Food Safety

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- Frumkin H [Ed.] (2010) Environmental Health: From Global to Local, 2nd Ed. Chapter 18 "Food Safety" pp.635-688. (In 3rd Ed. Chapter 19 "Food Systems, the Environment, and Public Health")
- KEY CONCEPTS
  - Foodborne illness can threaten public health
  - Three classes of hazard (biological, chemical, physical) can cause foodborne illness
  - Especially susceptible people to foodborne illness
  - Potentially hazardous foods escaping from time-temperature safety control
  - Interventions including HACCP
  - The "food environment" refers to the availability in schools, communities, and other settings, of both nutritious foods and unhealthy foods; complementing traditional food safety approaches
- Other reference web pages
  - [WHO/Food safety] https://www.who.int/health-topics/food-safety/
  - [FAO tools] https://www.fao.org/food/food-safety-quality/publications-tools/food-safety-tools/en/
  - https://extension.psu.edu/food-safety-and-quality/commercial-food-processing
  - [USMEF HACCP video] https://www.youtube.com/watch?v=50e_Ic2rPK4

Components of food systems

(Cited from Frumkin's text 3rd Ed., Fig 19-1)

- The food supply system is composed of various elements.

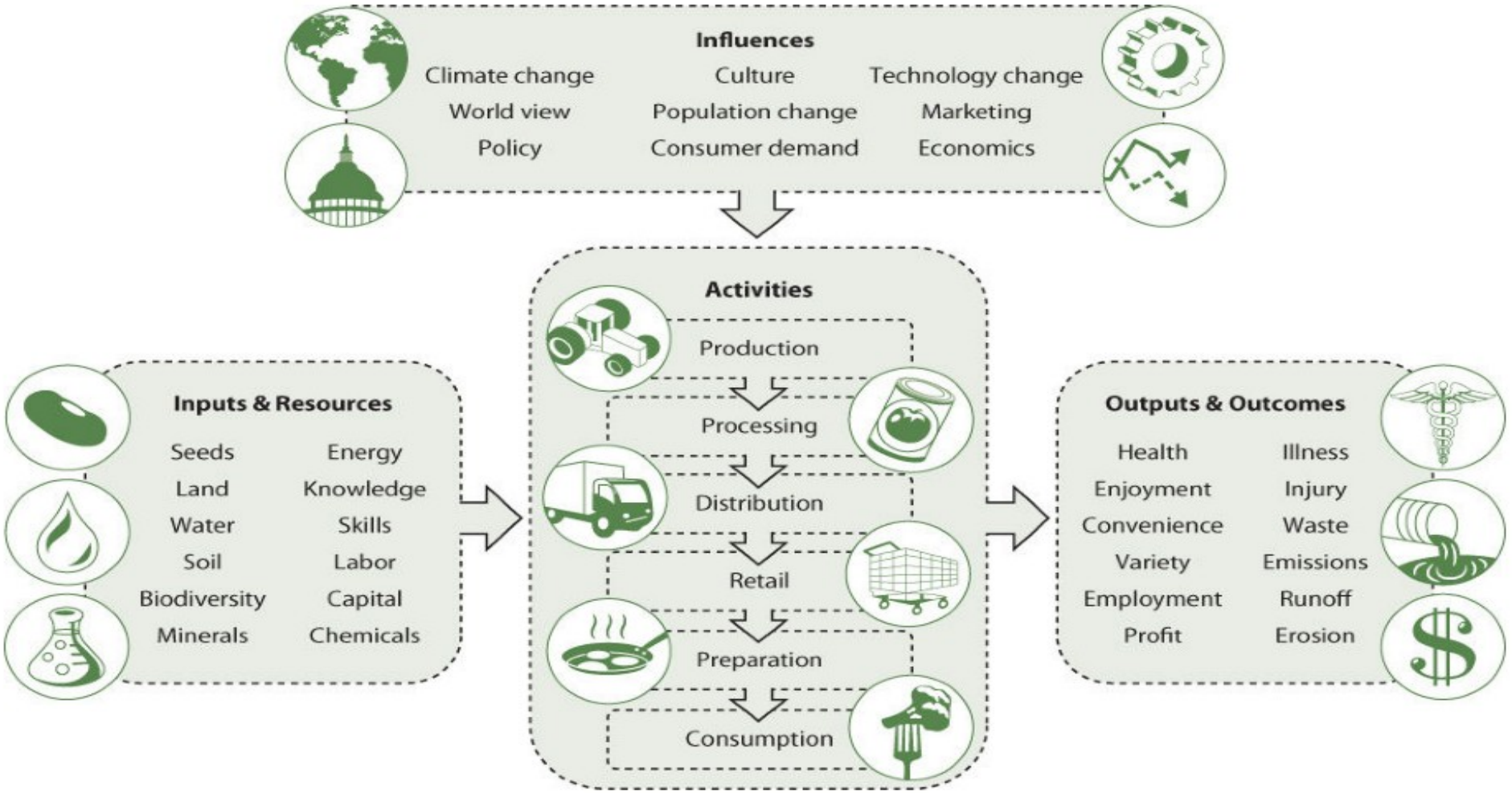


Figure 19.1 Selected Components of the Food System

Source: Brent Kim and Michael Milli, Johns Hopkins Center for a Livable Future, 2015.

Potential hazards in food production

- Industrialized agriculture
  - Mechanization: Less labor, large scale = fewer farmers, fewer farms. USA had 7 million farms in 1935 and 2 million farms in 2013.
  - Comparing with traditional agriculture (depending on and damaging natural resources such as soil, water, biodiversity and natural functions such as pollination, decomposition, predators to control pests), it uses:
    - Energy from fossil fuels
    - Pesticides (Insecticides, Herbicides, Fungicides): Enabled monoculture, but emergence of resistant pests, health risk of farmers
    - Fertilizers (esp. synthetic one including fixed N from atmosphere by Haber-Bosch method): 800% increased worldwide between 1960 and 2000, crops increased, but soil degraded, then nutrient pollution in river and/or sea (eutrophication), subsequently dead zones in coastal area and harmful algal blooms
    - GMOs (genetically modified organisms): Partially contributed to the reduction of total amount of pesticides (eg. Roundup, BT crops), but glyphosate (probably human carcinogen) use increased (527 million pounds were used in USA during 1996-2011).
- Industrialized food animal production (IFAP)
  - Raising animals in concentrated animal feeding operations: Efficiency improved, but easy to suffer from bacterial infection, then increased use of antibiotics in turn caused emergence of antibiotic-resistant bacteria.
  - People exposed to the swine facilities' water and air emissions showed elevated rates of depression, stress, fatigue, headaches, sore throats, etc. (Donham, 2010).

Sustainable agriculture

- In USA, 66% have thought about the sustainability of their food and beverages in the past year, 39% have shopped a farmer's markets, 26% have bought organic products, 22% have grown their own food (IFICF, 2012).
- Changes of food production have recently occurred.
  - Most conventional farms now adopt some practices to make their operations sustainable: eg., conservation tillage (leaving the previous year's crop residue such as corn stalks or wheat stubble on fields before and after planting the next crop, to reduce soil erosion and runoff), high-efficiency irrigation, IPM (integrated pest management)
  - Some farms adopt agroecological practices to mimic natural systems: ducks into rice paddies to eat weeds and insects resulted in less use of pesticides and fertilizers and 20% more rice crops (Takao Furuno, 2001), used in many countries including Cuba.

Figure 19.5 Ducks in One of Takao Furuno's Rice Paddies in Japan

The extent of food borne illness

- Food borne illness: the sickness which people experience after consuming food and beverages contaminated with pathogenic (disease-causing) microorganisms, chemicals, or physical agents
- Common symptoms: nausea, vomiting, diarrhea, abdominal pain, headache, fever, dehydration and those combinations
- Common and mild, so under-reported
- Annual burden in USA: 10 - 80 million cases
  - The wide range of the estimate comes from under-reporting and the fact that the same pathogen can transmit via water
  - CDC estimate in 1999: 76 million cases, 325000 hospitalization, 5000 deaths
- Natural / organic foods are not always safe
  - Human origin chemical hazards are less
  - But, biological hazards (Campylobacter, Salmonella, etc.) are equal

Annual incidences of food poisoning in Japan

https://www.mhlw.go.jp/english/policy/health-medical/food/dl/pamphlet.pdf

https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/kenkou_iryou/shokuhin/kigu/index_00004.html

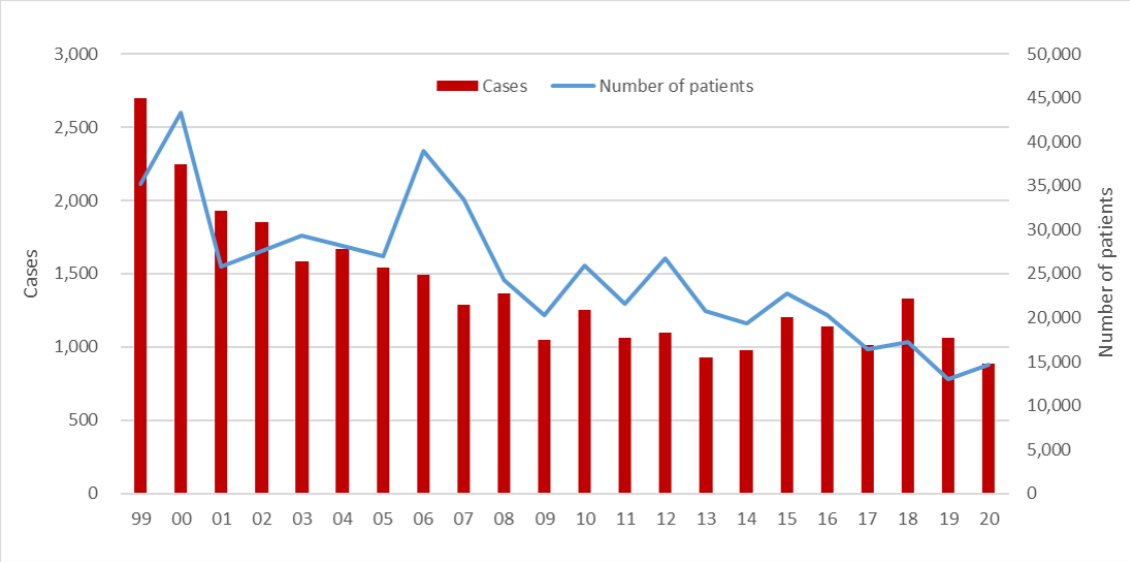


Fig.2-1 Annual variation in the percentage of incidents from food poisoning by serving place and preparing facility

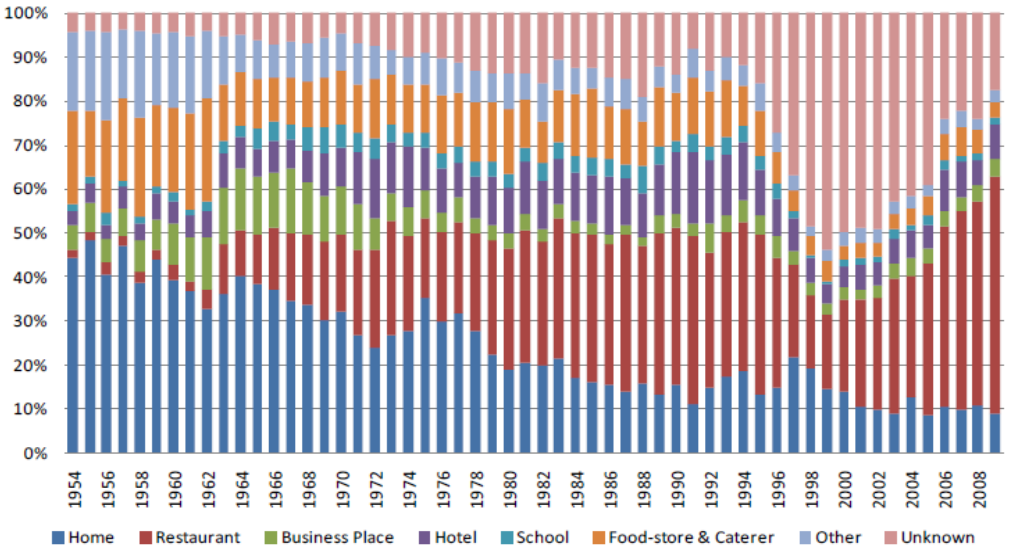
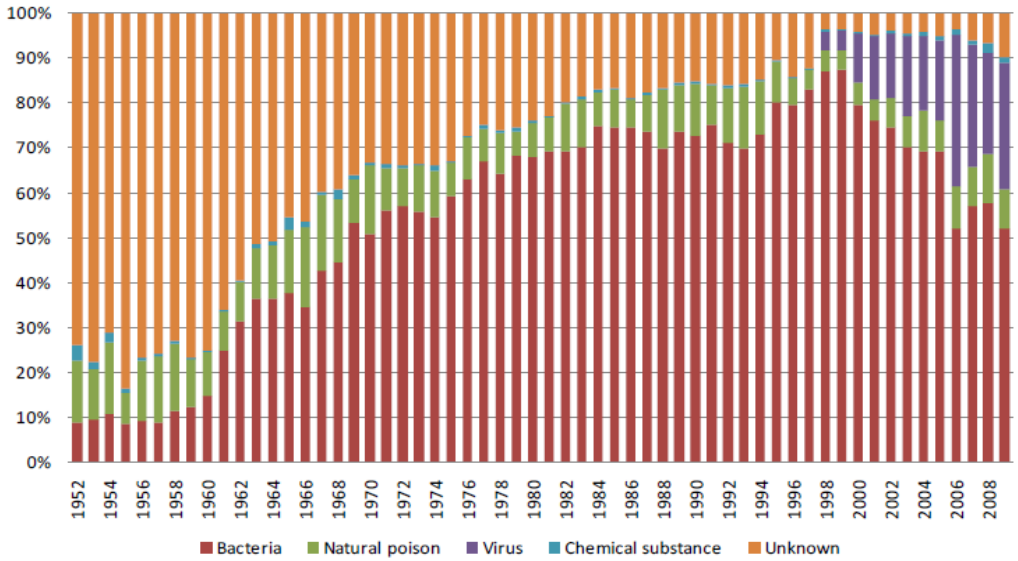


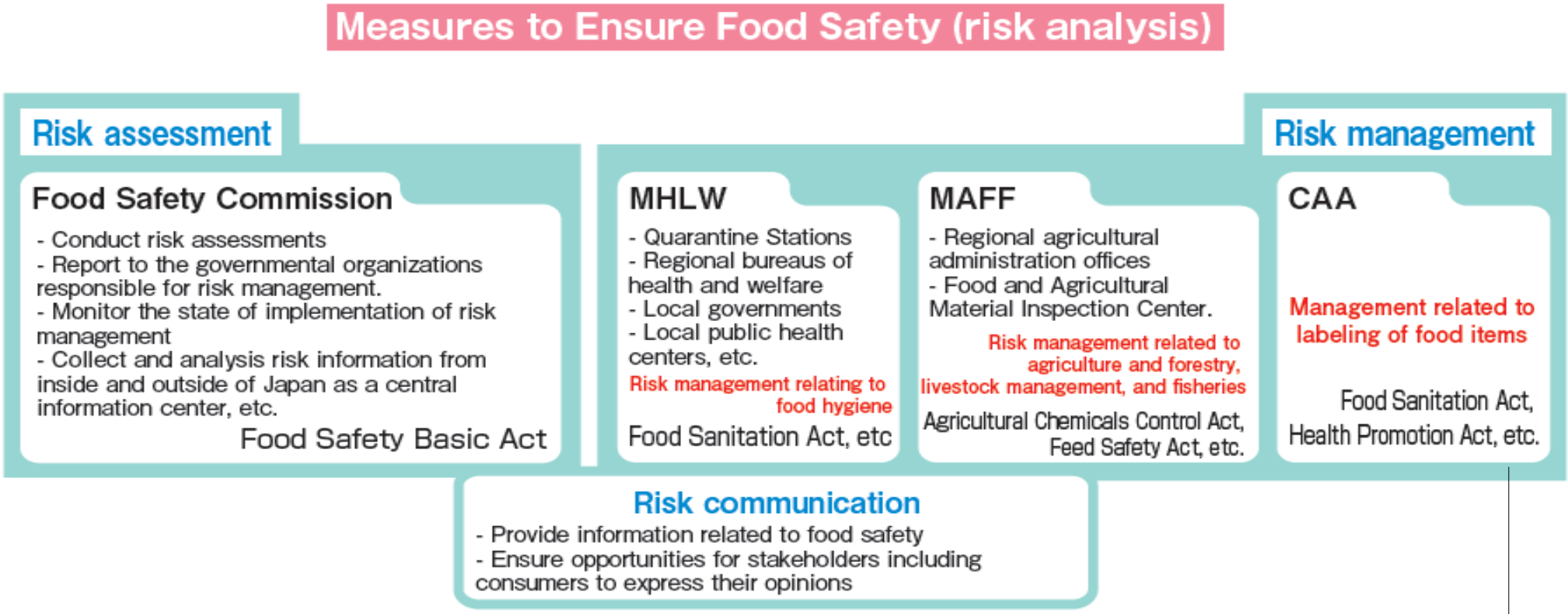
Fig.3 Annual variation in the percentage of incidents from food poisoning by Pathogenic substance

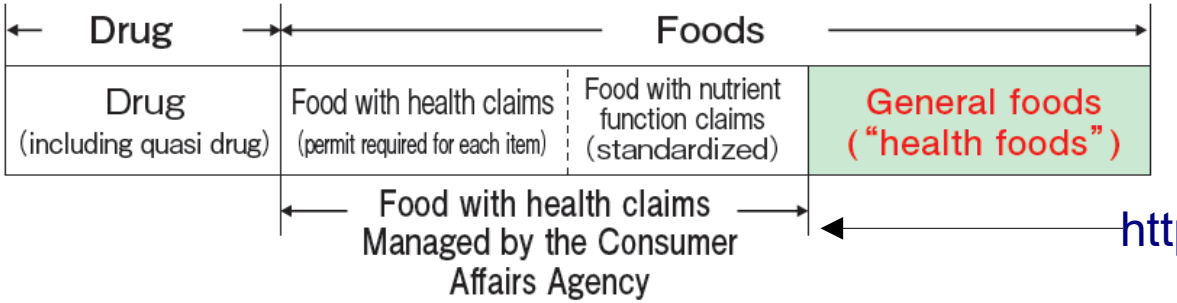


- Detailed information in 2009 is given by https://www.mhlw.go.jp/content/000522405.pdf

Food regulations in Japan

https://www.mhlw.go.jp/english/policy/health-medical/food/dl/pamphlet.pdf





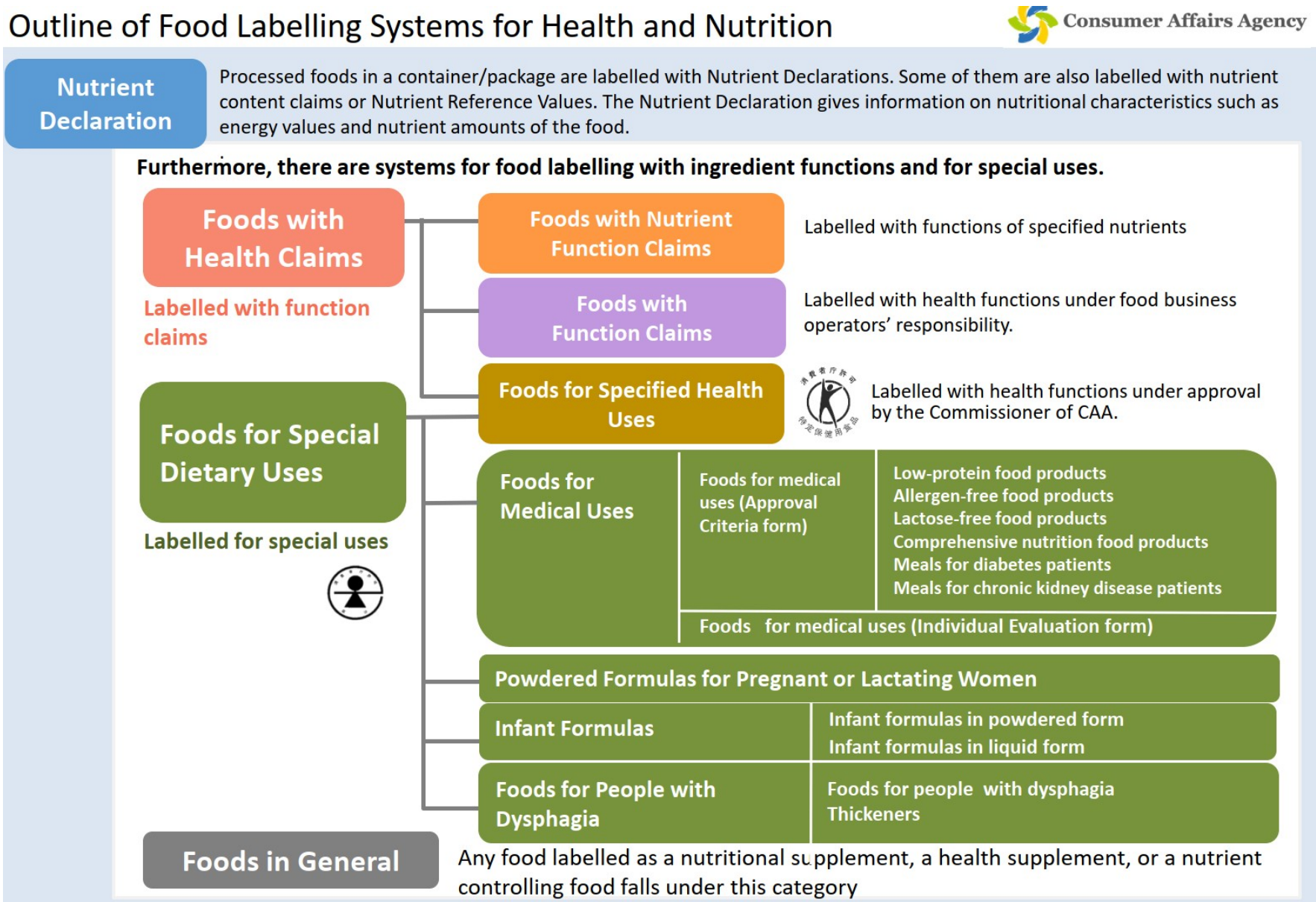
https://www.caa.go.jp/en/policy/food_labeling/

"Health foods", sold with labels for maintaining or promoting healh.

https://www.mhlw.go.jp/english/policy/health-medical/food/dl/health_foods.pdf

Food labelling

https://www.caa.go.jp/en/policy/food_labeling/pdf/food_labeling_cms206_201008_01.pdf



Regulations of radioactive materials in foods in Japan

https://www.mhlw.go.jp/english/policy/health-medical/food/dl/pamphlet.pdf

Limits for Radioactive Materials in Foods

In April 2012, the limits for radioactive cesium in foods were set for each food group based on the Food Sanitation Act.
The limits are based on 1 mSv in a year consistent with an intervention exemption level adopted by codex.

Limits of Radioactive Cesium in Foods

Food group	Limit (Bq/kg)
General foods	100
Infant foods	50
Milk	
Drinking water	10

Procedure of the Measures

Test the food items → All results are disclosed

↓

Excess the limits

↓ If the contamination is found widely in the region

Shipment is suspended for the specific region and item
(Restriction of distribution based on the Act on Special Measures Concerning Nuclear Emergency Preparedness)

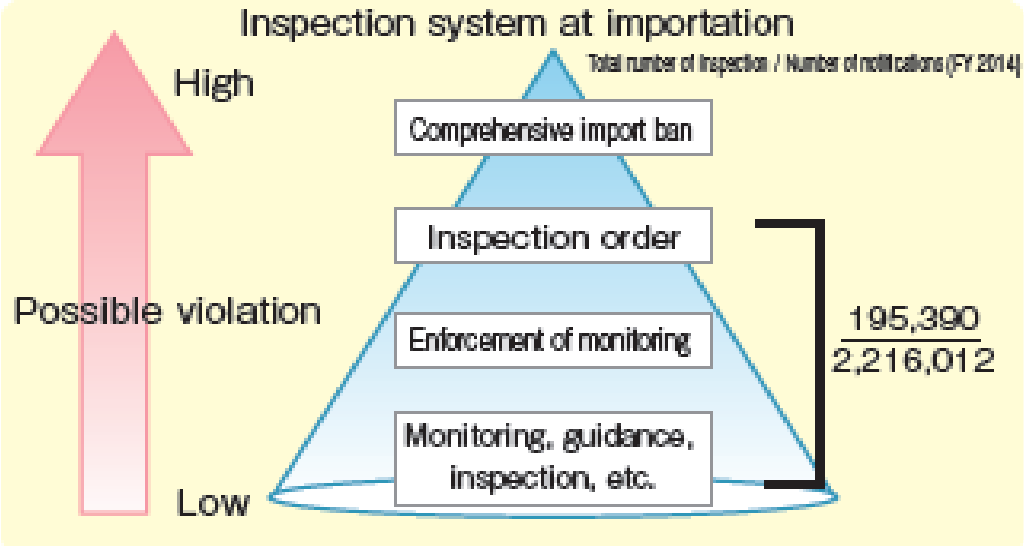
↓ If the contamination is found at a considerably high level

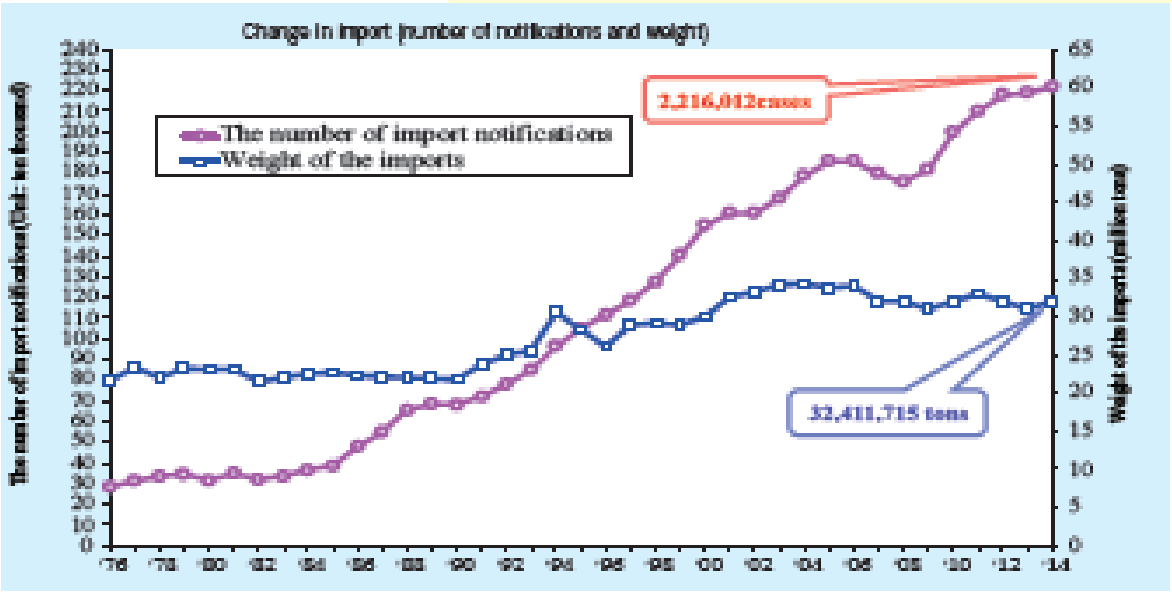
Consumption of the item is not allowed even for non-commercial (family) use
(Restriction of consumption based on the Act on Special Measures Concerning Nuclear Emergency Preparedness)

Japan imports huge amount of foods

https://www.mhlw.go.jp/english/policy/health-medical/food/dl/pamphlet.pdf

- Regulations to confirm the safety of imported foods are important.





Actual figures for import in FY 2014

Number of notification	2,216,012
Amount of import	32,411,715 tons (based on notifications)
Number of inspections conducted	195,390
Number of violations	877(gross number913)
	Violation concerning standards and criteria 245
	Violation concerning sanitation criteria for foods 539
	Violation concerning food additives 54
	Other violation 75

The 3 major reasons to focus on food-safety issues

- Known pathogens are found in a growing number of foods
  - Salmonella bacteria: Commonly found in raw poultry and eggs / caused food borne illness for many years. Recently linked to large outbreaks and "product recalls" of peanut butter and raw produce. More than 1440 cases caused food borne outbreak (FDA and CDC)
- New pathogens are being discovered
  - Listeria monocytogenes in soft cheeses
  - Cyclospora cayetanensis in fresh fruits and vegetables
- Number of immunocompromised people is growing
  - Healthy adults remain asymptomatic or mild
  - Infants, young children, elderly, pregnant women, nursing mothers, impaired immune function due to HIV, cancer, diabetes may have heavy symptoms

Common sources of food contamination

- **Air**
- **Water**
- **Soil**
- **Food handlers**
- **Packaging materials**
- **Animals, rodents, and insects**
- **Food contact surfaces**
- **Ingredients**
  - **Food additives**

Classification of food additives
(as of September 18, 2015)

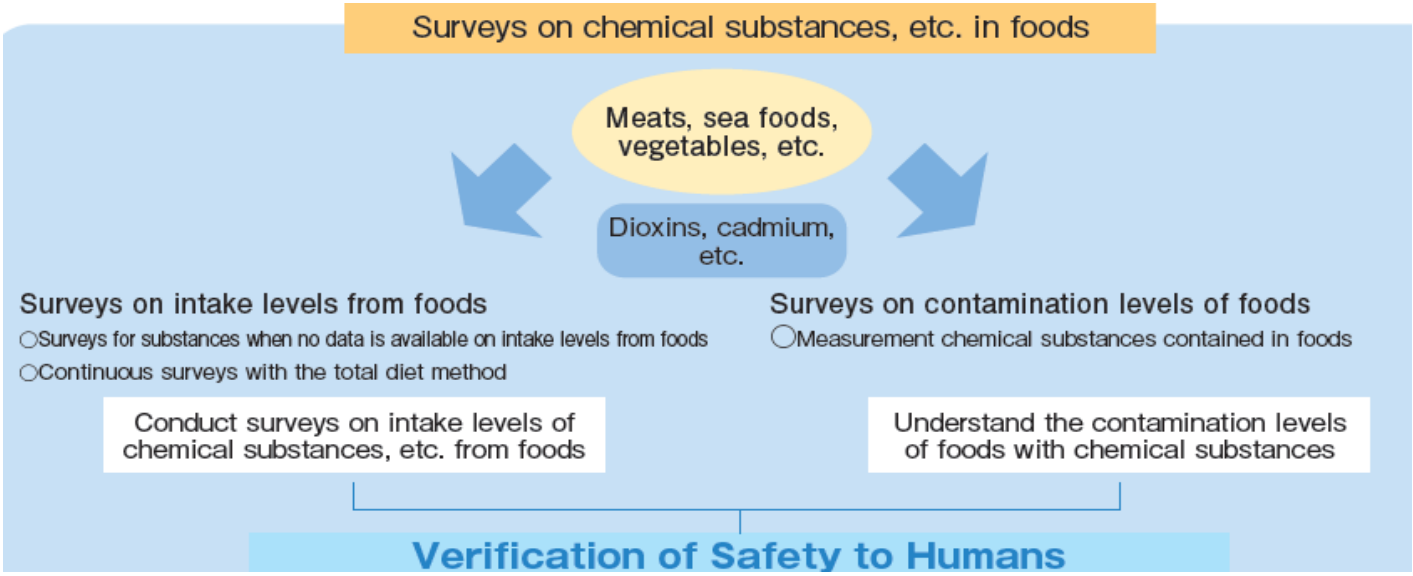
●Designated additives (449 items)
Substances that have been designated by the Minister of Health, Labour and Welfare to authorize the use of them, based on the safety assessment (e.g., sorbic acid and xylitol).

●Existing food additives (365 items)
Substances that have been permitted for use and distribution without having gone through the designation process specified by the Food Sanitation Act for the reason that they had had a long history of consumption at the time of the revision of the act in 1995 (e.g., gardenia coloring agent, Japanese persimmon tannin).

●Natural flavoring agents (approx. 600 items)
Substances that are derived from natural origins, including animals and plants, and used for flavoring food (e.g., vanilla flavoring and crab flavoring).

●Ordinary foods used as food additives (approx. 100 items)
Substances that are generally provided for eating or drinking as food and also used as food additives (e.g., strawberry juice and agar).

Monitoring of contaminants in Japan



Biological, Chemical and Physical Hazards

- Biological hazards
  - microscopic organisms: bacteria, viruses, parasites
    - bacteria origin: 2 types (caused by live bacteria proliferation within gut vs by toxins)
  - invisible challenges to food safety
  - Controlling biological hazards is a primary goal of every food safety program
- Chemical hazards
  - harmful substances
  - naturally occurring like food allergens, toxins associated with molds, plants (incl. fungi), fish, shellfish
  - human origin like pesticides, cleaning agents, metals, PCB
    - Pesticide residues sometimes cause hazards [https://www.who.int/news-room/fact-sheets/detail/pesticide-residues-in-food]
    - https://www.who.int/foodsafety/areas_work/chemical-risks/Pesticide_Residues_in_Food_18-27_September_2018.pdf?ua=1 (See, the right table)
- Physical hazards
  - foreign objects like stones, bone fragments from animals, pieces of glass, staples, jewery
  - originated from poor handling, processing

Jan 13, 2023

Long-term dietary exposure (IEDI: International Estimated Dietary Intake)			
CCPR code	Compound name	ADI (mg/kg bw)	Range of IEDI as % of UL of ADI
177	Abamectin	0-0.001	1-6
172	Bentazone	0-0.09	0-1
254	Chlorfenapyr	0-0.03	1-6
263	Cyantraniliprole	0-0.3	4-40
281	Cyazofamid	0-0.2	0-5
031	Diquat	0-0.006	2-30
304	Ethiprole	0-0.005	1-6
305	Fenpicoxamid	0-0.05	0
211	Fludioxonil	0-0.4	1-6
256	Fluxapyroxad	0-0.02	6-20
110	Imazalil	0-0.03	2-40
290	Isofetamid	0-0.05	0-6
199	Kresoxim-methyl	0-0.3	0-0.5
286	Lufenuron	0-0.02	2-10
231	Mandipropamd	0-0.2	0-6
308	Norflurazon	0-0.005	0-20
291	Oxathiapiprolin	0-4	0
171	Profenofos	0-0.03	0-20
148	Propamocarb	0-0.4	0-2
309	Pydiflumetofen	0-0.1	0
210	Pyraclostrobin	0-0.03	1-7
310	Pyriofenone	0-0.09	0
200	Pyriproxyfen	0-0.1	0-1
252	Sulfoxaflor	0-0.05	2-9
311	Tioxazafen	0-0.05	0

Examples of food-borne illness

- Biomagnification
  - Concentrated toxic chemicals, esp. organic chemicals increases with ascending trophic levels
- Chemical (anthropogenic) origin
  - Mercury: Minamata disease is well known. Whale eating and tuna eating sometimes cause it.
  - Poly-chlorinated biphenyls (PCB)
  - Bisphenol A
  - Pesticides (See, Table 3 below)
    - https://www.sciencedirect.com/science/article/pii/S2405844019308023
- Biological origin
  - Food allergens
  - Ciguatera toxins
  - Scombroid toxins (a toxic reaction to decomposing scombroid fish, such as kahawai, mackerel, tuna, bonito and butterfly kingfish, including histadine, which changes to scombrotoxin, mostly composed of histamine, under the temperature higher than 15 degree Celcius)

Table 3
Potential non-carcinogenic health risk estimation of OCP residues in *Amaranthus* spp from selected farms and markets in South-western Nigeria.

	Children				Adult		
Pesticides	ADI (mg $kg^{-1}d^{-1}$)	EADI (mg $kg^{-1}d^{-1}$)	Hazard index	Health risk	EADI (mg $kg^{-1}d^{-1}$)	Hazard index	Health risk
Heptachlor	0.0001	9.0×10^{-4}	8.972	Yes	2.5×10^{-4}	2.497	Yes
Heptachlor epoxide	0.0001	7.2×10^{-5}	0.722	No	2.0×10^{-5}	0.201	No
Aldrin	0.0001	1.1×10^{-3}	10.861	Yes	3.0×10^{-4}	3.023	Yes
Dieldrin	0.0001	4.1×10^{-3}	40.695	Yes	1.1×10^{-3}	11.327	Yes
Endrin	0.0002	9.8×10^{-4}	4.875	Yes	2.7×10^{-4}	1.357	Yes
Endrin aldehyde	0.0002	9.7×10^{-3}	48.487	Yes	2.7×10^{-3}	13.496	Yes
α- Endosulfan	0.006	2.2×10^{-4}	0.037	No	6.1×10^{-5}	0.010	No
β- Endosulfan	0.006	4.6×10^{-4}	0.275	No	4.6×10^{-4}	0.077	No
Endosulfan sulfate	0.006	2.2×10^{-3}	1.285	Yes	2.2×10^{-3}	0.358	No
Cumulative HI			116.210			32.345	

PHF/TCS foods and potential contamination by micro-organisms

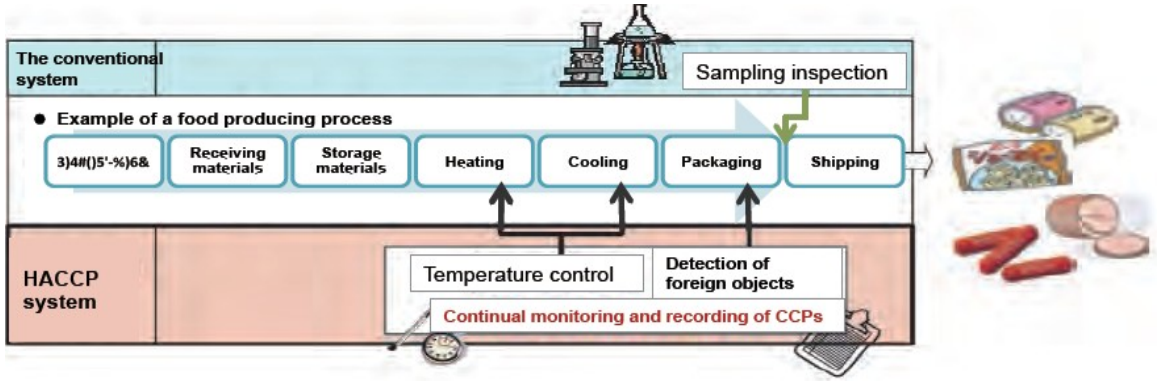
- Potentially hazardous foods and time/temperature control for safe foods
  - Foods of animal origin that are raw or heat-treated
  - Foods of plant origin that are heat-treated or consist of raw seed sprouts
  - Cut melons (for example, cantaloupe)
  - Garlic and oil mixtures that are not modified in a way to inhibit the growth of pathogenic microorganisms
  - Cut tomatoes
- Spore-forming bacteria
  - *Clostridium perfringens*: anaerobic
- Non-spore-forming bacteria: Shiga-toxin producing E. coli O157, Listeria Monocytogens, Salmonella, Staphylococcus aureus
- Viruses: Hepatitis A, Noro (increasing in Japan, rapid diagnostic test become available in insurance-covered since 2012)
- Parasites: Anisakis, Cyclospora cayetanensis

Investigation of food-borne disease outbreaks

- Purpose
  - Determine the cause of outbreak
  - Detect all cases, the foods and the beverages
  - Control the outbreak
  - Document foodborne disease occurrence
  - Correct poor handling
  - Revise HACCP plan
  - Foster public confidence in the food safety
- 9 steps (IAFP, 2007)
  - Obtain a description of food items and secure any leftover food items
  - Gather basic data
  - Formulate an initial hypothesis and case definition
  - Collect clinical specimens for testing
  - Develop a questionnaire
  - Analyze the questionnaires
  - Conduct an environmental investigation
  - Implement control measures
  - Summarize the investigation

Prevention of food-borne illness

- Avoid risk factors listed below
  - improper holding temperatures
  - poor personal hygiene
  - improper cooking temperatures
  - foods from unsafe sources
  - contaminated equipment and cross-contamination



- HACCP (Hazard Analysis and Critical Control Point) approach is a central paradigm of food safety (FAO training manual: https://www.fao.org/3/w8088e/w8088e.pdf)
  - The concept has been developed by NASA in 1971 to avoid food borne illness in the space
  - Hazard analysis / Determine CCP / Establish Critical Limit / Establish monitoring system / Establish corrective action / Verify that the HACCP system is working effectively / Establish effective record keeping
  - Mandatory in Japan since 2021 (https://www.mhlw.go.jp/english/topics/foodsafety/consideration/dl/outline.pdf)
- Food safety agencies and initiatives in USA
  - USDA (cf. HACCP advertisement for exporting meat, see Movie on https://www.youtube.com/watch?v=50e_Ic2rPK4), FDA (Good Agricultural Practices, Good Manufacturing Practices, 2005 Food Code), CDC, EPA
  - PulseNet, Fight BAC! Campaign, Consumer Advisories, Food Irradiation
- Emerging threats: Mad cow disease (Bovine-Sponge-form Encephalitis), bioterrorism, industrial production of food
- WHO 5 keys:
  https://www.who.int/foodsafety/publications/consumer/manual_keys.pdf
  https://www.youtube.com/watch?v=ONkKy68HEIM