



# Microbial Risk Analysis of Food Products

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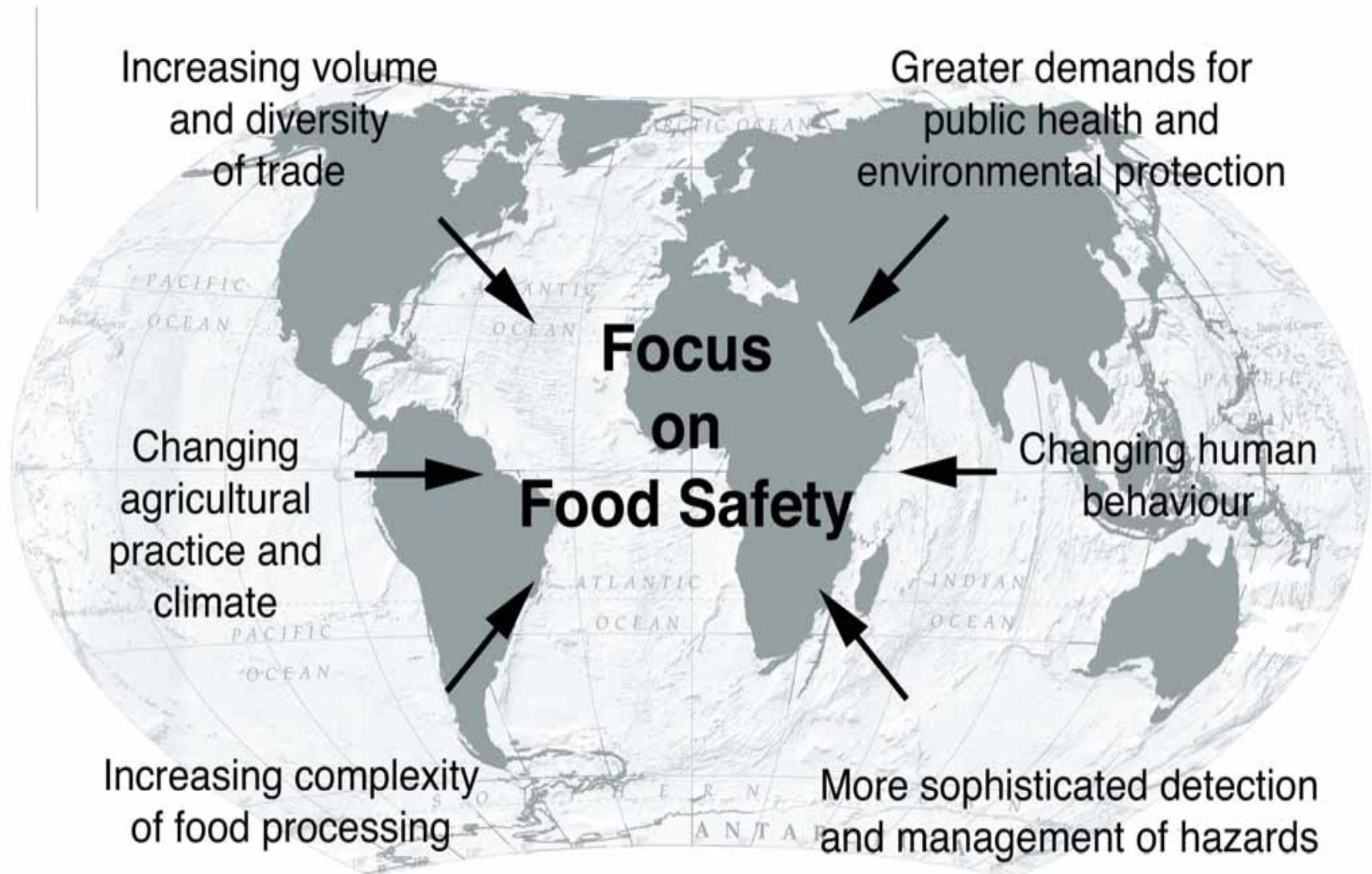
# Outline

- Risk based food safety management
- Risk Analysis and Microbiological Risk Assessment
- Example of using risk based approach in processed food industry

# Food Safety

- Food safety means assurance that food is acceptable for human consumption according to its intended use.
- Food Safety refers to absence of adverse health effects due to presence of biological and/or chemical contaminants in foods.

# Factors Impacting Food Safety



# Evolution of Food Safety Systems

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<b>Distant Past</b>	<b>Use of prohibition principle to protect special groups within the society</b>
<b>1900- Until now</b>	<b>Microbiological examination of food</b>
<b>1922</b>	<b>Introduction of <b>Process Performance Criteria</b> for Canned low acid foods</b>
<b>1930- 1960</b>	<b>Use of risk assessment in setting process performance criteria for heat pasteurization of milk</b>
<b>1960</b>	<b>Introduction of Good Manufacturing Practices (<b>GMP</b>)</b>
<b>1971</b>	<b>Introduction of Hazard Analysis and Critical Concept Point (<b>HACCP</b>)</b>
<b>1978</b>	<b>Start of predictive modelling for bacterial growth in foods</b>
<b>1990</b>	<b>Introduction of Quantitative Microbiological Risk Analysis (<b>QMRA</b>)</b>

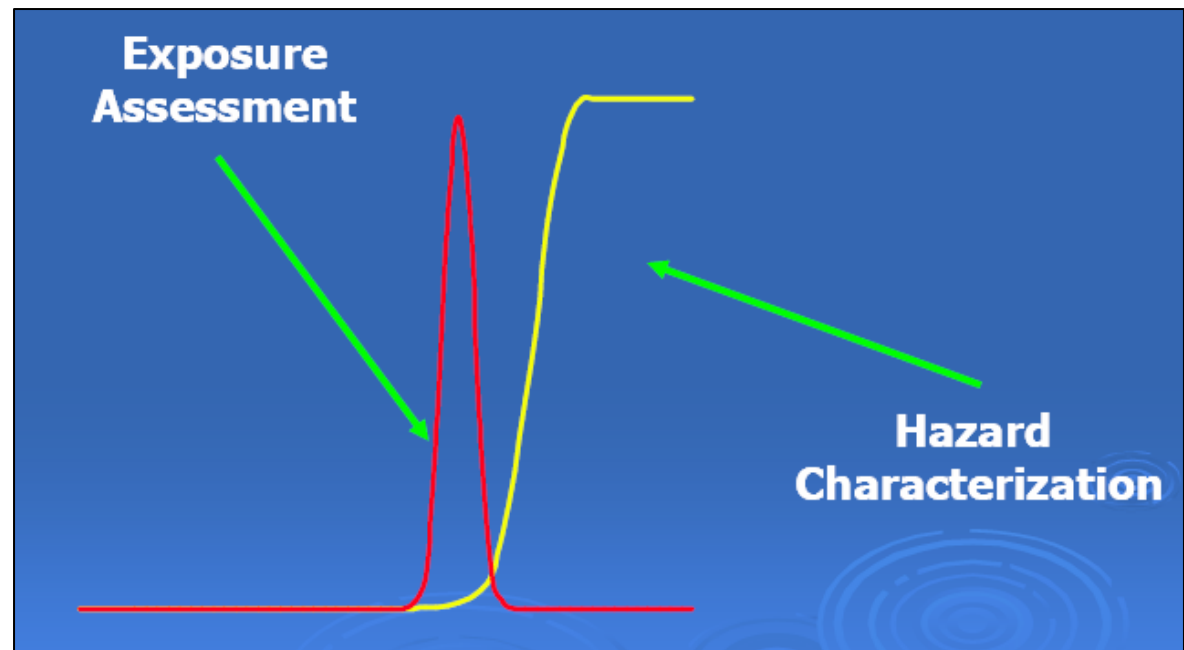
# Risk Based Approach to Food Safety

Risk based approach uses scientific data to identify, characterize and measure hazards and exposure to estimate the impact on consumer health.

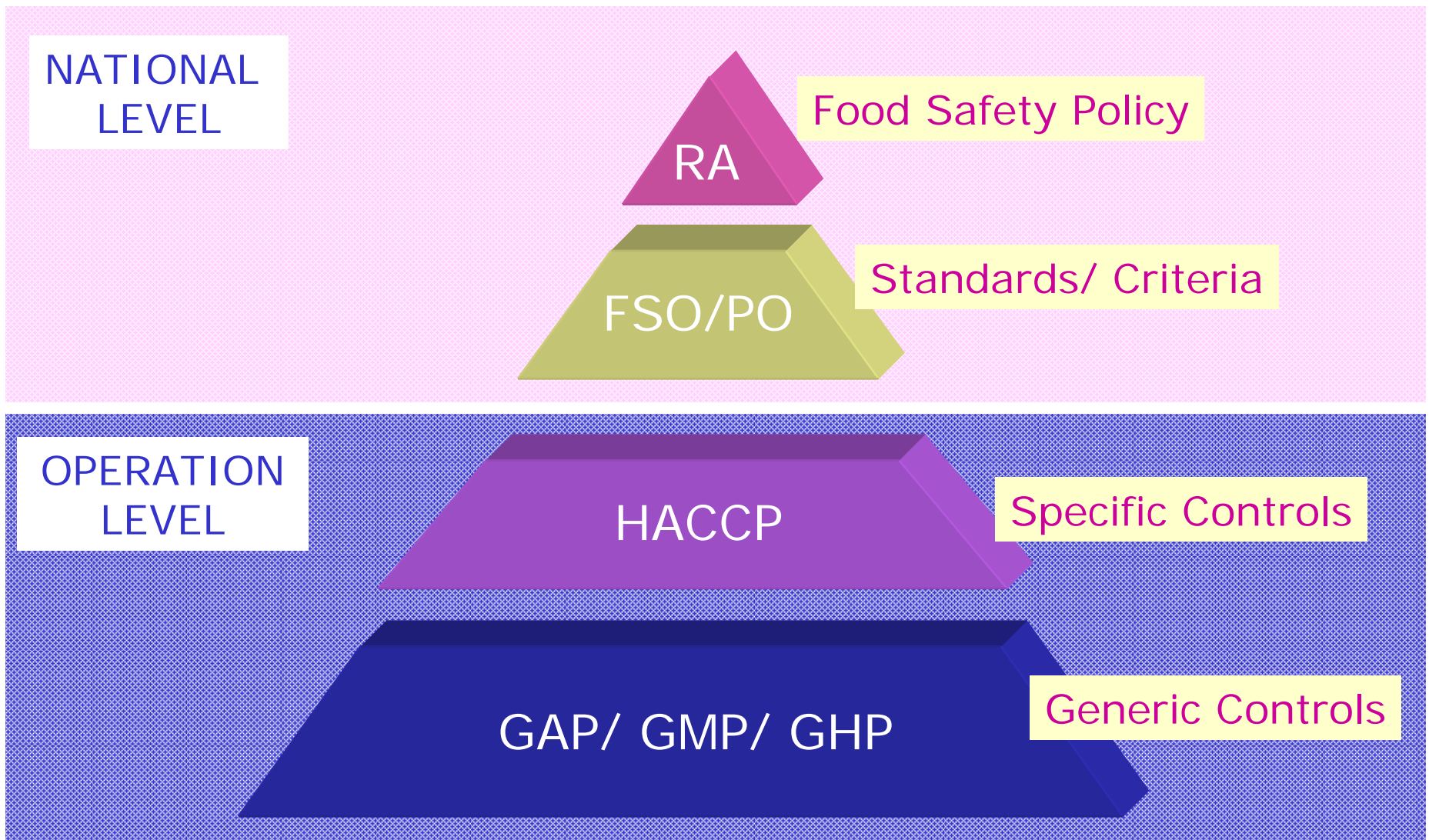
Hazard - an agent with the potential to cause harm

Risk - adverse health effect on the consumer

$$\text{Risk} = \text{Hazard} \times \text{Exposure}$$



# Food Safety Management: The Guiding Framework



# Risk Management

**Governments**

Quantitative Risk Analysis



Appropriate Level of Protection (ALOP)



Performance Objectives (PO)



Food Safety Objective (FSO)



**Food Industry**

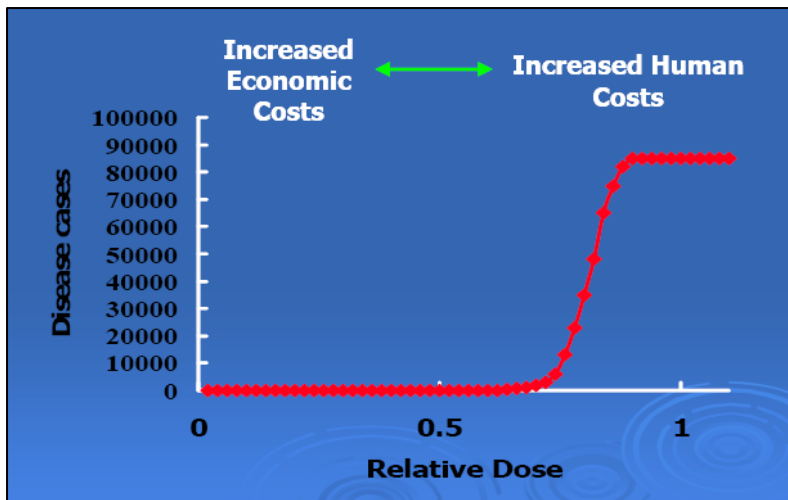
Performance Criteria (PC)



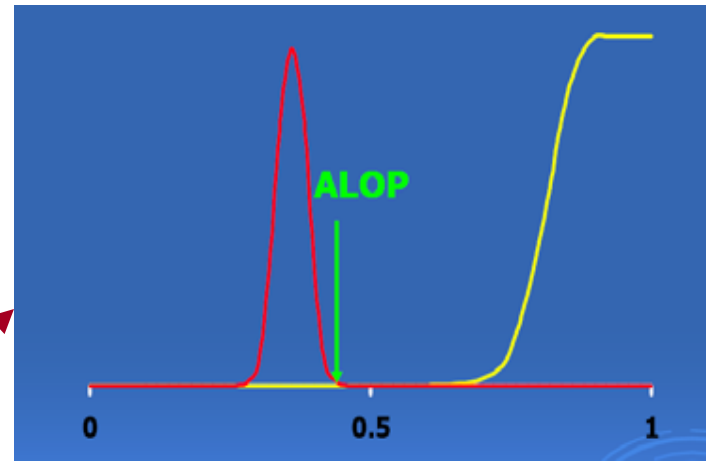
HACCP



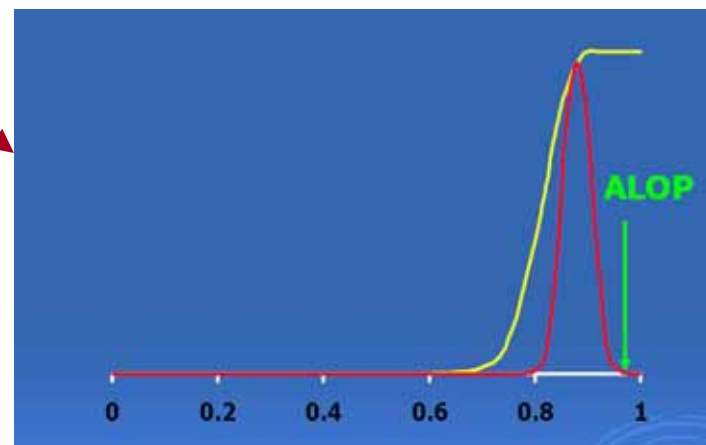
# APPROPRIATE LEVEL OF PROTECTION (ALOP)



A decision on the degree of stringency required



Risk Averse decision



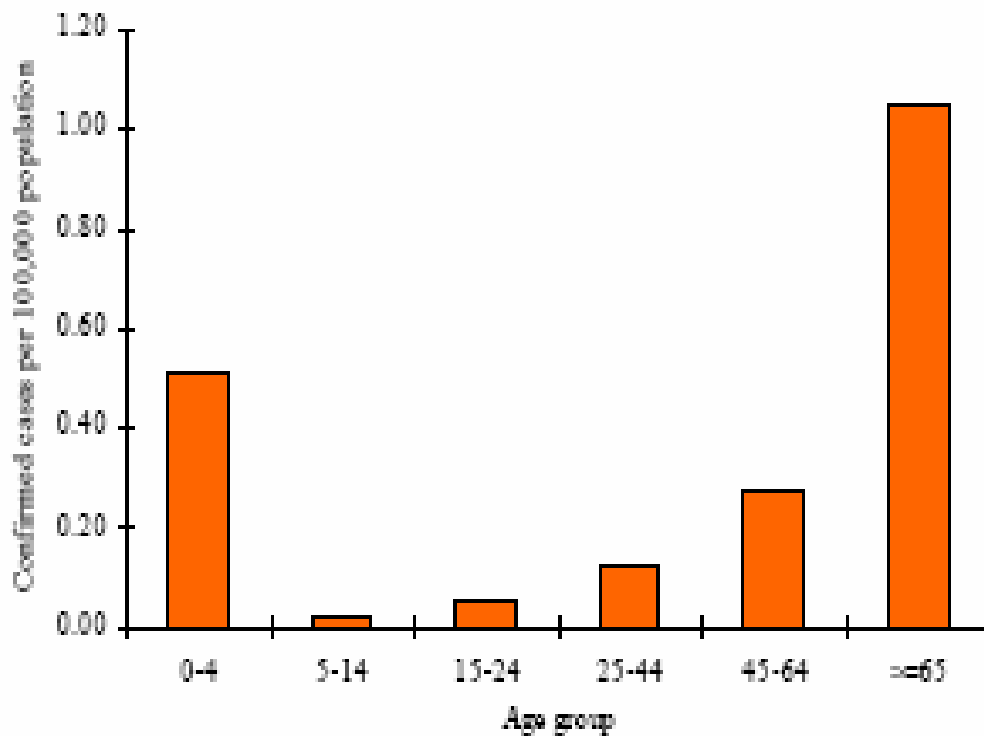
Risk Tolerant decision

# Risk (and not Hazard) Based Approach



EU Compliance Criteria for  
*L. monocytogenes*

Age-specific Distribution of  
Listeriosis in EU,  
High Risk for Young and Old



**Absence:** in RTE products intended for infants and for special medical purposes, must not be present in 25 g

**Limit:** must not be present in levels >100 cfu/g during the shelf life of the other RTE products

# Examples of Risk Ranking by NZFSA

- New Zealand Food safety Authority aims to achieve a measurable reduction in foodborne illness. It has developed strategies to control three major pathogens in the food supply: *Campylobacter*, *Salmonella* and *Listeria*.
- Campylobacteriosis is not usually severe, but it is the most frequently reported gastrointestinal infection in New Zealand, so the probability that it will occur is high. This ranks it high on NZFSA's list of priorities.
- Infection with *L.monocytogenes* is relatively uncommon but the consequences, including miscarriage and stillbirth, are severe, so it too ranks highly.
- In contrast, *Salmonella enteritidis* is a big problem in Britain and the US. It is one of the few *Salmonella* strains carried by poultry that can transfer from the shell to the middle of the egg and grow inside it. However, New Zealand does not have that particular strain in commercial flocks so the probability of foodborne illness occurring as a result of *S. enteritidis* ranks it low on NZFSA's list of priorities.

# End product criteria based on infective dose

Pathogenic organism	Minimum dose considered to cause disease <sup>1)</sup>	Probability of infection from exposure to 1 organism <sup>2)</sup>	General end-product criteria used <sup>3)</sup>
Infectious organism			
<i>Shigella</i>	1	$1.0 \times 10^{-3}$	Absence/ 25 gram
<i>Salmonella</i>	1	$2.3 \times 10^{-3}$	Absence/ 25 gram
<i>Campylobacter</i>	1-10	$7.0 \times 10^{-3}$	Absence/ 25 gram
<i>Listeria monocytogenes</i>	$> 10^3$		$< 100/$ gram
<i>Vibrio parahaemoliticus</i>	$> 10^4$		$< 10^3 /$ gram
Toxico-infectious organisms			
<i>Clostridium perfringens</i>	$> 10^6$		$< 10^5 - 10^6 /$ gram
<i>Bacillus cereus</i>	$> 10^6$		$< 10^5 - 10^6 /$ gram
Organisms causing intoxication			
<i>Staphylococcus aureus</i>	$> 10^6$		$< 10^5 - 10^6 /$ gram

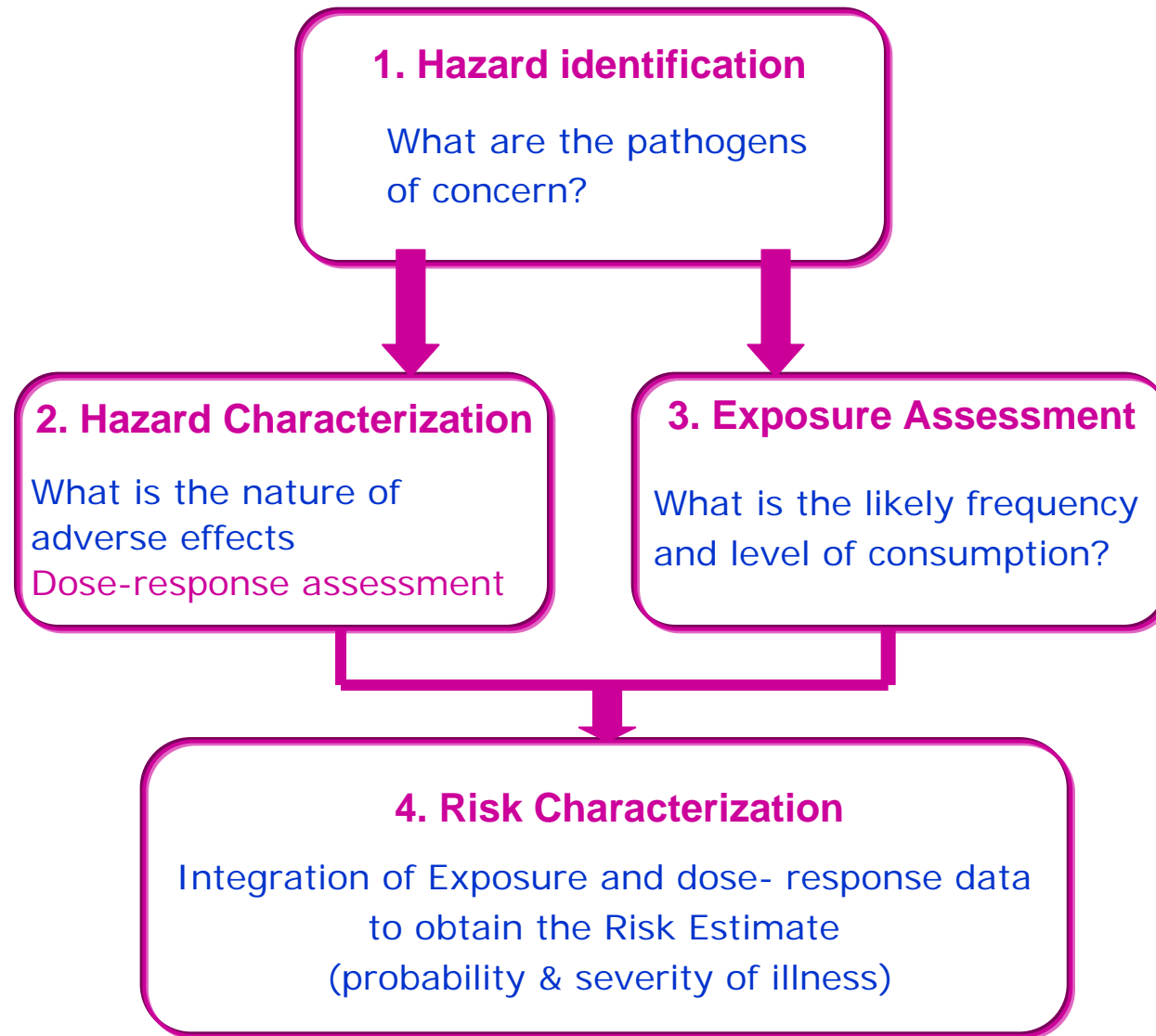
For different pathogens the dose for infection may vary and therefore from the risk Assessment point of view their limits in food products differ

# Risk Analysis Framework: Codex Alimentarius Commission



# Microbiological Risk Assessment

# Four steps in Microbiological Risk Assessment



# Risk Assessment of Salmonella in Chicken

## 1. Hazard Identification

- Salmonellosis- most frequently related foodborne illness; major food poisoning from poultry
- Chickens carry Salmonella in intestine & skin-meat contamination
- Poultry meat can appear cooked before it is pasteurized.

Table 3. Estimated incidence of food-borne salmonellosis in India:

Product	Minimum	Mean	Maximum
Poultry (Raw)	22,300	28,300	34,300
Eggs (Raw)	2,520,000	2,830,000	3,150,000
Beef (Raw)	273,000	405,000	535,000
Pork (Raw)	487,000	584,000	681,000
Milk & dairy products (Ready-to-eat)	0	241,000	561,000
Fish & seafood (Ready-to-eat)	0	1,410,000	3,520,000
Fruit & vegetables (Ready-to-eat)	0	12,600	50,500
<b>TOTAL</b>	<b>3,300,000</b>	<b>5,510,000</b>	<b>8,530,000</b>

Source: WHO.



## 2. Hazard Characterization

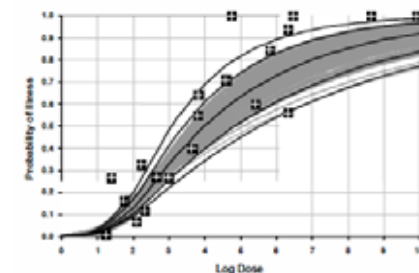
### Dose response assessment

- Data on the number of organisms present in food implicated in outbreaks

Table 2. Uncertainty ranges assigned to the variables in reported outbreak data

Out-break	Serovar	Log Dose (Uncertainty)		Response [Attack Rate] (Uncertainty)	
		Min	Max	Min	Max
1	S. Typhimurium	1.57	2.57	11.20%	12.36%
2	S. Heidelberg	1.48	2.48	28.29%	36.10%
3	S. Cubana	4.18	4.78	60.00%	85.71%
4	S. Infantis	6.06	6.66	100.00%	100.00%
5	S. Typhimurium	3.05	4.05	52.36%	57.64%
7	S. Newport	0.60	1.48	0.54%	2.59%
11	S. Enteritidis	4.00	5.00	100.00%	100.00%
12	S. Enteritidis	1.00	2.37	6.42%	7.64%
13	S. Typhimurium	8.00	8.88	100.00%	100.00%
18	S. Enteritidis	5.13	5.57	60.00%	60.00%
19	S. Enteritidis	6.03	6.48	87.70%	103.51%
20	S. Enteritidis	2.69	3.14	18.61%	36.41%
22	S. Enteritidis	6.02	6.47	52.17%	61.32%
23	S. Enteritidis	5.53	5.97	84.62%	84.62%
24	S. Enteritidis	1.45	1.89	12.19%	23.96%
25	S. Enteritidis	3.36	3.80	39.85%	39.85%
30	S. Enteritidis	3.53	3.97	60.14%	70.90%
31	S. Enteritidis	2.37	2.82	25.62%	30.04%
32	S. Enteritidis	1.11	1.57	26.92%	26.92%
33	S. Oranienburg	9.63	10.07	100.00%	100.00%

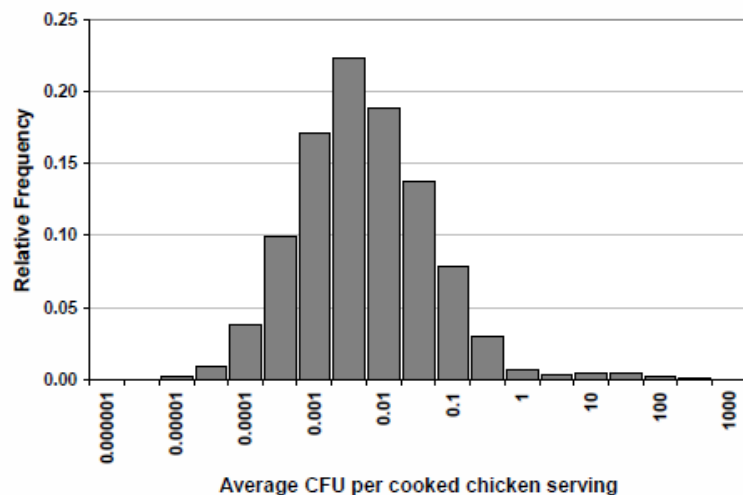
NOTE: "Outbreak" refers to the number of the outbreak as listed in the main report.



Source: MRA of Salmonella in eggs and broiler chicken, WHO/FAO 2002

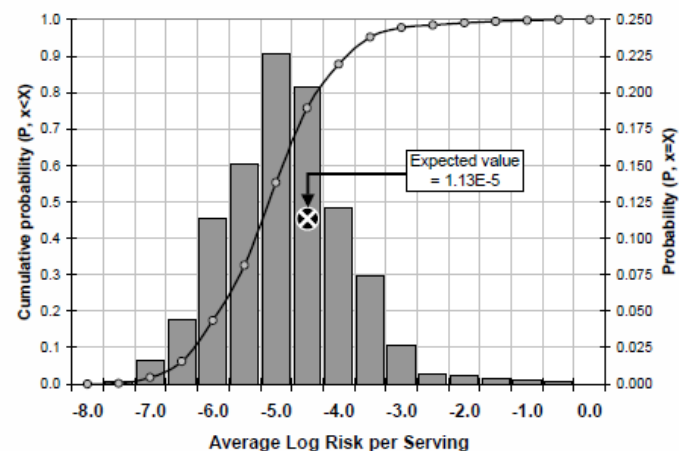
### 3. Exposure Assessment

- Level and distribution of microorganisms in the cooked product
- Size of serving portion
- Frequency of consumption



### 4. Risk Characterization

- Risk per serving



- Expected annual risk in a population

#### Calculation of expected annual risk.

Prevalence of contaminated carcasses	20%
Expected risk per serving	1.13E-05 (1.13 illnesses per 100 000 servings)
Number of servings in year	26
Annual expected risk	2.94E-04 (2.94 illnesses per 10 000 servings)
Rate of illness per 100 000	29.38

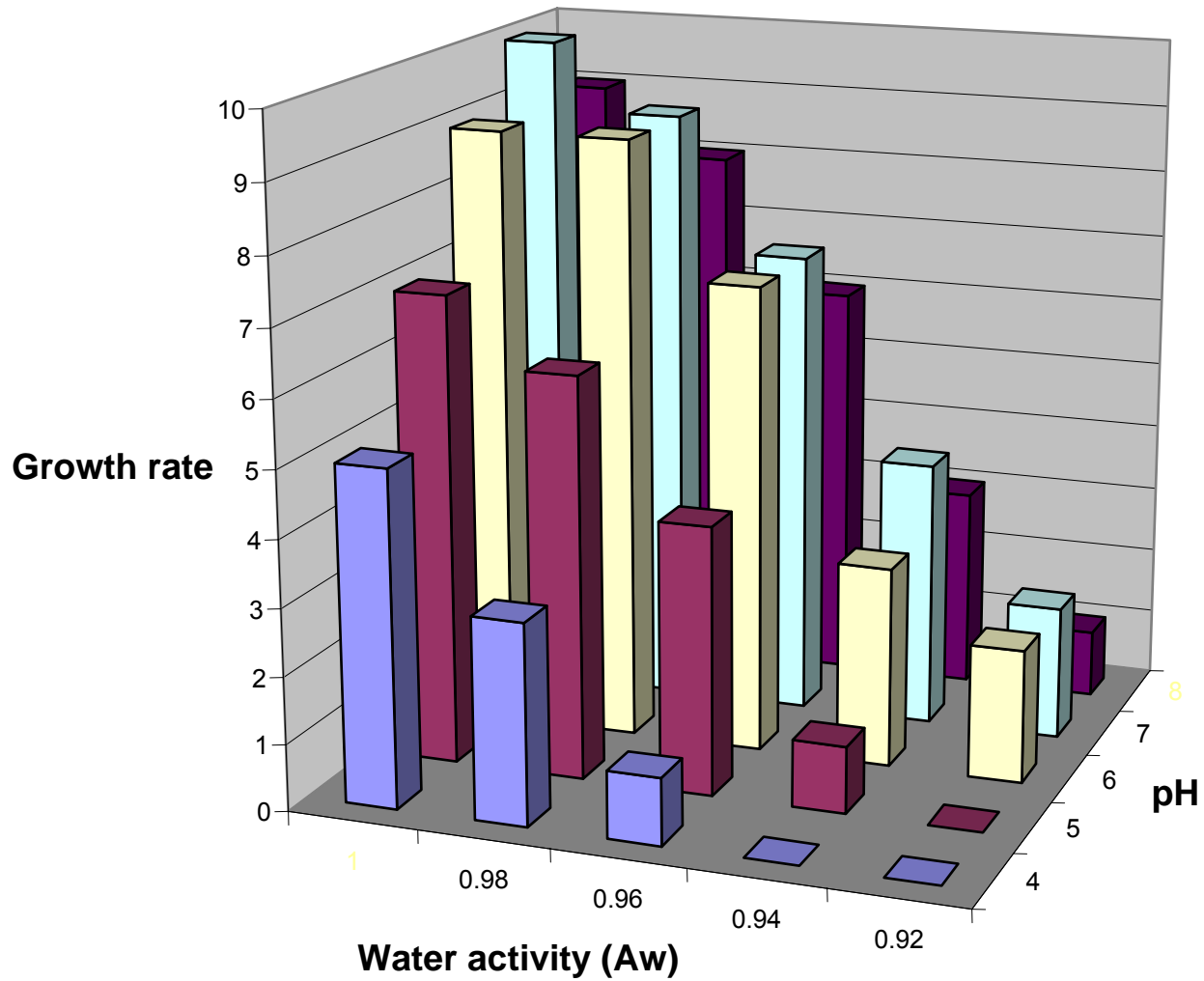
Illustrative calculation for annual expected number of illnesses for a country or region with this annual expected risk:

Population	20 000 000
Proportion of population that eats chicken	0.75
Potentially exposed population	15 000 000
Expected number of cases in the year	4406

# Information Sources

- Pathogen Modeling Program (PMP) Online  
<http://pmp.arserrc.gov/PMPOnline.aspx?ModelID=1&Aerobic=True>
- Combase Growth Predictive Tool  
<http://www.combase.cc/toolbox.html>
- European Food safety Authority  
<http://www.efsa.europa.eu/cs/Satellite>
- FoodRisk.org <http://www.foodrisk.org/>
- WHO <http://www.who.int/foodsafety/>
- Codex Alimentarius  
[http://www.codexalimentarius.net/web/index\\_en.jsp](http://www.codexalimentarius.net/web/index_en.jsp)

# Effect of pH + water activity on growth of *S.aureus*



**Environment**  
Temperature (C)

25

pH

6

NaCl(%)

Aw

1.8

0.990

Factor4:

0

Initial logc.

Phys. state

3

0.04505

Obs.time (h)

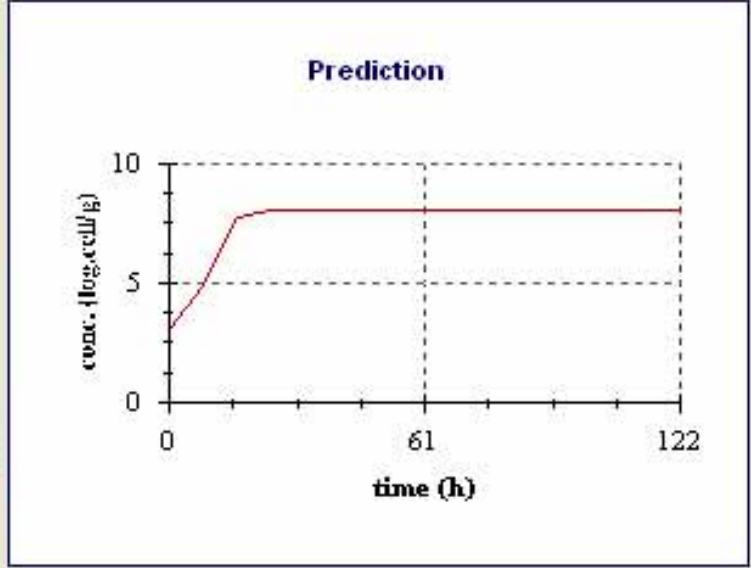
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*Staphylococcus aureus*

In broth

time(h)	conc.(log cells/g)
0.00	3.00
8.13	4.89
16.27	7.75
24.40	8.09
32.53	8.09
40.67	8.09
48.80	8.09
56.93	8.09
65.07	8.09
73.20	8.09



**Max rate (log conc/h)**  
0.3975

**Doubling time (h)**  
0.76

**Model region**

	Temp (C)	pH	Aw
min	7.5	4.3	0.907
max	30	7.1	1

**Predict**

**Exit**

**Zoom In**

**Help**

Growth model: Baranyi, J. and Roberts, T. A. (1994): A dynamic approach to predicting bacterial growth in food. International Journal

**Environment**

Temperature (C)

pH

NaCl(%)      Aw  
     

Factor4

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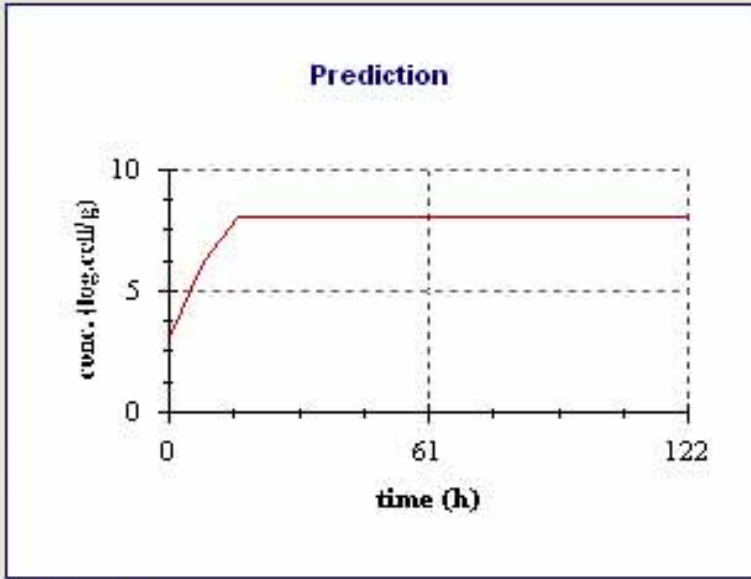
Initial logc.      Phys. state  
     

Obs.time (h)     

For default values, leave these boxes empty

*Staphylococcus aureus*      In broth

time(h)	conc.(log cells/g)
0.00	3.00
8.13	6.20
16.27	8.08
24.40	8.09
32.53	8.09
40.67	8.09
48.80	8.09
56.93	8.09
65.07	8.09
73.20	8.09



**Max.rate (log conc/h)**  
 0.5604

**Doubling time (h)**  
 0.54

**Model region**

	Temp (C)	pH	Aw
min	7.5	4.3	0.907
max	30	7.1	1

**Predict**

**Exit**

**Zoom In**

**Help**

Growth model: Baranyi, J. and Roberts, T. A. (1994): A dynamic approach to predicting bacterial growth in food. International Journal

# Risk Assessment in Different Contexts

- Product Pathogen Pathway- Absolute risk assessment
  - Specific pathogen/ specific food (e.g. *E. sakazakii* in infant formula)
- Risk ranking- Relative risk estimate
  - One pathogen/ multiple foods (*L. monocytogenes* in Milk/ Ice cream/ fermented meat products etc)
  - Multiple pathogens/ One food
- Geographic risk evaluation- Risk of introduction in a new region (e.g. Avian Flu/ BSE)

# Example of using Risk Based Approach in the Food Industry

# Chemical Vs. Microbiological Hazards

## Chemicals

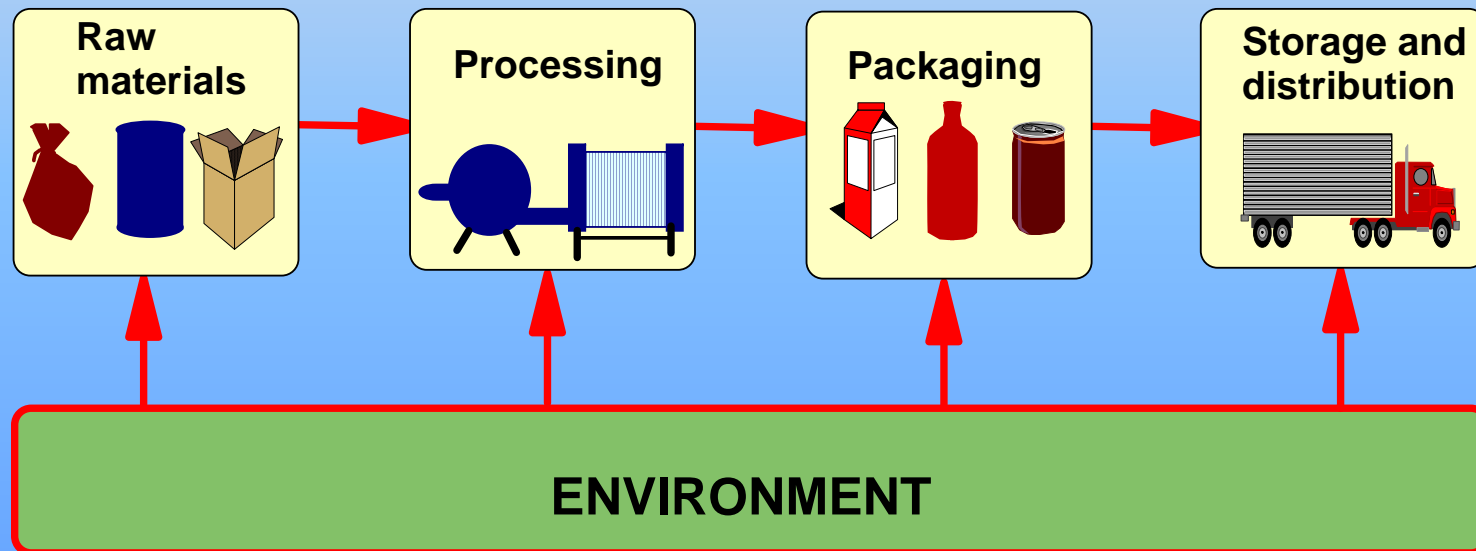
- Levels unchanged
- May not be destroyed cooking
- Often homogeneous distribution
- Not transmitted
- Consumer has less responsibility for safety
- Mostly chronic exposure

## Microorganisms

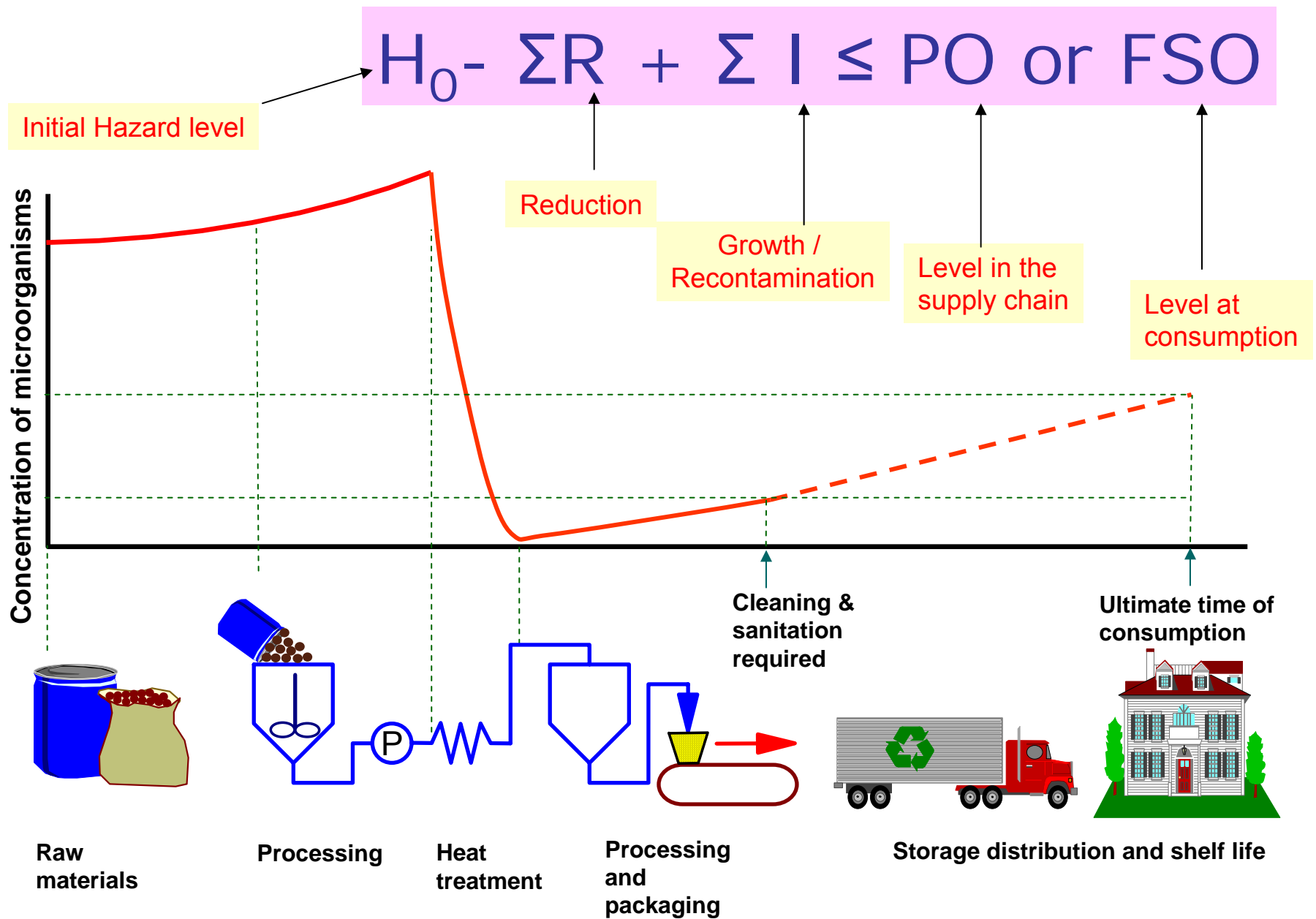
- Levels can be contained
- May be destroyed by cooking
- Heterogeneous distribution
- Person-to-person transmission
- Role of the consumer in ensuring safety is essential
- Acute exposure

# Sources of infection

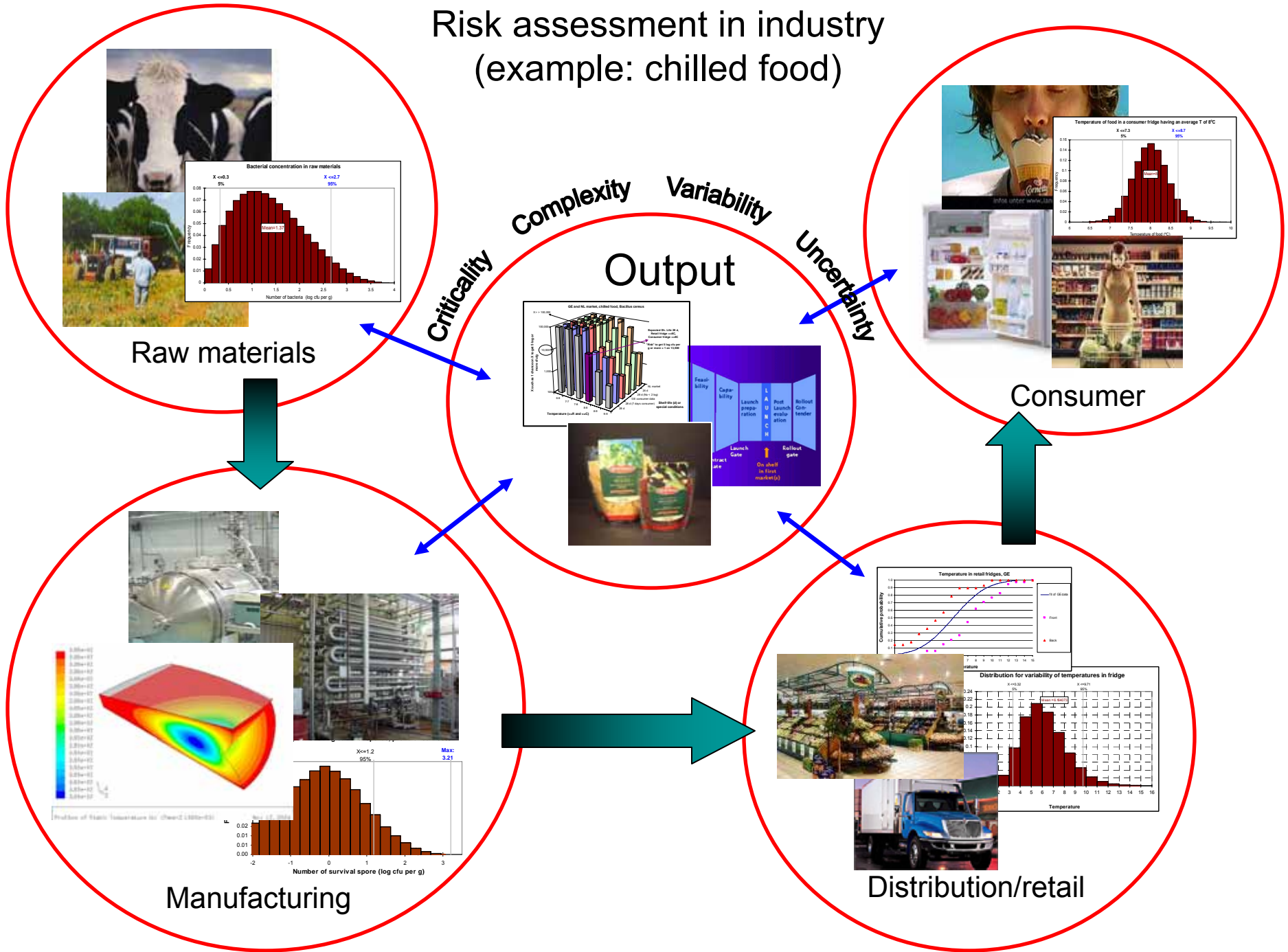
- during processing & distribution



\* ICMSF's conceptual Equation



# Risk assessment in industry (example: chilled food)



Thank you

