, and after they slowly subside, the patient is exhausted and gets convulsions, respiratory weakness, cardiac arrhythmias, motor coordination disorders, and finally coma. Death occurs within 5 minutes to 4 hours.

Chronic poisoning is characterized by the same symptoms, but stretched over time. Long-term nicotine poisoning causes an increased incidence of cardiovascular diseases by increasing blood pressure, poorer blood supply to the vessels, and accelerates atherosclerotic processes in blood vessels. Vascular changes result in collapse states, angina pectoris, and destroy the coronary vascular system. Other symptoms are associated with the nervous system - poor memory, poor coordination of thoughts, slowing mental processes, decreased energy and general weakness[58].

Protection: Keep away all tobacco products, especially products containing liquid nicotine from food products, store nicotine products in their original container.

[57] Mehrdad Rafati Rahimzadeh, Mehravar Rafati Rahimzadeh, Sohrab Kazemi, and Ali-akbar Moghadamnia. Cadmium toxicity and treatment: An update. Caspian J Intern Med. 2017 Summer; 8(3): 135–145. doi: 10.22088/cjim.8.3.135.

[58] Nicotine Poisoning After Ingestion of Contaminated Ground Beef --- Michigan, 2003. https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5218a3.htm.

13. The most common food borne - radionuclides

13.1 Radionuclides

A radionuclides or radioisotopes are a nuclides of chemical element which possess excess of nuclear energy and from this reason are unstable. Radionuclides show radioactive decay (alpha, beta or gamma decay). Radioactive isotopes have found applications in many fields of science and economy (food preservation, nuclear medicine - cancer treat, energy source, radiocarbon dating, nondestructive testing, mining).

Food products and drinking water may be contaminated radionuclides of natural or artificial origin from soil, water pathways or fallout. The sources of radionuclides in food include:

- Radionuclides of natural origin, particularly radionuclides of potassium, carbon, polonium, uranium or thorium and which are present throughout the environment
- Radionuclides of industry origin from authorized discharges from nuclear and other licensed facilities (especially from nuclear power plant or nuclear wastes landfill), or from mining and processing activities
- Tests or use of nuclear weapons in the 40s, 50s and 60s of XX century (the main radionuclides are plutonium, uranium, strontium and cesium)[59]
- Accidental releases as an effect of accident in nuclear facilities (Windscale in 1957, Chernobyl in 1986 and Fukushima in 2011)

The other way to contamination of food products may be intentional use as a terroristic act (murders of Alexander Litvinenko in 2006 or Yasser Arafat in 2004). Food products at high risk of high level of accumulated radionuclides include: milk, nuts, forest mushrooms, fish, shellfish, offal (liver and kidneys), rice, leafy green vegetables and hedgerow fruits.[60]

Radioactive isotopes make a threat to human health and life due to their easy absorption and ability to accumulate in the body. Radionuclides cause biological effects in human body that depend on dose and time of influence and on body weight. Radioisotopes after ingestion can cause cancer and teratogenic activity, in cases when high dose of isotopes are ingested they cause death in a few days. Radionuclide can cause a cancers of bones, thyroid, liver, lung, kidneys, myeloid leukemia, and bone marrow atrophy. Children and embryos are particularly

[59] Nobuaki Kunii, Maya Sophia Fujimura, Yukako Komasa, Akiko Kitamura, Hitoshi Sato, Toshihiro Takatsuji, Masamine Jimba, and Shinzo Kimura. The Knowledge and Awareness for Radiocesium Food Monitoring after the Fukushima Daiichi Nuclear Accident in Nihonmatsu City, Fukushima Prefecture. Int J Environ Res Public Health. 2018 Oct; 15(10): 2289. doi: 10.3390/ijerph15102289.

[60] Shuying Kong, Baolu Yang, Fei Tuo, Tianxiang Lu. Advance on monitoring of radioactivity in food in China and Japan after Fukushima nuclear accident. Radiation Medicine and Protection Volume 3, Issue 1, March 2022, Pages 37-42. https://doi.org/10.1016/j.radmp.2022.01.006.

sensitive to radiation, even small doses of radiation can cause mental retardation, stunted development, disability and cancer[61].

Prevention:

- eat food only from checked sources
- avoid eating mushrooms from high radiation level regions
- avoid eating fish and shellfish from sea nearest the nuclear power plants

[61] Laurent Bodin, Florence Menetrier. Treatment of radiological contamination: a review. Journal of Radiological Protection, 2021, 41 (4), pp.S427-S437. ff10.1088/1361-6498/ac241bff.

14. Factors of food-borne Illnesses and Prevention Strategies - General best practices for prevention of food CBRN incidents

14.1 Detection of Food-Related Problems

Detection of the agent that caused the disease in a sample of the food that the ill person has eaten. Detection of the agent causing the infection can be a problem. Several steps can be taken if it is assumed that the illness of a person is food-borne. One method is to analyze samples of the food that a sick person has eaten in an effort to find the agent that caused the illness in one of them. Sometimes many people show the same symptoms of disease at the same time. If there is such a cluster of cases of the illness, questioning the affected patients to identify a consumed food item that all have in common may be sufficient to detect the source of the illness. Common places that have such food-disease outbreaks include potlucks, picnics, family reunions, food courts etc. In these first three places and events there is usually a totally unregulated and uncontrolled access to food, which increases the risk for food-borne diseases.

Observing a cluster of cases of an illness among persons who had nothing else in common than having eaten the same food. Transmission via food may be inferred because the illness affects the digestive tract and can be a false clue. Absence of digestive tract symptoms does not prove that a disease was not food-borne. Transmission via food may be suspected when the disease is one that is known to be conveyed in this way. Transmission via food may be inferred because the illness affects the digestive tract, but this clue may not always be available. Individual persons might have no digestive tract symptoms yet. Have the infection and sometimes the infectious agent may cause primarily other symptoms like fever or dizziness. Finally, certain diseases are known for having a food connection. It is therefore natural to start the search into the cause of the disease with an inspection of the food items that were consumed recently[62].

[62] B. Priyanka, Rajashekhar K. Patil and Sulatha Dwarakanath. A review on detection methods used for foodborne pathogens. Indian J Med Res. 2016 Sep; 144(3): 327–338. doi: 10.4103/0971-5916.198677.

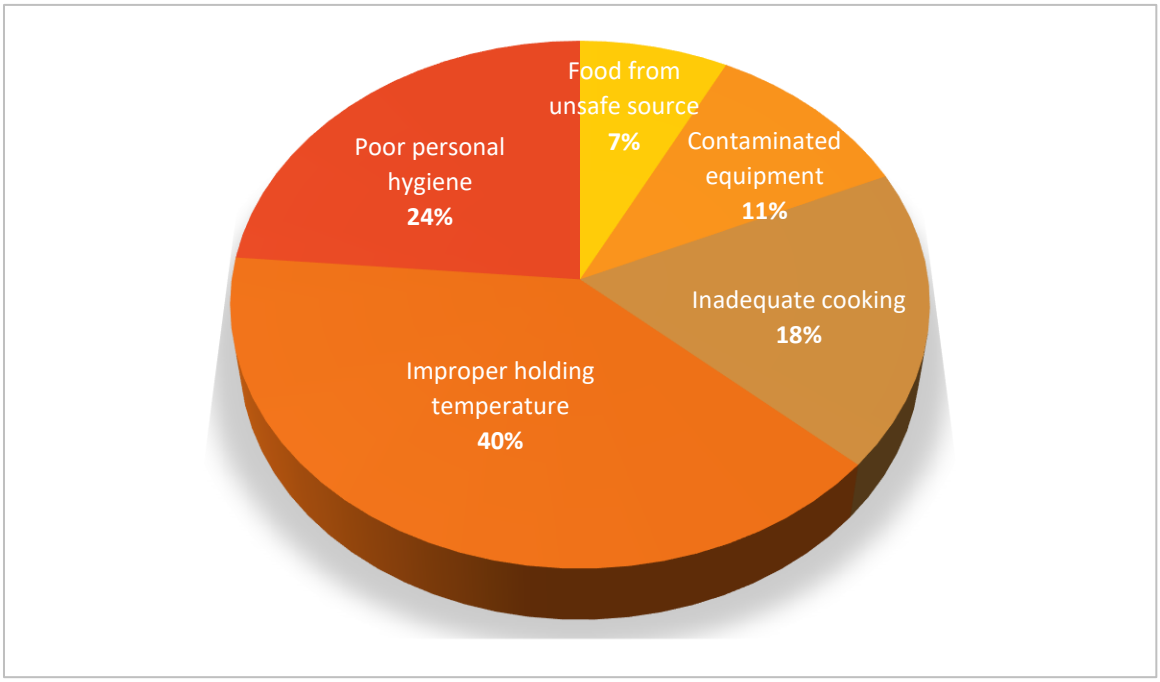

Figure 1: Factors that contribute to contaminated food and food borne illness

The prevention strategies are as follows:

- Food from unsafe source → **CLEAN**
- Contaminated equipment → **SEPARATE**
- Inadequate cooking → **COOK**
- Improper holding temp. → **CHILL**
- Poor personal hygiene → **WASH and REPORT**

14.2 Symptoms of food-borne diseases

Upper gastrointestinal tract symptoms (nausea, vomiting) occur first or predominate. Later symptoms include: cyanosis, headache, dizziness, dyspnea, trembling, weakness, loss of consciousness.

Lower gastrointestinal tract symptoms (abdominal cramps, diarrhea) occur first or predominate – Clostridium perfringens, Bacillus cereus, Streptococcus faecalis, others: in 2-36h, mean 6-12h. Abdominal cramps, diarrhea, sometimes nausea and vomiting. – Salmonella species, Shigella, Escherichia coli, other Enterobacteriacae, Campylobacter jejuni: in 12-74 h, mean 18-36h. Abdominal cramps, diarrhea, vomiting, fever, chills, malaise, nausea, headache, possible. Giardia lamblia: in 1-6 weeks - Mucoid diarrhea (fatty stools) abdominal pain, weight loss.

Generalized infection symptoms (fever, chills, malaise, aches, swollen lymph nodes) – Salmonella typhi: in 7-28 days, mean 14 days. Later malaise, headache, fever, cough, nausea, vomiting, constipation, abdominal pain, chills, rose spots, bloody stools. Neurological symptoms (visual disturbances, vertigo, tingling, paralysis) occur – Muscaria-type mushrooms:

in less than 1h. Excessive salivation, perspiration, gastroenteritis, irregular pulse, pupils constricted, asthmatic breathing – Clostridium botulinum and its neurotoxins: in 2h to 6 days, usually 12- 36h - vertigo, double or blurred vision, loss of reflex to light, difficulty in swallowing. speaking, breathing, dry mouth, weakness, respiratory paralysis – Organic mercury: in more than 72h - numbness, weakness of legs, spastic paralysis, impairment of vision, blindness, coma.

Sometimes the symptoms can be easily mistaken for a common cold, other times they may be so puzzling and the onset so late that the patient has problems to see a connection.

Incidence of food-borne Illnesses z WHO reports that in 7 food-borne pathogens found in animal products cause 3.3 -12.3 million cases of food-borne illness per year (roughly 1 in 30). Food-borne illness often shows itself as flu-like symptoms such as nausea, vomiting, diarrhea, or fever, so many people may not recognize the illness is caused by bacteria or other pathogens on food[63].

The incidence rate of food-borne illnesses is huge, even in a countries, where refrigeration and clean water are everywhere available. In fact in the area of Public Health there is no other problem that affects a population as much as this. Food-borne illness may compare or exceed water-borne illnesses. The key problem in food-borne illnesses is adequate reporting, since mild cases will go unreported and many cases will not even be recognized as being food-borne, due to flue like symptoms instead of typical GI (gastro-intestinal) symptoms.

14.3 Food Sanitation

Definition: protection of food from contamination

- Prevent foods from becoming contaminated
  - source, cross-contamination, personal hygiene
- Limit the growth of contamination in foods
  - proper cooking and storage

Food sanitation in general means eliminating potential sources of food contamination. Taking a personal inspection in our own kitchens, asking how long we should use and disinfect our sponge, which places are not cleaned regularly, what goes on inside our refrigerators, and other issues like the use and cleaning of cutting boards. The goal is to prevent contamination as well as to limit the growth of contamination in foods (for example via refrigeration).

Contamination in definition is the presence of harmful agents: biologic, chemical, radiological or physical.

Spoilage in definition is a damage to the edible quality of foods caused by yeasts, molds, bacteria. Observed through unacceptable taste, smell, or appearance.

Contamination can be biological, chemical, radiological or physical and may cause illness. On the other hand, spoilage is when food items start looking bad in the refrigerator, typically from the growth of yeasts, molds, and bacteria. An example is when we have had the jar of jam in

[63] https://www.who.int/activities/estimating-the-burden-of-foodborne-diseases.

the refrigerator for some time and upon opening it, we find that mold is forming on the top of it. Many may think that food-borne illnesses are a problem that is confined to the developing world, but that assumption is wrong. There are huge problems associated with food-borne illnesses, including deaths, loss in time at work, and medical costs which run into millions each year. With regards to these problems, the published recent data showing that the problems are actually even larger than first suspected by the WHO[64].

14.4 Primary Bacterial Growth Factors

- Temperature
- Time
- Neutral environment (pH)
- Moisture (Water Activity)
- Oxygen
- Food (Nutrients)

Only the first two can be controlled on a daily basis.

There are several factors that affect the growth of bacteria in food. Bacteria need nutrients, without that they are not going to grow too well. They take up these nutrients after the nutrients have been dissolved in solution; this means that a certain amount of moisture is required. Also needed is a fairly neutral environment, so pH is also important. Oxygen is required if the bacteria are aerobic. Other factors are time and temperature. We cannot easily control most of these factors, without using special techniques like dehydration, canning etc., with the exception of time and temperature[65].

14.5 Holding temperature

For example: ideal temperature for growth of Salmonella near 30°C. Any temperatures above or below 30°C will slow growth. Holding temperatures should be: less than 4°C or greater than 60°C (in between is the “Danger Zone”). Holding temperatures are important in food handling. Thus, outdoor weather in the summer is often at a good temperature for salmonella growth. A certain area of temperatures exist that promotes growth so holding temperatures should be less than or greater than this “danger zone”. It is important to follow precisely the precaution of not allowing food to be left out too long in the danger zone; 2 hours is the maximum time food should remain in the danger zone of 4-60°C (while on a serving table for example). 74 degrees is the temperature every food should be reheated to[66].

[64] Somnath Pal. Incidence of Foodborne Illness. US Pharm. 2017;42(12):14.
[65] Siddig Hussein Hamad. Factors Affecting the Growth of Microorganisms in Food. https://doi.org/10.1002/9781119962045.ch20.
[66] https://www.statefoodsafety.com/Resources/Resources/holding-time-and-temperature-log.

14.6 Cooking Temperatures

Upper danger zone level: 60°C. Internal temperatures required to ensure disinfection of certain foods – stuffed meat, poultry, all stuffing 74°C, ground beef 68°C, pork 65°C, rare roast beef 55°C. All other potentially hazardous foods 60°C. All foods must be reheated to 74°C. Cooking temperatures required to ensure disinfection vary between 60 and 74 degrees Celsius[67].

14.7 Time

Under ideal conditions, bacteria double every 10 to 30 minutes. Foods must be cooled and heated quickly to avoid time spent at or near ideal conditions. Foods must be reheated to 74°C within 2 hours. Foods must be cooled to less than 4°C within 4 hours. Use a temperature monitor inserted in food to record the change in temperature over time to ensure proper cooling[68].

14.8 Methods to cool foods fast

Shallow containers, no deeper than 10cm. Do not stack hot pans. Provide adequate air circulation. Ice bath. Withhold water during cooking, add ice at end. Size reduction. Pre-chill ingredients prior to mixing. There are several ways to hasten the cooling of foods. One method is refrigeration; walk-in refrigerators are often used in restaurants. Opening doors and placing hot food inside, however, heats refrigerators momentarily. Storing food in shallow pans (not deeper than 10cm), which increases surface area, helps to cool it down quickly. Don't stack hot pans. Ice baths can also be used to hasten the cooling process[69].

14.9 pH

Microorganisms of food safety concern grow in surroundings that are at neutral pH (~7). These organisms do not grow, or grow very slowly below a pH of 4.6. Spoilage organisms can grow at low pH. A pH of 7 is conducive to most microbes - a pH of 4.6 has been found to limit microbial growth.

pH values:

- Vegetables 4.2 – 6.5
- Fruits 2.0 – 6.7
- Cheese 4.9 – 5.9
- Fish 6.6 – 6.8
- Ground Beef 5.1 – 6.2

While the optimum pH for:

[67] https://www.statefoodsafety.com/Resources/Resources/cooking-times-and-temperatures-poster.
[68]https://www.statefoodsafety.com/Resources/Resources/time-temperature-control-for-safety-tcs-foods-poster.
[69] https://foodsafetytrainingcertification.com/food-safety-news/cooling-food-safely-two-stage-process/.

- Yeast 4.0 – 6.5
- E. Coli 6.0 – 8.0
- Salmonella 6.0 – 7.5

The ranges of pH values for different microbes relative to those existing in various foods. For food, items like fruits are going to be less likely to be contaminated by microbes, especially items like an orange or lemon with low pHs[70].

14.10 Moisture

Water activity (Aw) - microorganisms need water in an available form. Solutes (salts and sugars) decrease the available water. Water activity is the ratio of the vapor pressure of foods compared to that of water (a measure of moisture content). Typical Water activity values:

- Fresh fruits and pudding 0.97 - 1.00
- Cheese and fresh meat 0.95 - 1.00
- Jam 0.75 - 0.80
- Crackers 0.10

Water Activity (Aw) is defined in those foods with an Aw > 0.85 as “potentially hazardous”. Methods to reduce water activity are:

- Freezing
- Dehydrating
- Mixing with a solute (salt or sugar)
- Cooking (e.g. bacon)

Water activity can be increased in some foods (rice, beans) by soaking. The recommendation for water activity is that it be kept at < 0.85, which is a pretty high number. Anything above 0.85 will encourage bacterial growth. Quite a number of techniques can be used to reduce water activity, like dehydrating the food, freezing, cooking, or mixing with a solute. Raw bacon has a high water activity, but when cooked it gets dry. This is the opposite to what we do with rice and beans when we prepare them, i.e. soaking which increases water activity[71].

14.11 Personal Hygiene

Hand washing must follow any act that offers a possibility of picking up contaminants. Using the restroom. Using a handkerchief or tissue. Handling raw food or chemicals. Touching areas of the body: ears, nose, hair, mouth, infected areas on body. Touching unclean equipment. Smoking or chewing tobacco. Cleaning dirty dishes or scraping dishes, etc. Eating food or drinking beverages. Personal hygiene mainly comes down to hand washing and habits like not touching your nose, and not sneezing into food. This may sound trivial, but everybody who self observes for a short time will realize how often we unconsciously touch our face, ears,

[70]https://extension.okstate.edu/fact-sheets/the-importance-of-food-ph-in-commercial-canning-operations.html.

[71] Chiachung Chen. Relationship between Water Activity and Moisture Content in Floral Honey. Foods 2019, 8(1), 30; https://doi.org/10.3390/foods8010030.

hair etc. A person who is sick should not show up for work – again common sense, but a very commonly broken rule. And many people do not realize how easy it is to carry a contamination from one food-item or dirty dish to another, so hand washing during the handling of different food items is often not considered necessary, a wrong assumption[72].

14.12 Hand Washing

Procedure: use very warm water. As hot as can be tolerated. Lather with soap up to the elbow. Scrub between fingers, back of hands, and under nails. Rub hands together for 20 seconds. Rinse thoroughly. Dry with disposable towel. Turn water off using the towel. In hand washing, 20 seconds is the magic number for rubbing the hands together. The mechanical dislodging of microbes by rubbing and flowing water is most important. Substituting alcoholic solutions for soap and running water is efficient to kill most bacteria, but some spores can survive. After washing, turning off the water by using the towel that was used to dry your hands will prevent re-contaminating your hands. The method of drying the hands is very important and in discussion. There is the issue of paper towels versus electric dryers. The debate is whether or not electric dryers help to decontaminate our hands more than the mechanical drying of using paper towels[73].

14.13 Cross-Contamination

In simple – separation. Practice good hygienic habits: example: clean and sanitize equipment between raw and cooked foods and between working on different species of meat. Proper storage of raw meats and ready to eat foods: example: thaw meats below other foods so juices don't drip down. Proper storage of toxic items: example: bleach and pesticides do not belong in the kitchen. In terms of cross-contamination, there needs to be good hygienic habits and proper storage habits. For instance, frozen meat products can contaminate other food items in a refrigerator during defrosting, if it is stored on a higher shelf and juices drip on the food below it. During food preparation using different equipment or sanitizing the equipment between raw and cooked food preparation will also limit cross contamination. Another possible source of contamination with toxins is from chemicals that are stored in the kitchen. To avoid this possibility toxic chemicals like bleach, pesticides against cockroaches or ants etc. should never be stored in the kitchen[74].

14.14 Cross-Contamination cutting boards

Problem associated with cuts and grooves in surface that can harbor bacteria. Best to use separate boards for raw and cooked foods. Need to be washed, rinsed and sanitized between every use z Hard plastics can be sterilized in dishwashers. Cutting boards are a major source of cross-contamination. Therefore different cutting boards should be used for raw and cooked foods, or they must be properly sanitized in dishwashers between uses. Also, cutting boards

[72] https://www.health.vic.gov.au/food-safety/personal-hygiene-for-food-handlers.
[73] https://www.cdc.gov/handwashing/handwashing-kitchen.html.
[74] https://www.food.gov.uk/safety-hygiene/avoiding-cross-contamination.

with a lot of grooves in them allow potential places to grow bacteria, so the cutting boards should be changed regularly[75].

14.15 Establishing Multiple Barriers

A temperature barrier to slow growth. Cooking at high temperatures or maintaining food at low temperatures throughout preparation period. Good personal hygiene of food handler and properly cleaned and sanitized utensils. Minimizing the possibility of cross- contamination. A temperature barrier is needed to slow growing microbes for example by cooking at high temperatures and maintaining food at low temperatures throughout the preparation period. Another barrier involves good personal hygiene among food handlers, as well as properly cleaned and sanitized utensils to minimize cross contamination during preparation of food. Adjust the pH (if possible). Commercial mayonnaise has a lower pH than homemade. Lemon juice may be added to lower pH. Multiple barriers could also involve adjusting pH, if possible, and serving considerations. This would include minimizing serving time by keeping hot food hot, and cold food cold at all times[76].

14.16 Serving Considerations

Minimize serving time. Keep hot or cold at all times (60°)[77].

14.17 Sound Food Sanitation Program

A Sound Food Sanitation program, includes a safe water supply, adequate garbage and refuse disposal, proper wastewater and sewage disposal, effective insects and rodent control. During food safety inspections, for instance in a restaurant, the inspectors check out these possible sources of problems by going over a long checklist of items associated with these concepts[78].

14.18 Approaches to Rodent Control

Rodent control can include the elimination of their sources of food, which can be done by control of refuse/garbage and by minimizing access to water (standing water can be a source). Another method is to rat-proof buildings. Rats can get through holes as small as 12 mm in diameter and mice can get through holes of 6 mm diameter size, or a quarter of an inch. This means that any hole equal or bigger than these dimensions should be sealed. Typically old buildings that are vacant have lots of rodents. Recommendations for rat-proofing include

[75] https://totalfood.com/avoid-cross-contamination-cutting-boards/.
[76] Ian Young1 and Lisa Waddell. Barriers and Facilitators to Safe Food Handling among Consumers: A Systematic Review and Thematic Synthesis of Qualitative Research Studies. PLoS One. 2016; 11(12). doi: 10.1371/journal.pone.0167695.
[77] https://www.cdc.gov/foodsafety/serving-food-safely.html.
[78] Leslie H. Bond. Sanitation is part of Good Food Management: A sound sanitation program is based upon management's knowledge of bacterial hazards and upon line enforcement of good sanitary practices. https://doi.org/10.1177/001088046000100113.

sealing around pipes with sheet metal or concrete and putting channels underneath doors (so that they are close to the ground)[79].

14.19 Eradication programs

Include the use of traps, poisons, or fumigation of the building with methyl bromide (done with caution, because it is harmful). An example of a rat poison is warfarin. It is well known and in use, but rats have developed some immunity to it. Other poisons are in development. The main issue is that it has to be appealing to rats, but not to other animals. Education and organization is critical; one without the other is not good enough; particularly education without organization, because if in an apartment complex only half the residents are trying to deal with rodents, then it cannot be a successful intervention[80].

14.20 Approaches to Arthropod Control

Besides rodents, arthropods are a major health problem for humans. Arthropods are the most successful phylum in the animal kingdom with respect to number of species and number of individuals. All Arthropods have a hard exoskeleton and breath through a trachea system. The lifecycle of most arthropods includes four stages; egg to larvae, then nymph, and finally adult (complete metamorphosis in flies, moths, butterflies, etc.), while others are just in three stages (without larval stage, incomplete metamorphosis; roaches, body lice, etc.). Control can be applied at any of these stages. The males could also be rendered infertile so that there would not be fertilization of eggs.

The two classes within the phyla of Arthropods that we are most concerned about with respect to human health are the Insecta and the Arachnida. The difference between insects and arachnids. Insects have a head, thorax, and abdomen, while arachnids (spiders) have either one or two body segments. Arachnids have simple eyes and 4 pairs of legs, but no wings and include spiders, scorpions, ticks. Insects have only 3 pairs of legs and typically one or two sets of wings as adults (but not always). Five-sixth of all species on earth are insects, including cockroaches, flies, lice, flees, wasps, butterflies, beetles, bees, and ants. Both groups are very adaptable. Both can live in brackish water, fresh water, salt water, and in various conditions in the soil. They can also live on or in plants and animals. Both very successfully compete with other parasites and have a very well established sensory system. They can detect people by sensing body heat or exhaled carbon dioxide or through other means. Roaches are an ancient species. They have been around almost unchanged for 400 million years. There are many different kinds. Examples are German cockroaches, American cockroaches, Oriental cockroaches, etc. Discussed mainly with regards to the allergens, they are also good sources of endotoxin and bacteria.

Approaches to Arthropod control include proper sanitation: use of screens, refuse control, and basic public health measures. Insecticides can be applied but they sometimes carry risks

[79] https://www.slcgrouponline.com/food-safety-and-pest-control-several-ways-to-prevent-food-poisoning/.
[80]https://inspection.canada.ca/preventive-controls/preventive-control-plans/the-food-safety-enhancement-program/eng/1525869691902/1525869759693.

associated with them, so they have to be used judiciously and carefully. Environmental changes include the removal of tires and other water collecting /stagnant products. Radiation to sterilize the males can also be attempted. What is most important here is an integrated pest management plan[81].

14.21 Integrated Pest Management

With integrated pest management, the whole life cycle of the arthropod is considered. Then a number of different approaches to deal with the problem can be explored. This is performed while taking into account the weaknesses of certain pests. Environmental opportunities can sometimes be applied rather than the use of insecticides[82].

14.22 Effective Workplace Infection Control Program

Identify infection risks and develop control measures. Educate workers about infection control and personal responsibility. Coordinate infection control personnel to effectively monitor cases and control outbreaks. An administrative structure to monitor compliance and efficacy of the program. Provide health care and counseling for workers who sustain exposures or develop infectious diseases. Educating workers about infections and personal responsibilities is an important element in controlling them. This is very important with certain types of diseases, like ones that might be life threatening. Workplace Infection Control Measures are effective where: workers are concentrated, the workforce is well structured, infection hazards are recognized, resources are available to provide, physical controls, training programs, surveillance, confidentiality.

Infection control approaches include an adequate ventilation system, hand washing, and personal protective equipment e.g. gloves[83].

14.23 Outbreak vs Incident

Sometimes “outbreak” and “incident” are used interchangeably, but specifically an outbreak is when there is a cluster of two or more people getting sick, while the term incident is typically used for an individual case. The likelihood of the detection of an outbreak is dependent on the alertness and activity of physicians and health care workers. Sometimes an outbreak remains undetected in a community with many physicians, since individual patients go to different physicians and neither of them sees enough cases to realize that an outbreak occurred, since they don’t communicate these cases among each other.

[81] Lina Bernaola, Jocelyn R Holt. Incorporating Sustainable and Technological Approaches in Pest Management of Invasive Arthropod Species. Annals of the Entomological Society of America, Volume 114, Issue 6, November 2021. https://doi.org/10.1093/aesa/saab041.
[82] https://www.food-safety.com/articles/2462-food-safety-calls-for-an-integrated-pest-management-plan.
[83] https://www.qcs.co.uk/infection-control-policy-importance-risk-assessment/.

14.24 Communication with the Public

- Why are we communicating?
- Who is our audience?
- What do our audiences want to know?
- What do we want to get across?
- How will we communicate?
- How will we listen?
- How will we respond?
- Who will carry out the plans and when?
- What problems or barriers have we planned for?
- Have we succeeded?[84]

How do you communicate about risk to the public? For a long time there were no formal thoughts about how to communicate risk. Some people are just naturally good at it, while others are terrible. Generally, it is better to have a lot of communication, but sometimes it is not good. Timing is important and it is necessary to take into consideration who the audience is, what they may want to know, and what we want to get across. Other important factors to be considered include, what is their level of education? Typically for this, it is best to assume an average of a 7th grade education. Enough time should be left in the meeting for questions and answers, and it is important to let people speak out on any feelings they might be having, and even if you don't have a relevant answer, you can let them know that you are sympathetic to their concerns and that you will get the information they want at a specific time. It is most important to involve the public as a legitimate partner, unlike the past concept of the government where the public was seen as an obstacle. Now, listening to the public's specific concerns and being honest and open with them, coordinating properly with credible sources, and meeting with the media (this involves making adequate arrangements to dialogue with them) is normal. When speaking on this issue, it should be done with compassion and in the language of the community being addressed.

[84] C Chess, BJ Hance, PM Sandman. Improving dialogue with communities: a short guide for government risk communication.

15. Conclusions

Our lifespan has increased, so that we have become more worried about the more minor risks. Another way to say this is, as we have become a safer society with better medicines and less concerns about threats (in other words, better able to prevent deaths). We are now more concerned about other types of risks. We know the risk of death from injury in to be 610 per million people. These are measured (actuarial) risks, and knowing these kinds of risks are what insurance companies are very good at. Predicted risks, on the other hand, are tougher and include things like chemicals, for which there have never been any human exposure assessment, and therefore an estimation of probability is based on data from animal toxicology studies. Risk is dependent on toxicity and exposure, so if there is no exposure there is no risk. For example, if we assume that smallpox (which still exists although only in labs), is controlled and contained, then there will be no exposure and therefore no risk. Starr's Laws of Acceptable Risks state that: the public is willing to accept risks from voluntary activities roughly 1,000 times greater than those from involuntary activities, which provides the same level of benefit. And, the acceptable level of risk is inversely related to the number of people exposed (this is from that fact that if risk is widely shared by many people then it is not regarded as significant). And, the level of risk tolerance from voluntarily accepted hazards is similar to the risk from infectious diseases[85]. We still think that, the food which is consumed especially in public places e.g. restaurants, catering points (e.g. Shopping Malls) are safe. However, these places are perfect for unintentional or intentional food contamination and by this create serious threat to public health. The presented in this report best practices to prevent CBRN incidents are crucial to minimalize this possibility.

[85] Baruch Fischhoff, Paul Slovic, Sarah Lichtenstein, Stephen Read, Barbara Combs. How Safe is Safe Enough? A Psychometric Study of Attitudes Towards Technological Risks and Benefits. PolicySciences9(1978), pp. 127-152.