Topic 3 - Lecture 3

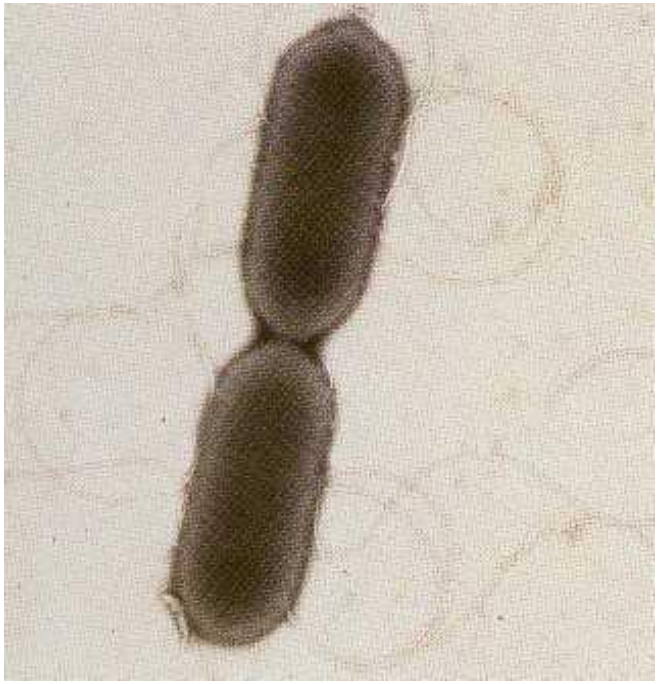
Microbiological Risk Assessment: Example - The FAO/WHO *Listeria monocytogenes* risk assessment

Purpose of lecture

- Introduce the reasons for the FAO/WHO *Listeria monocytogenes* risk assessment
- Explain how the MRA was performed
- Show some of the outcomes
- Present the answers given to the questions formulated by the CCFH

Listeria monocytogenes
Background information

- May cause listeriosis when present in high numbers in food
- Food-borne - can grow at chill temperatures
- Ubiquitous



Listeriosis

- Relatively rare, but serious disease
- High-risk groups include pregnant women, newborn babies, immunocompromised
- Incidence is 0.3-10 cases per million persons in Europe, USA, Australia
- “High case-fatality" rate that largely affects specific higher-risk segments of the population

Sources of food-borne listeriosis

Typically ready-to-eat (RTE) foods with a long shelf-life e.g.:

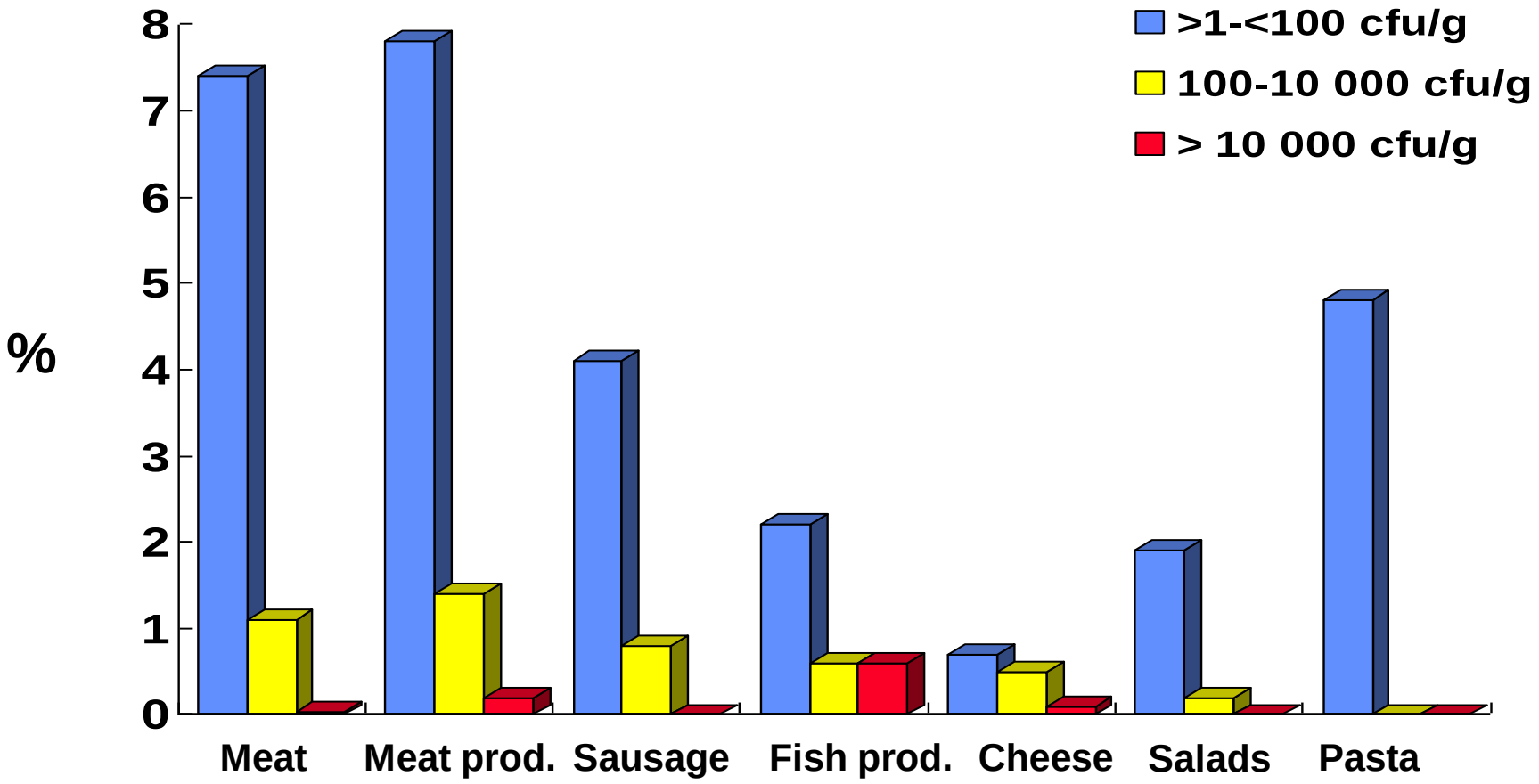
- Soft cheese
- Meat products
- Smoked fish
- Deli salad

Product contamination

Product	Total	Positive for *L. monocytogenes*	
		Number	%
Soft cheeses (white)	2 931	5	0.17
Blue cheese	1 623	23	1.42
Other soft cheeses	1 347	14	1.04
Packed salads	2 966	22	0.74
Meat, luncheon	9 199	82	0.89
Deli salads	8 549	202	2.36
Fish salads	2 446	115	4.70
Smoked fish	2 644	114	4.31
Total	31 705	577	1.82

Gombas et al. 2003. JFP, 66: 559-569

L.m. in German food (1990s)



L. monocytogenes regulatory policies

- "Zero tolerance" (i.e. < 1/25 g)
- < 100 L.m./g food (at the moment of consumption)
- Guidelines on the Application of General Principles of Food Hygiene to the Control of Listeria monocytogenes in Ready-to-Eat Foods

Need for risk assessment

CCFH decided to commission an MRA…

to evaluate different

microbiological criteria

and control measures

CCFH formulated three questions…

to be addressed by the risk assessors

L.m. MRA commissioning (1)

Question 1

Estimate the risk of serious illness from L.m. in food when the numbers range from absence in 25 g to 1 000 cfu/g or ml, or when numbers do not exceed specified limits at the point of consumption

CAC, 2000

L.m. MRA commissioning (2)

Question 2

Estimate the risk of serious illness for consumers in different population groups (elderly, infants, pregnant woman and immunocompromised patients) relative to the general population

CAC, 2000

L.m. MRA commissioning (3)

Question 3

Estimate the risk of serious illness from L.m. in foods that support its growth and in foods that do not support its growth under specific storage and shelf-life conditions

CAC, 2000

FAO/WHO MRA initiative

FAO and WHO

- Called upon various experts in the field of food microbiology, epidemiology, food technology and microbiological risk assessment
- Launched a worldwide call for data pertinent to the questions to be addressed

Scope of the MRA

Only ready-to-eat (RTE) foods were to be considered

The following foods were selected for the assessment:

- Pasteurized milk
- Ice-cream
- Fermented meat
- Cold smoked fish

From retail level to consumption

Data

- The call for data was partially successful
- Most data were from industrialized countries
- Risk assessment models and data from the USA were particularly useful

The Risk Assessment

Microbiological Risk Assessment

Hazard identification

potential danger

Exposure assessment

N

Hazard Characterisation

P(*N*)+severity

Risk Characterisation

Probability and severity including variability and uncertainty

Slide courtesy of M. Zwietering

Hazard Identification

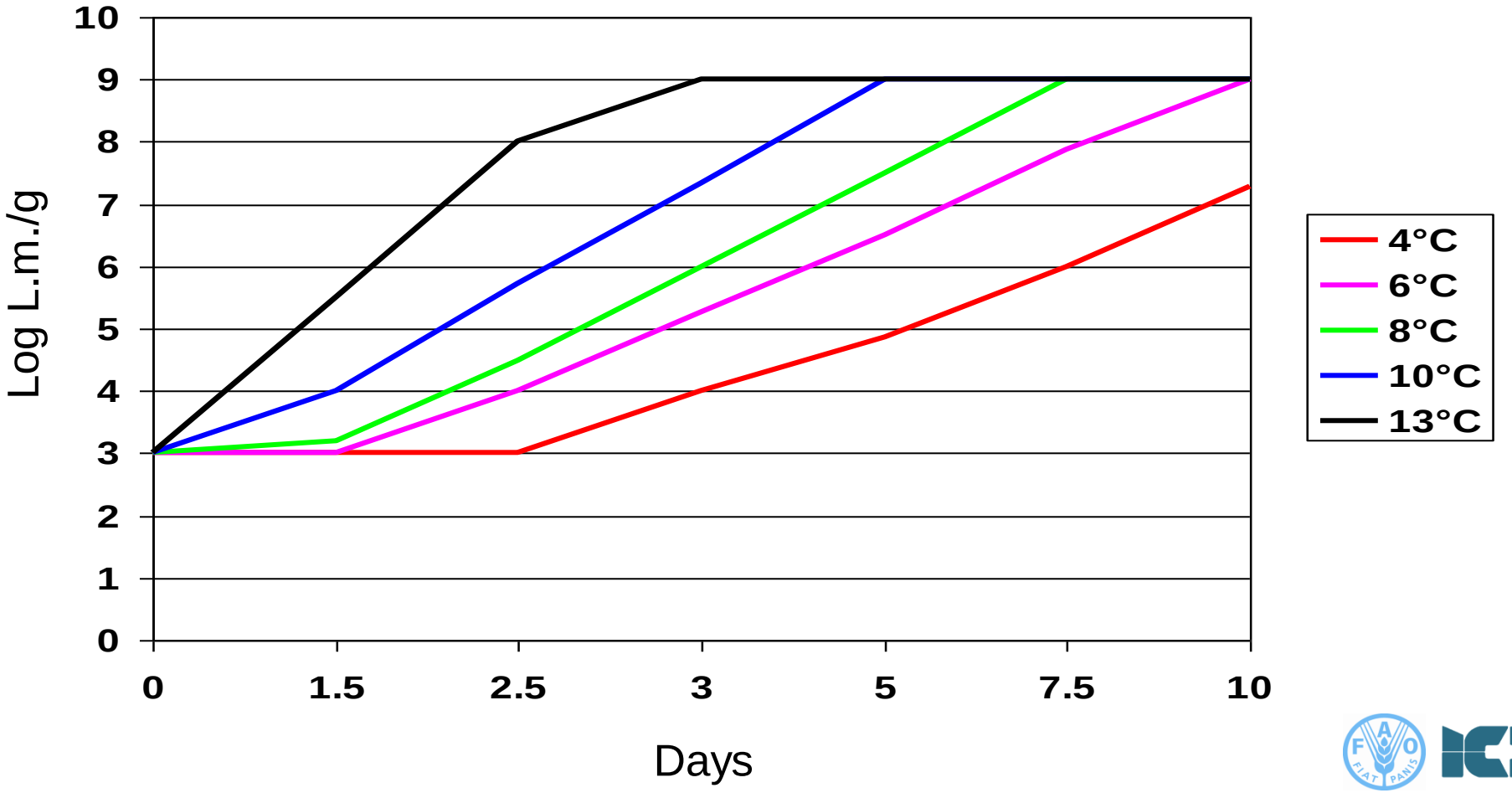
Focus on *Listeria monocytogenes* in ready-to-eat foods

Description of the hazard

Growth limits for L.m.	Minimum	Optimum	Maximum
Temperature °C	-0.4	37	45
pH	4.4	7.0	9.4
Water activity	0.92	-	-

ICMSF, 1996

Description of the hazard: effect of temp. on growth



Persistence in factory environments

Food	Persistence	Country	Implicated in illness?
Cheese	4 years	Switzerland	Yes
Cheese, blue-veined	7 years	Sweden	No
Ice-cream	7 years	Finland	No
Smoked mussels	3 years	New Zealand	Yes
Cold smoked salmon	4 years	Denmark	No
Trout, gravad/smoked	11 months	Sweden	Yes (gravad)
Smoked trout, gravad salmon	> 4 years	Sweden	Possibly
Pâté	2 years	UK	Yes
Jellied pork tongue and rillets	8 years	France	Yes
Cooked poultry	1 year	Ireland	No
Cooked poultry	12 years	USA	Yes

Hazard Characterization

Severity

- The young, old, diseased and immunocompromised and pregnant women are more susceptible
- Invasive forms of listeriosis, such as septicaemia, meningitis, miscarriage and death, were chosen as the “end-points” in this MRA
- Main vehicles of food-borne listeriosis have been shown in previous slides

Dose response relationship

- The response to exposure is highly variable
- Some of the factors involved are:
  - The virulence of the strain
  - The susceptibility of the host
  - The food matrix
  - The number of L.m. ingested

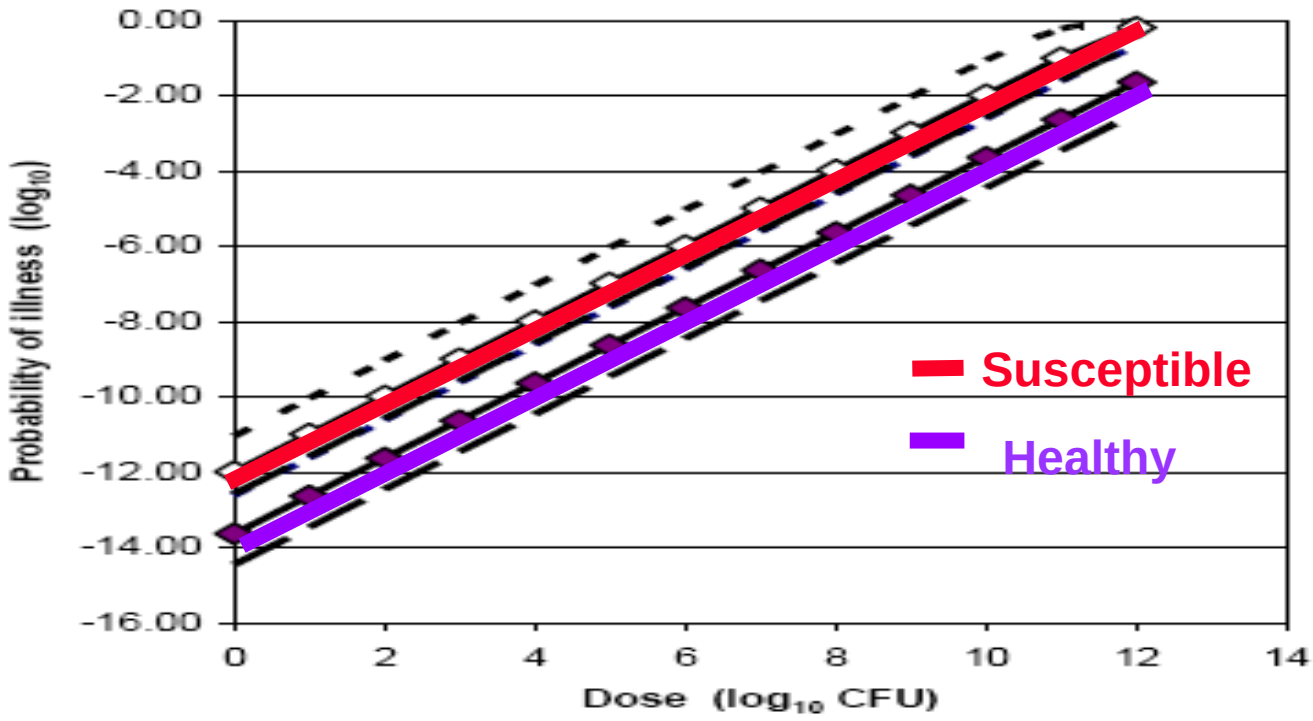
Dose response models

- Various models exist, most of which assume that one cell can cause an infection
- An exponential model was chosen
- With this model the probability of infection is expressed with a parameter called the “r-value”
- Epidemiological and exposure data were used to estimate the “r-value”

"r-values" used

Used for question	Population	Median	5% percentile	95% percentile
Q1 (levels)	Susceptible	5.8 x 10-12		
Q2 (consumers)	Healthy	5.3 x 10-14		
Q3 and the 4 product examples	Susceptible Healthy	1.0 x 10-12 2.4 x 10-14	2.5 x 10-13 3.5 x 10-15	9.3 x 10-12 2.7 x 10-13

Dose response relationship



Exposure Assessment

Exposure assessment

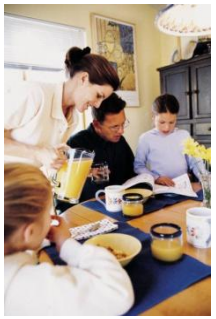
- Questions did not need a “farm to fork” approach
- Changes in frequency and extent of contamination in the selected products were studied and modelled between retail and consumption
- Consumption patterns (size and number of servings) were estimated
- “What if” scenarios were considered for milk and smoked salmon

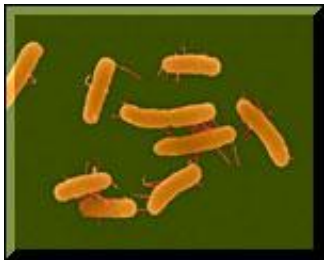
Characteristics of the products

- Milk: pasteurized, low L.m. contamination, supports growth, high consumption
- Ice-cream: as for milk, but does not support growth
- Fermented meat: frequently contaminated, no “killing step” during production, no growth (even some decrease), low consumption
- Cold smoked fish: as for fermented meat, but supports growth

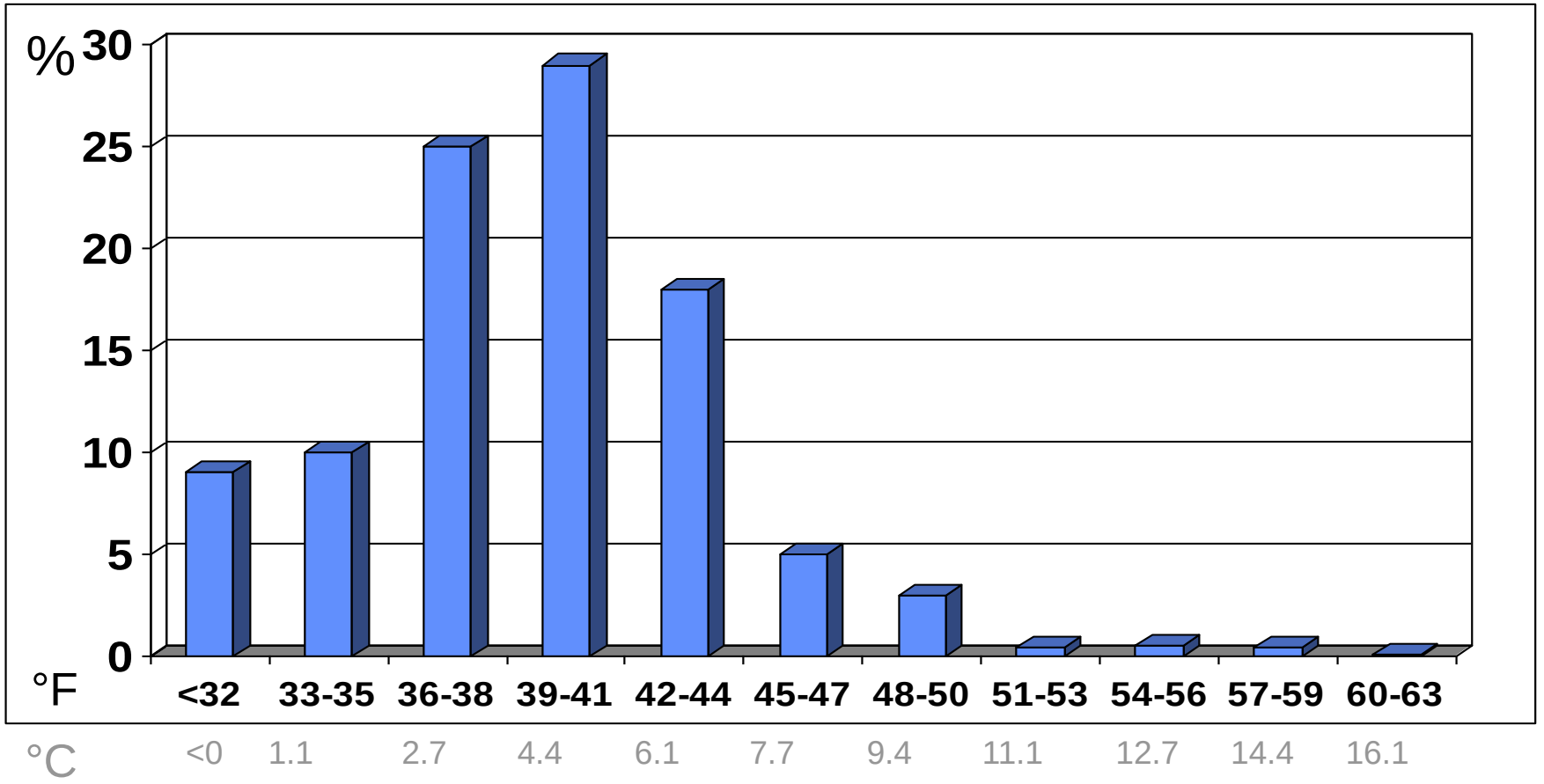
Inputs to exposure assessment

- Prevalence and concentration characteristics at retail
- Product characteristics
- Product storage characteristics and growth characteristics of *Listeria* under such conditions
- Consumption characteristics
- Proportion consumed by more susceptible population groups

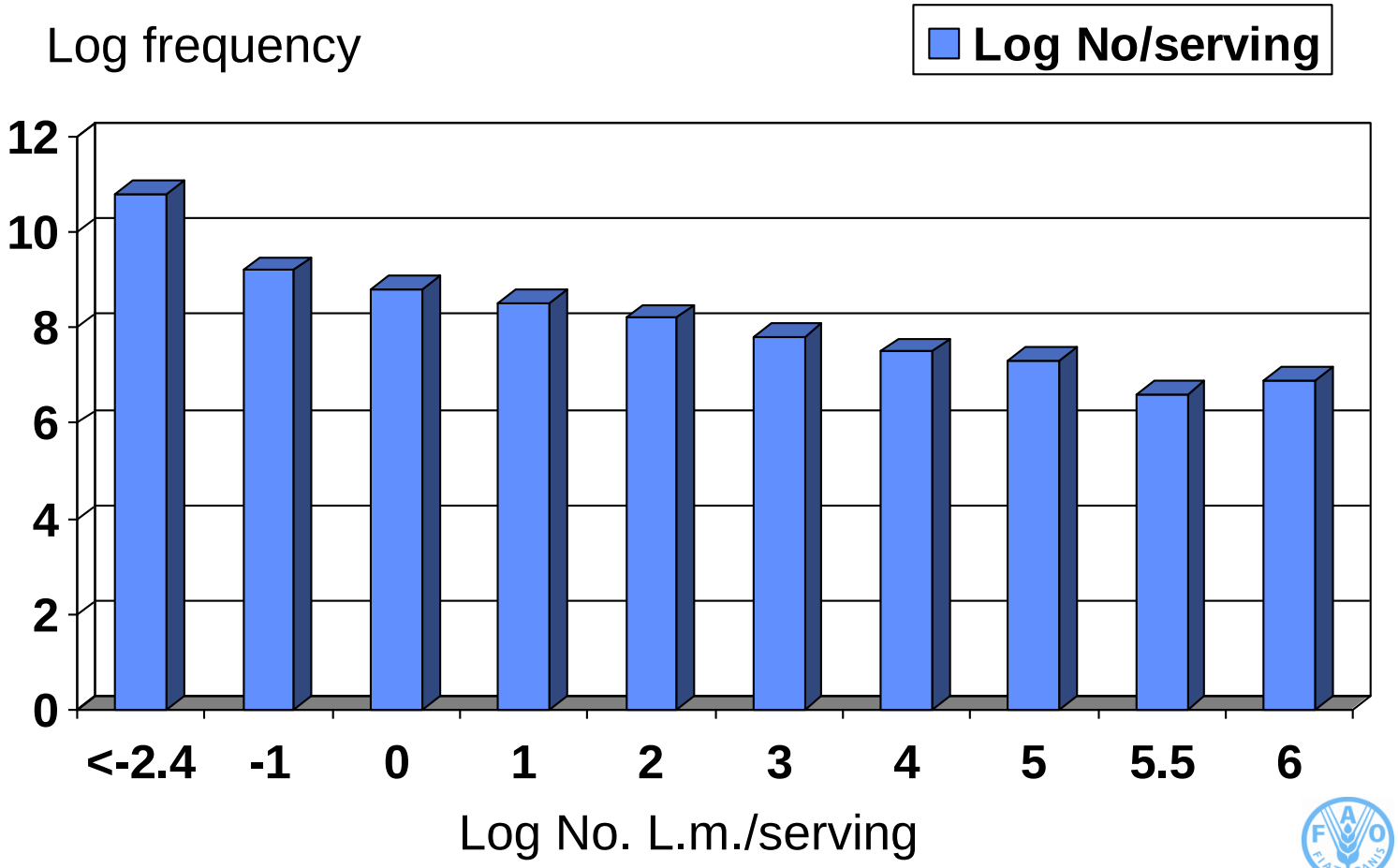




Inputs: Household refrigerator temps (USA)



Inputs: Distribution of L.m. in servings



Risk Characterization

Risk characterization

- The dose-response models and exposure data were used to calculate the probability of contracting listeriosis
- Risks per million servings for healthy and susceptible populations were estimated
- The number of illnesses per 10 million persons per year was also a model output

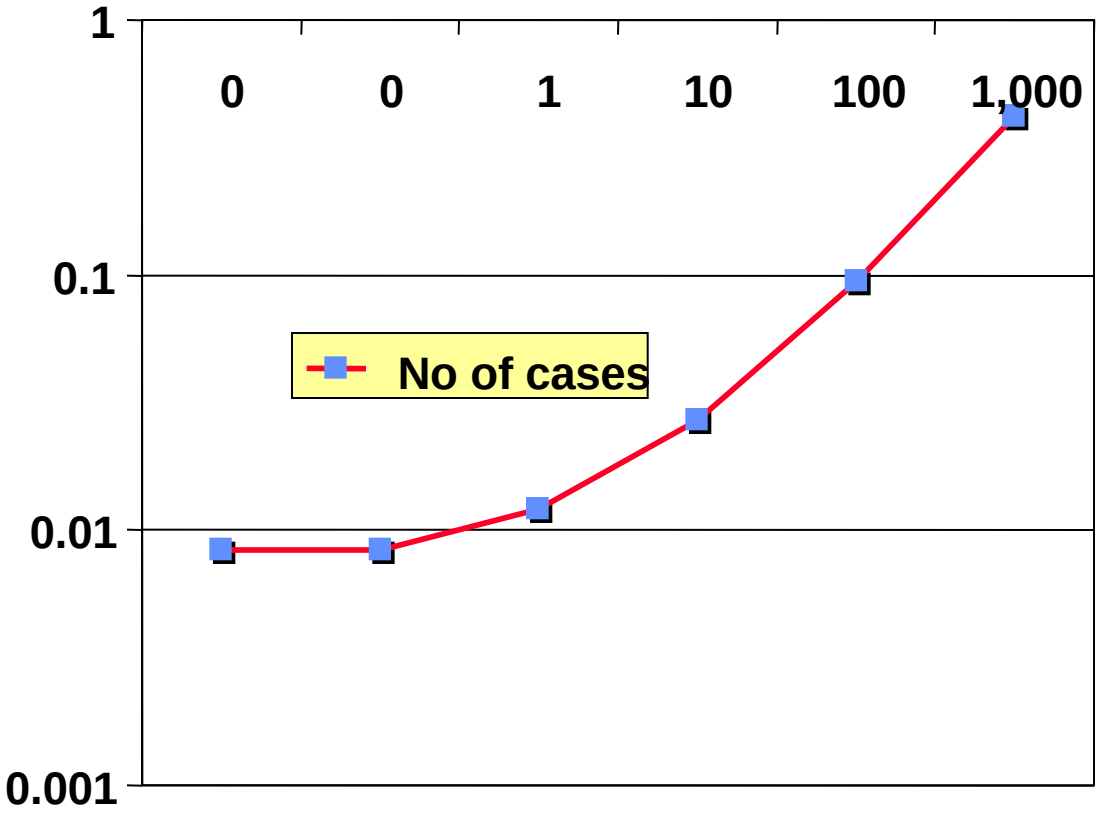
Two risk estimates

Food	Mean cases of listeriosis per 10 million people per year	Mean cases of listeriosis per million servings
Milk	9.1	0.005
Ice-cream	0.012	0.000014
Fermented meat	0.00055	0.0000021
Smoked fish	1.6	0.053

Response to Question 1

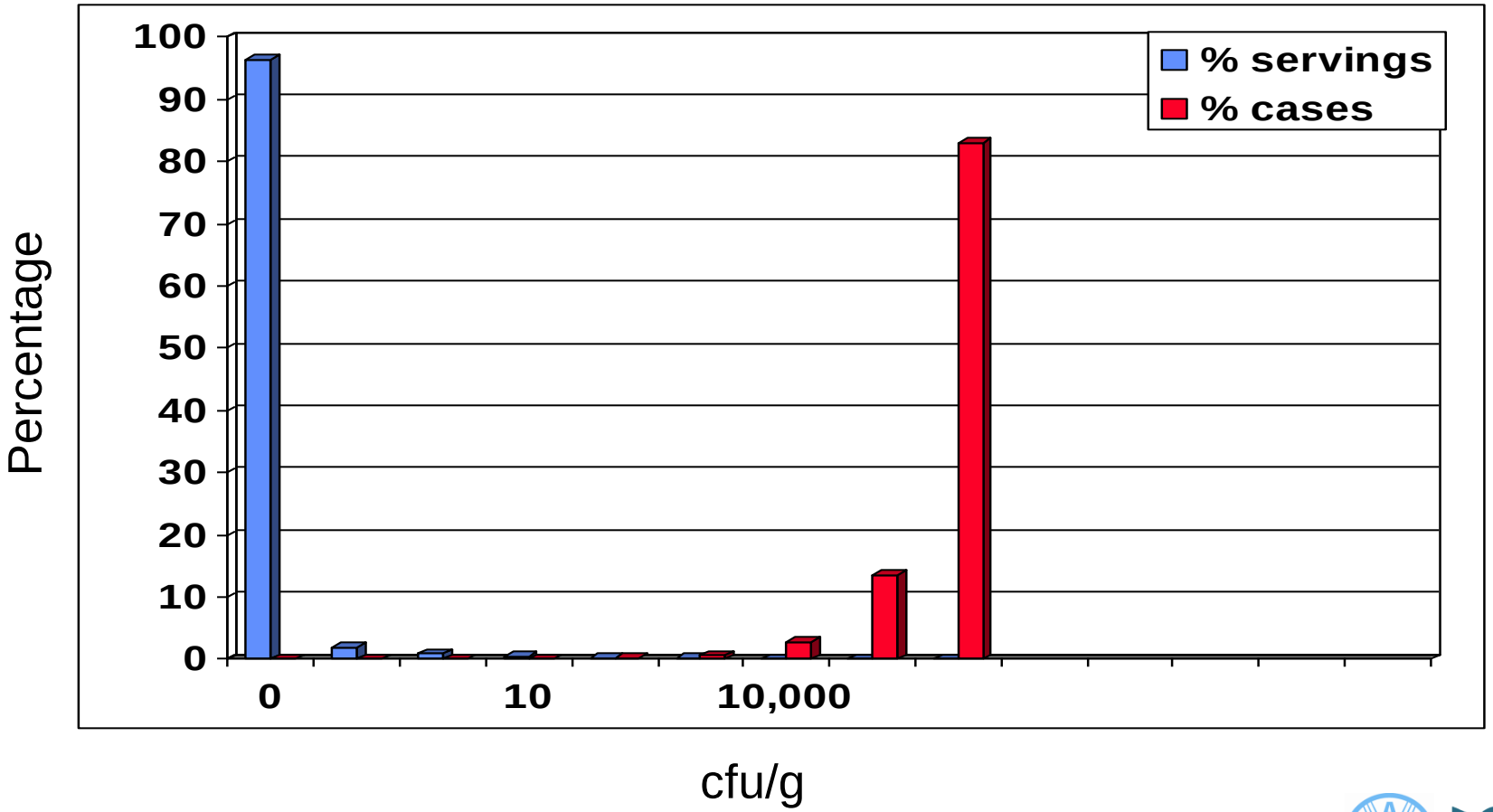
Estimated number of listeriosis cases as a consequence of contamination level

No. of cases/ million susceptible people/ year

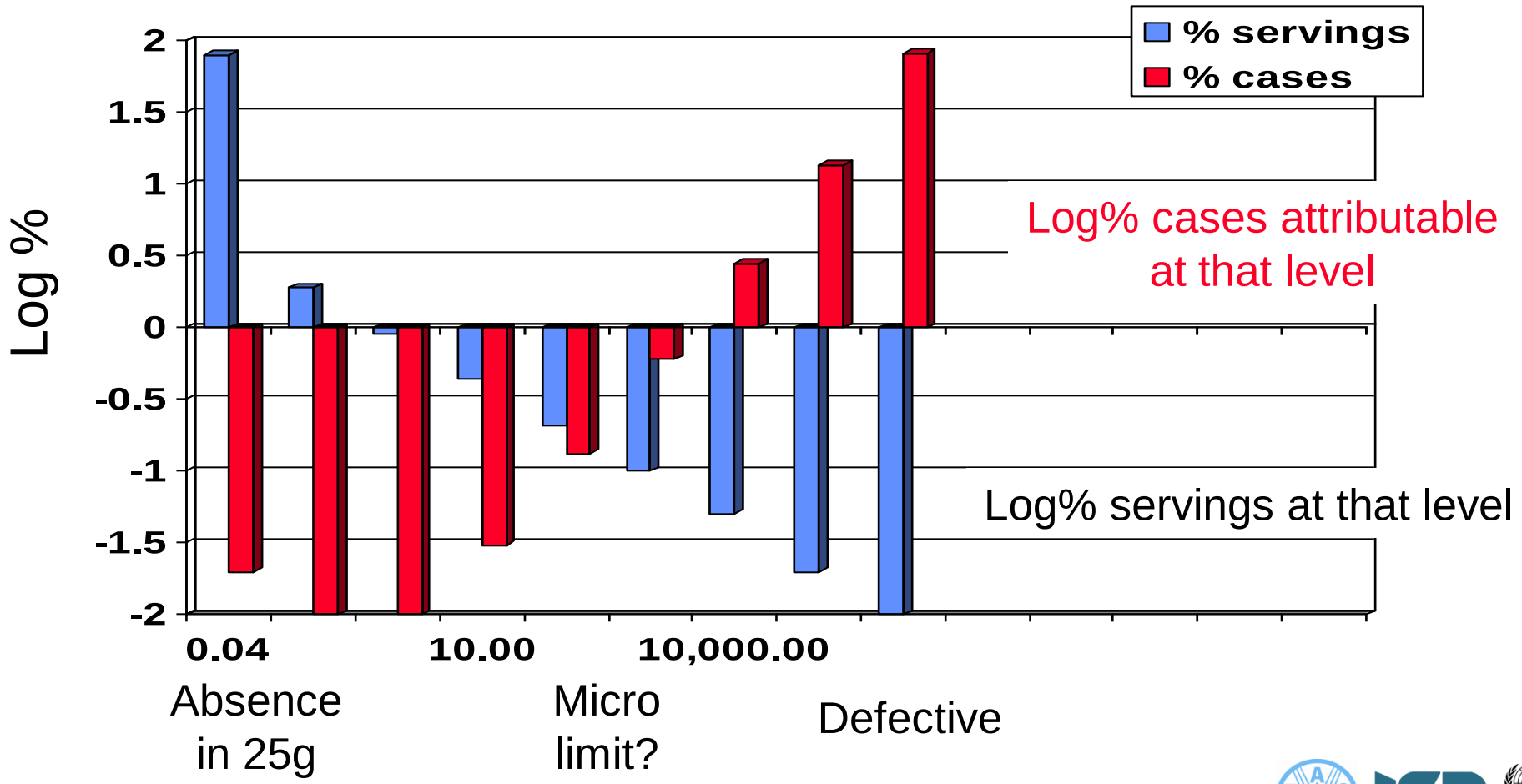


No of L.m./g

Relationship between dose and incidence due to that dose (1)



Relationship between dose and incidence due to that dose (2)



Influence of microbial limit on incidence in relation to % of "defectives"

% "detective" servings	Predicted no. of listeriosis cases * when:	
	absent in 25 g	< 100/g
0	0.002	0.02
0.00001	0.006	0.025
0.0001	0.04	0.61
0.001	0.42	0.44
0.01	4.23	4.25
0.1	42.3	42.3
1	419	419

"Defective" servings assumed to contain ≥ 10^6 L.m./g

* In the USA per Mill population

Response to Question 2

Susceptibility of various populations

Condition	Relative susceptibility	Calculate "r-value"
Transplant	2 584	1.4×10^{-10}
Aids	865	4.6×10^{-11}
Cancer – pulmonary	229	1.2×10^{-11}
Diabetes	25	1.3×10^{-12}
> 65 years old	7.5	4.0×10^{-13}
< 65 years old, healthy	1	5.4×10^{-14}

Response to Question 3

Abbreviated answers

- The potential for growth of L.m. strongly influences the risk of contracting listeriosis
- The extent is dependent on the characteristics of the food and the conditions and duration of refrigerated storage
- The increase in risk may be a factor between 100 and 1 000

Limitations and caveats

No MRA is complete without a listing of the uncertainties, variabilities, assumptions, lack of data etc. that influence the outcomes

In the FAO/WHO report they are summarized
in 9 bullet points

Limitations: examples

- Uncertainties and variability in the MRA because:
  - Reality was simplified
  - Quantitative data on L.m. contamination were limited and restricted primarily to European foods
  - Prevalence and number data for L.m. in foods came from many different sources, adding to uncertainty and variability
  - Consumption characteristics came mainly from the USA and Canada
- The dose-response curve used in some of the calculations was one for the susceptible population; thus some risks may be over-estimated.

Key points

- Estimating risk can be very useful for risk managers in their decision-making
- The way in which an MRA is conducted and the outcomes depend largely on the questions that need to be addressed
- Communication between risk managers and assessors is essential for the best use of the resources and the interpretation of the outcomes of the MRA
- The outcomes should be carefully presented, anticipating and preventing misinterpretations