Participatory risk assessment I

- Introduction -

‘Learning Event’ on risk analysis and participatory methods
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Outline

- Food safety in informal market
- Participatory Risk Analysis
- Monte Carlo simulation
- Key distributions

Why food safety?

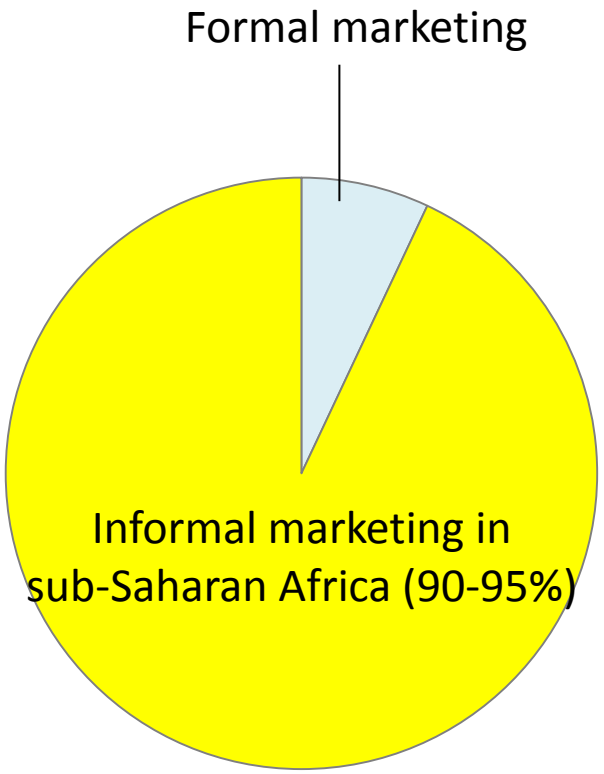
- Every year, at least 2 billion cases of diarrhea occur and 1.5 million children under 5 yrs die worldwide
- Poor, young, elderly, pregnant women and immune-suppressed most affected
- Food borne diseases include non-diarrheal severe zoonoses

Why animal source foods?

- Two-thirds of human pathogens are zoonotic – many of these transmitted via animal source food
- Animal source food is a single most important cause of food-borne disease
- Many food-borne diseases cause few symptoms in animal host
- Many zoonotic diseases controlled most effectively in animal host/reservoir

Dominance of informal markets in developing countries

"Absence of structured sanitary inspection"



Informal ≠ Illegal

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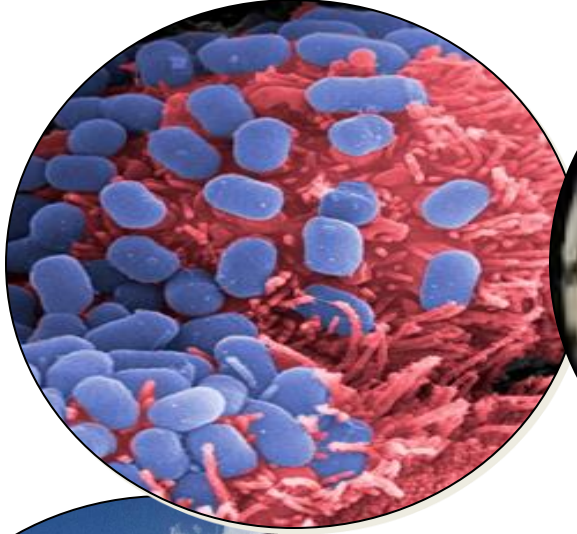
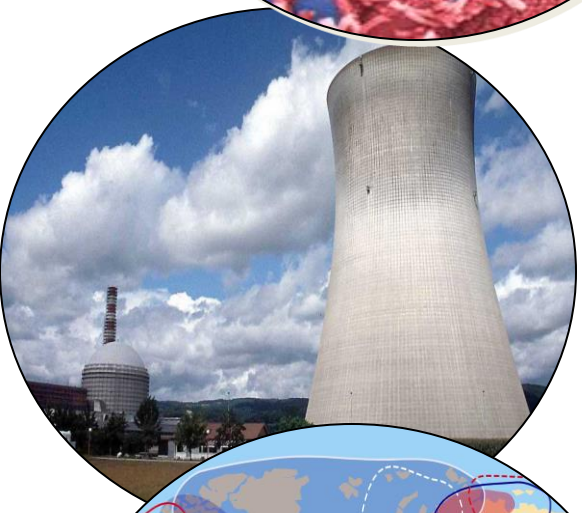
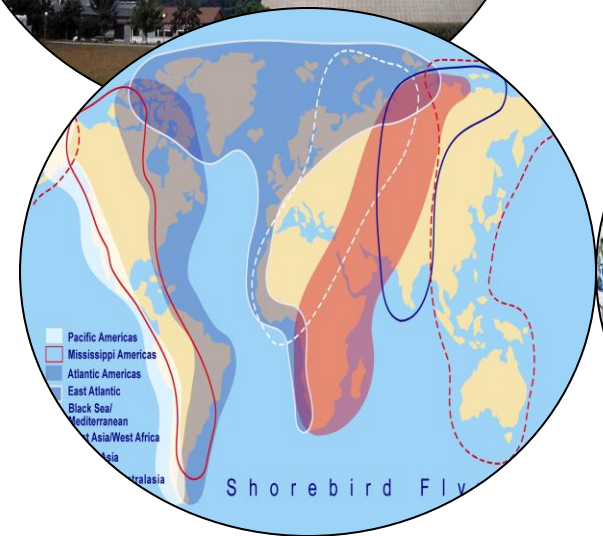
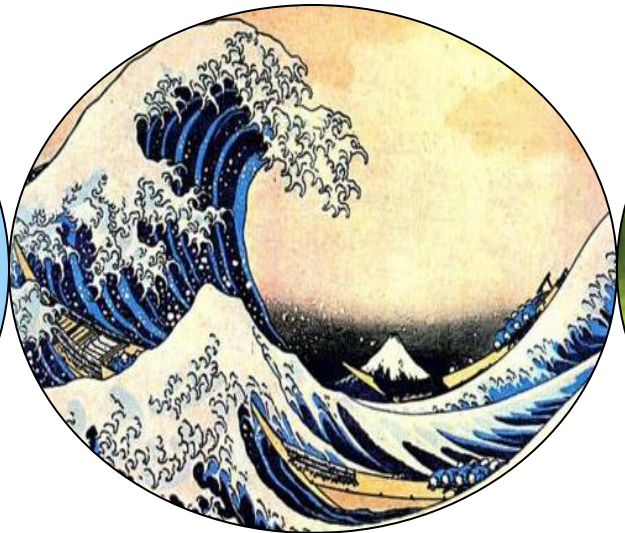




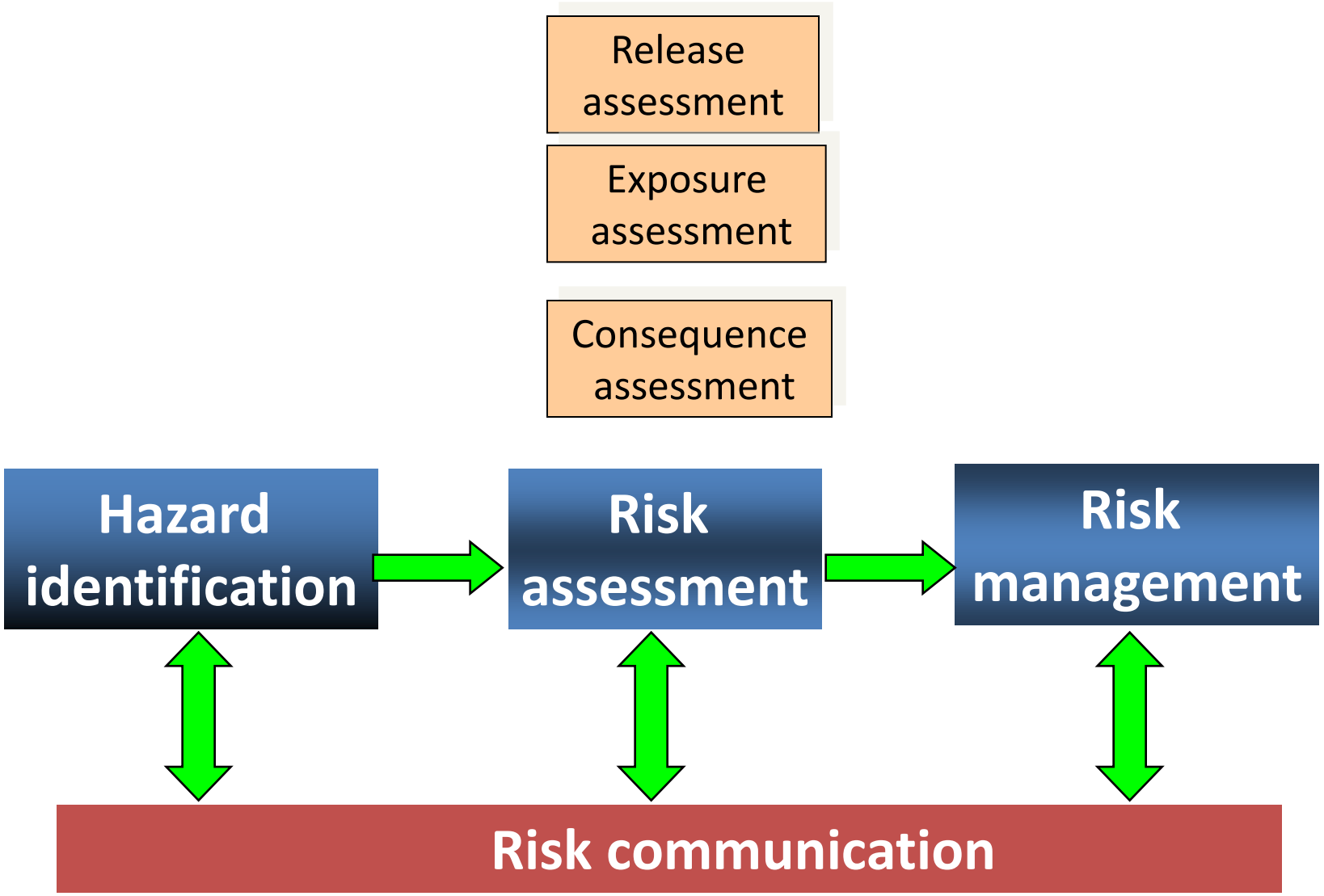
Risk analysis

A tool for decision-making
under uncertainty

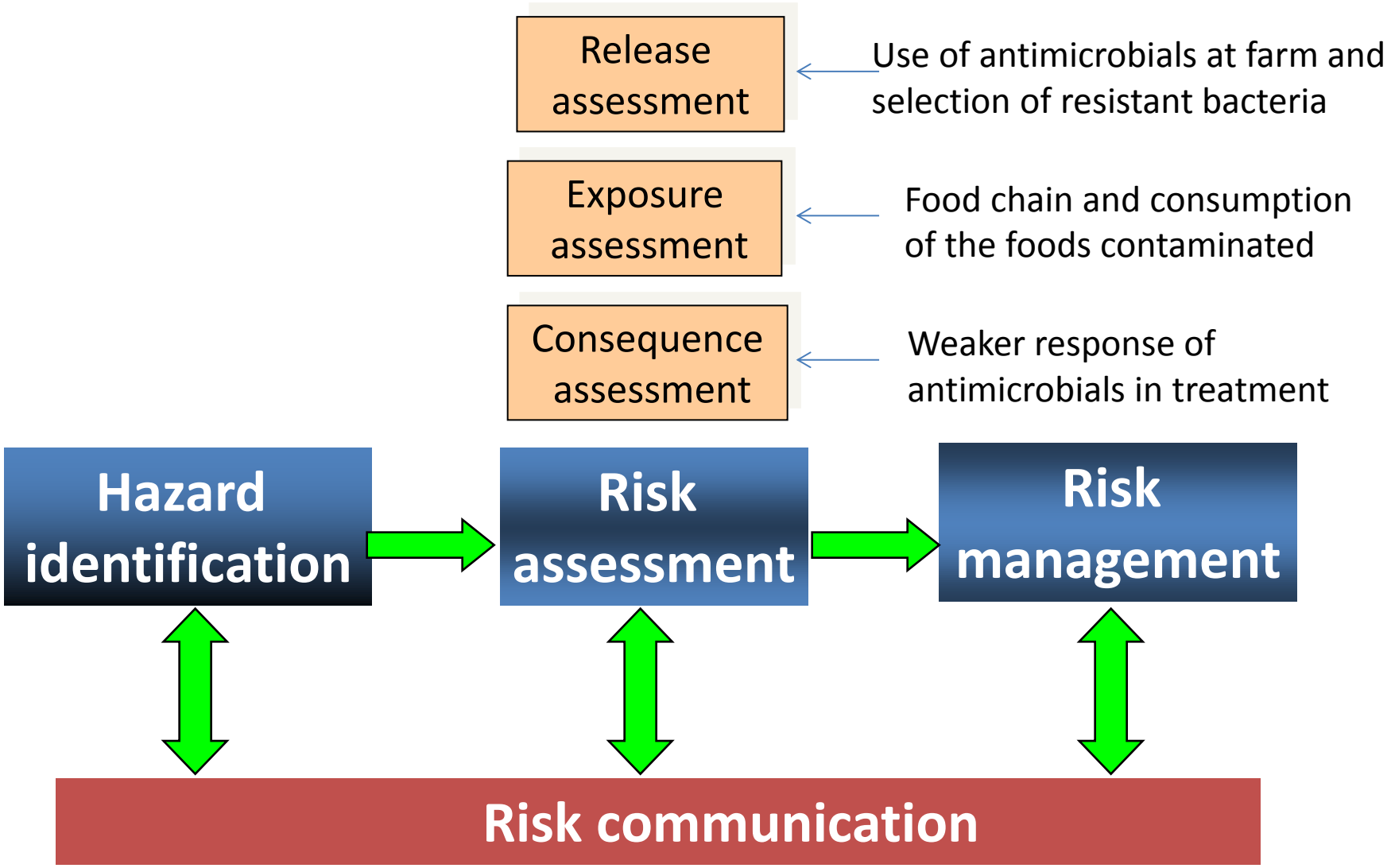




OIE Import Risk Analysis



OIE Risk analysis for antimicrobial resistance



Hazard Analysis and Critical Control Point (HACCP) system

- Adopted by Codex Alimentarius Commission
- Science based and systematic system which identifies specific hazards and measures for their control to ensure the safety of food

Codex Alimentarius Commossion

Food safety risk analysis

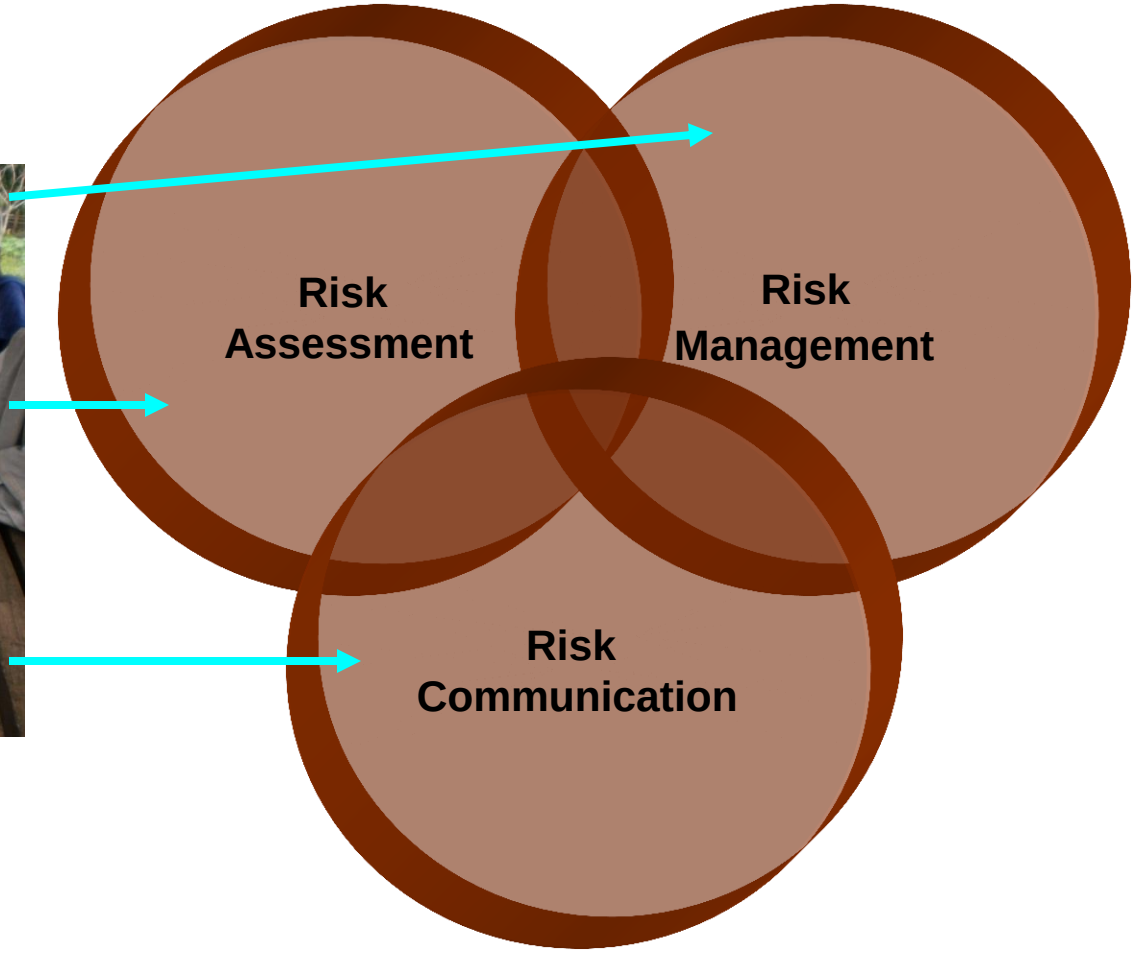
A tool for decision-making under uncertainty

*Risk is a probability of occurrence of a scenario and its size of impact (Vose, 2008)

Food safety risk analysis

in informal marketing system

Participatory methods

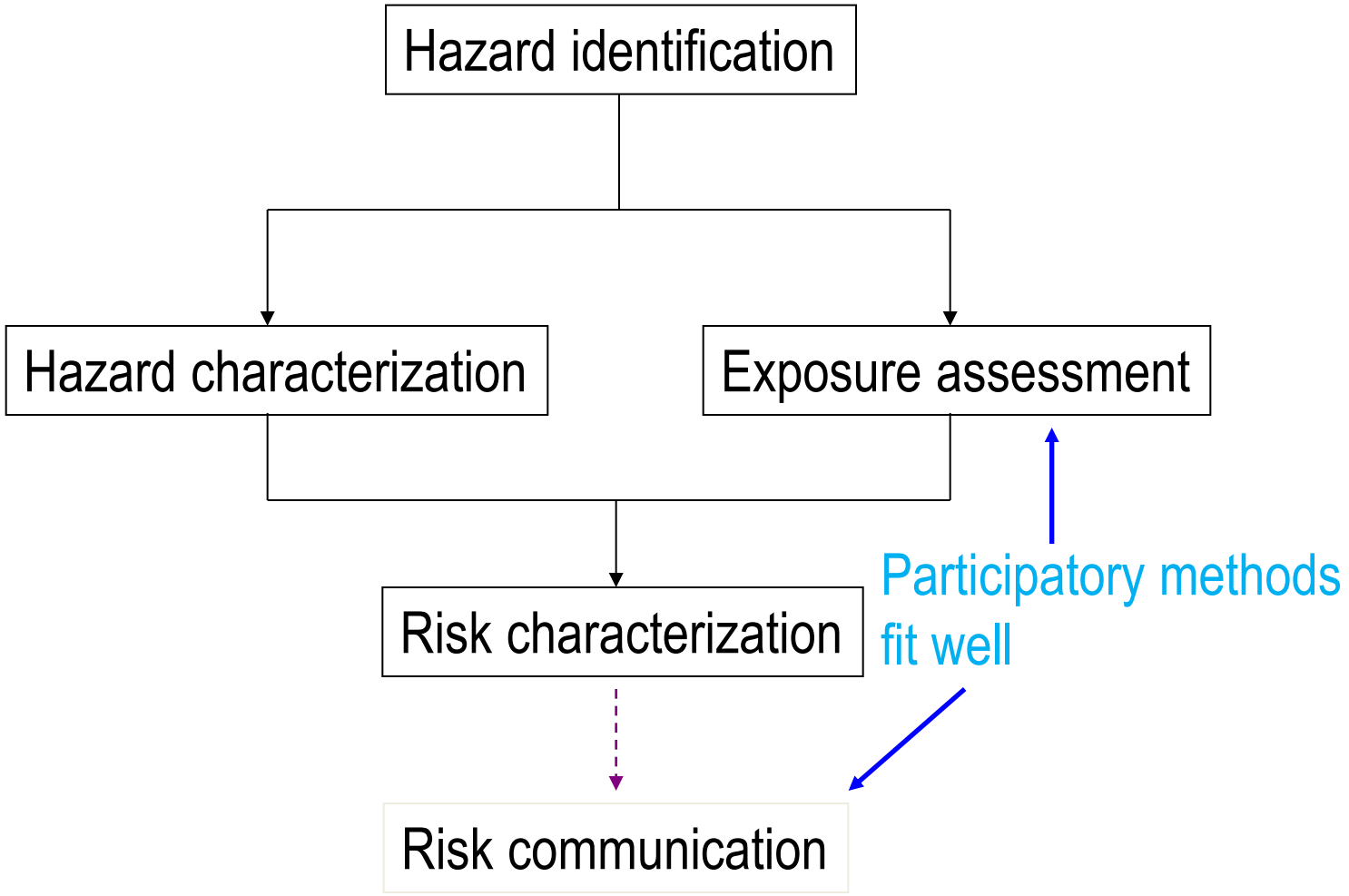


Advantage of participatory risk assessment

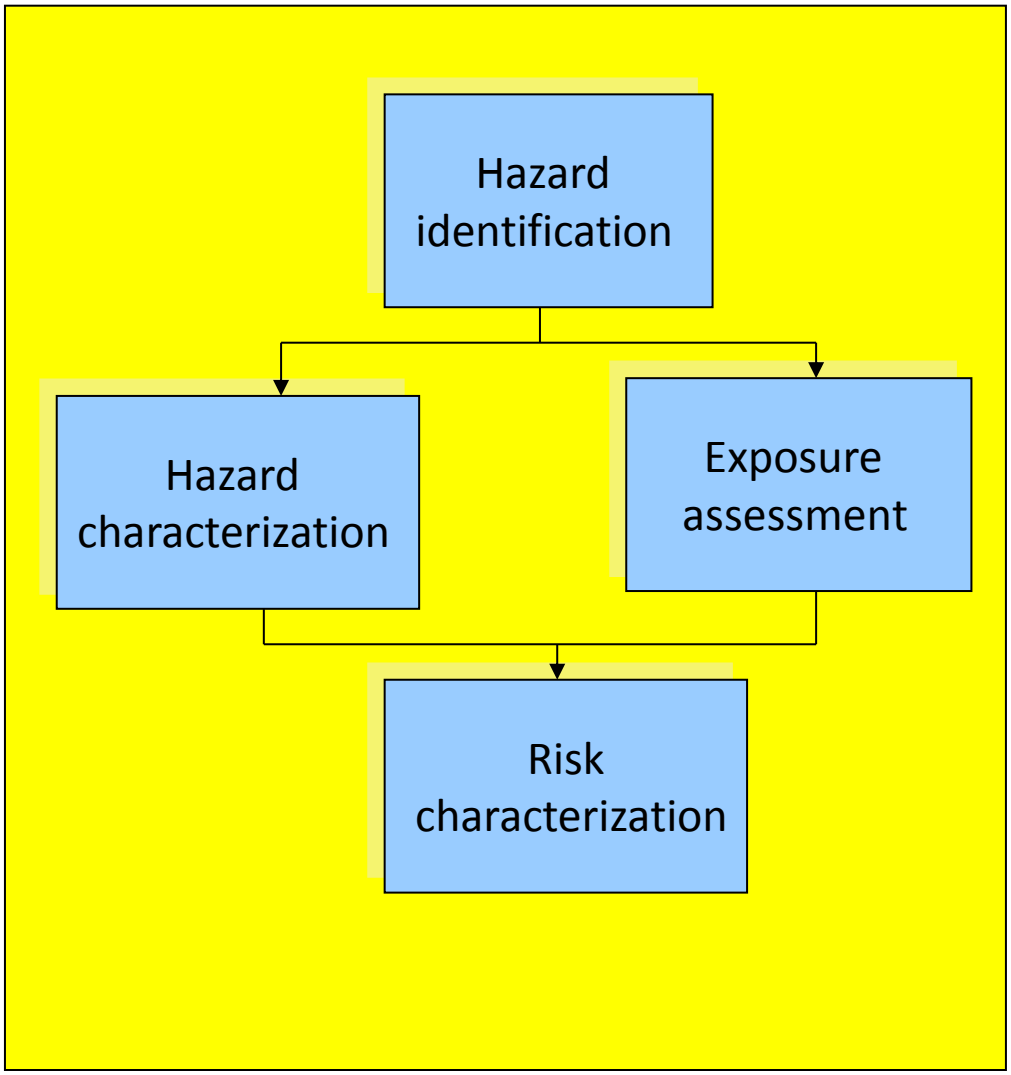
- -Speed
- -Affordability
- -Flexibility in application
- -Understanding of culture
- -Best control option
- -Potential to change behavior

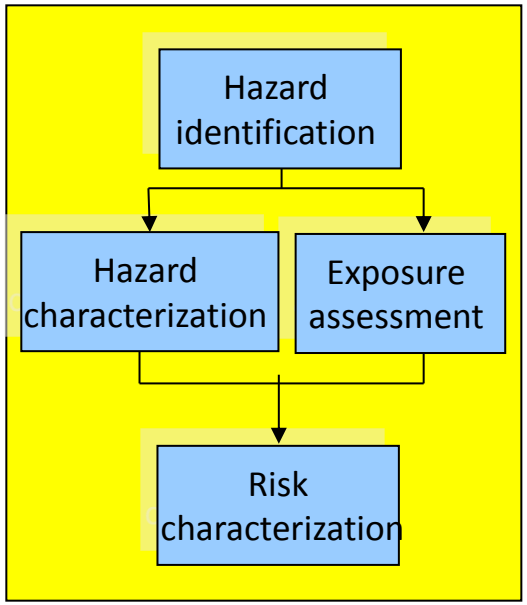
Food safety risk assessment

Codex Alimentarius Commission system



Codex Alimentarius Commission
Risk assessment framework (CAC/GL-30 (1999))

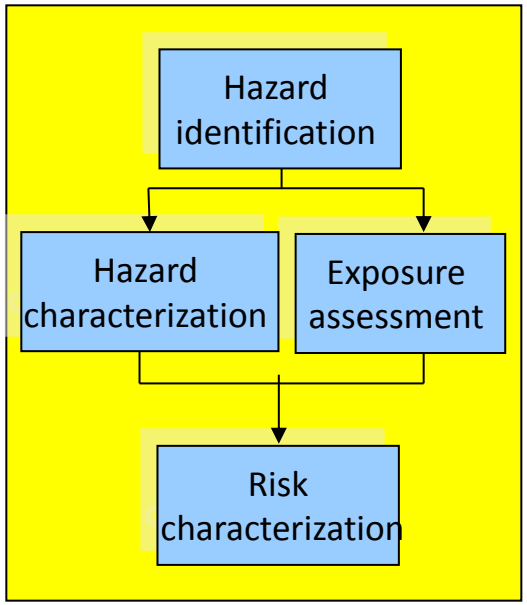




Statement of purpose of risk assessment

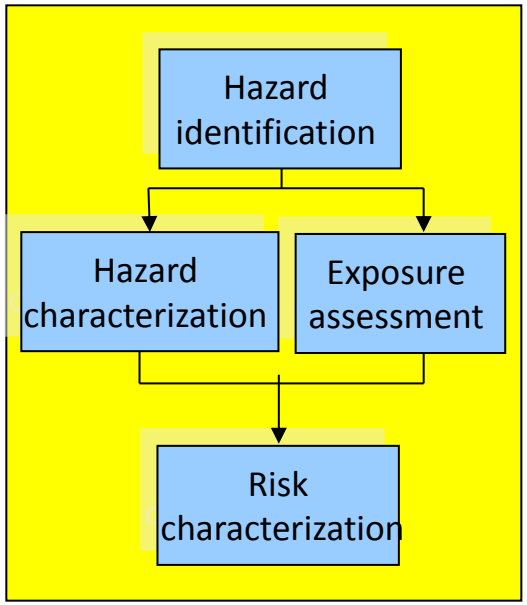
- Clear statement of the specific purpose of the particular risk assessment
- Output form
  - Prevalence of illness
  - Annual incidence rate (eg. case/10,000)

- Preliminary investigation phase may be required



Hazard identification

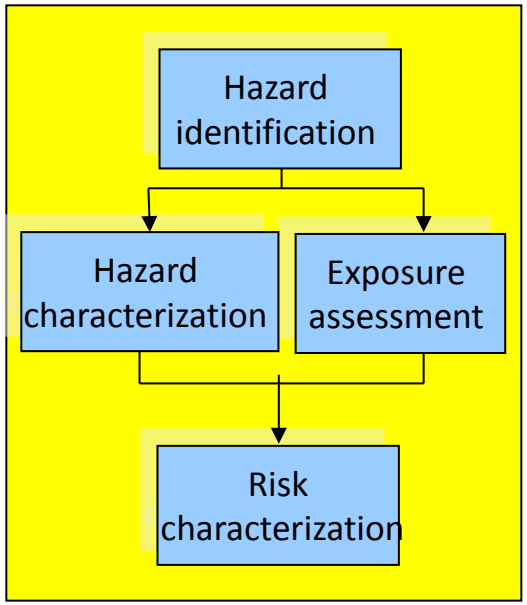
- The identification of biological, chemical, and physical agents –
- capable of causing adverse health effects –
- and which may be present in a particular food or group of foods



Exposure assessment

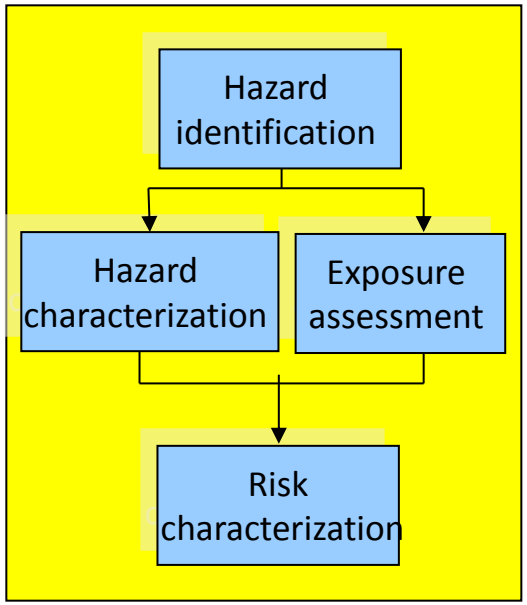
- Assessment of the extent of actual or anticipated human exposure

- Based on potential extent of **food contamination** by a particular agent or its toxins, and on **dietary** information



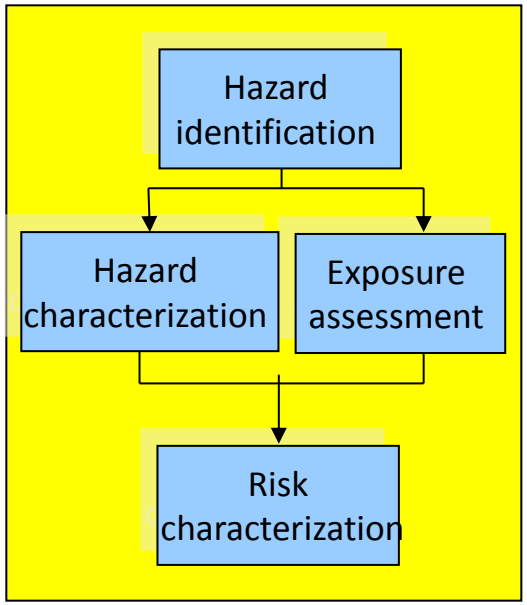
Hazard characterization

- Qualitative or quantitative description of the **severity and duration** of adverse effects that may result from the ingestion of a microorganisms or its toxin in food
- A **dose-response** assessment should be performed if the data are obtainable



Factors that need to be considered in hazard characterization

- Factors related to the microorganism
  - Replication
  - Virulence and infectivity
  - Delay of onset following exposure
  - Attributes altering pathogenicity, e.g., high fat content of a food vehicle
- Factors related to the host
  - Genetic factors
  - Host susceptibility characteristics
    - Age, pregnancy, nutrition, immune status etc.
  - Population characteristics
    - Population immunity, access to and use of medical care etc.



Dose-response Assessment

- Determination of the relationship between the **magnitude of exposure** (dose) to a chemical, biological or physical agent and the **severity and/or frequency of associated adverse health effects** (response)

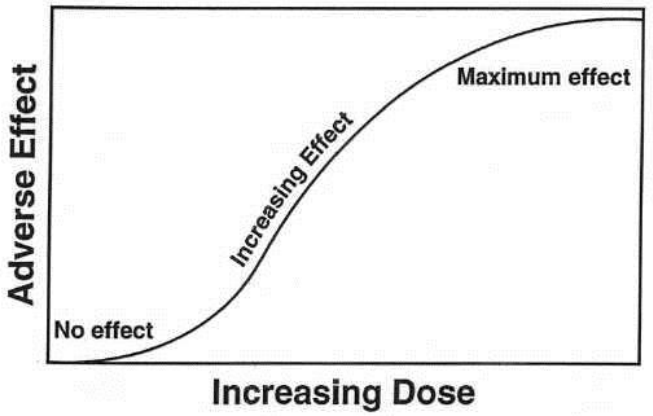
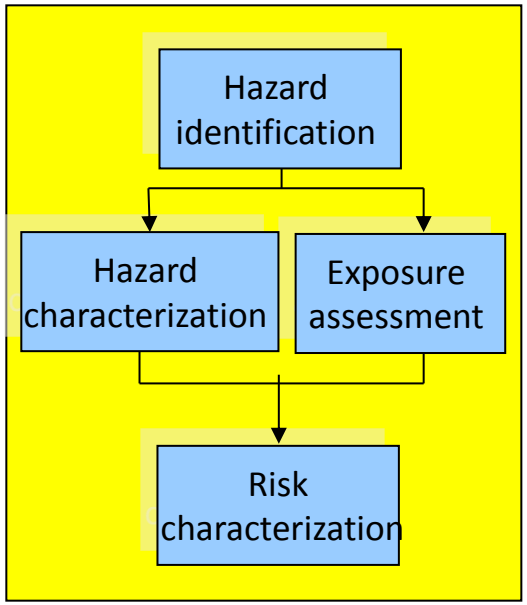


FIGURE 3.1. Adverse response as a result of increasing dose.



Risk characterization

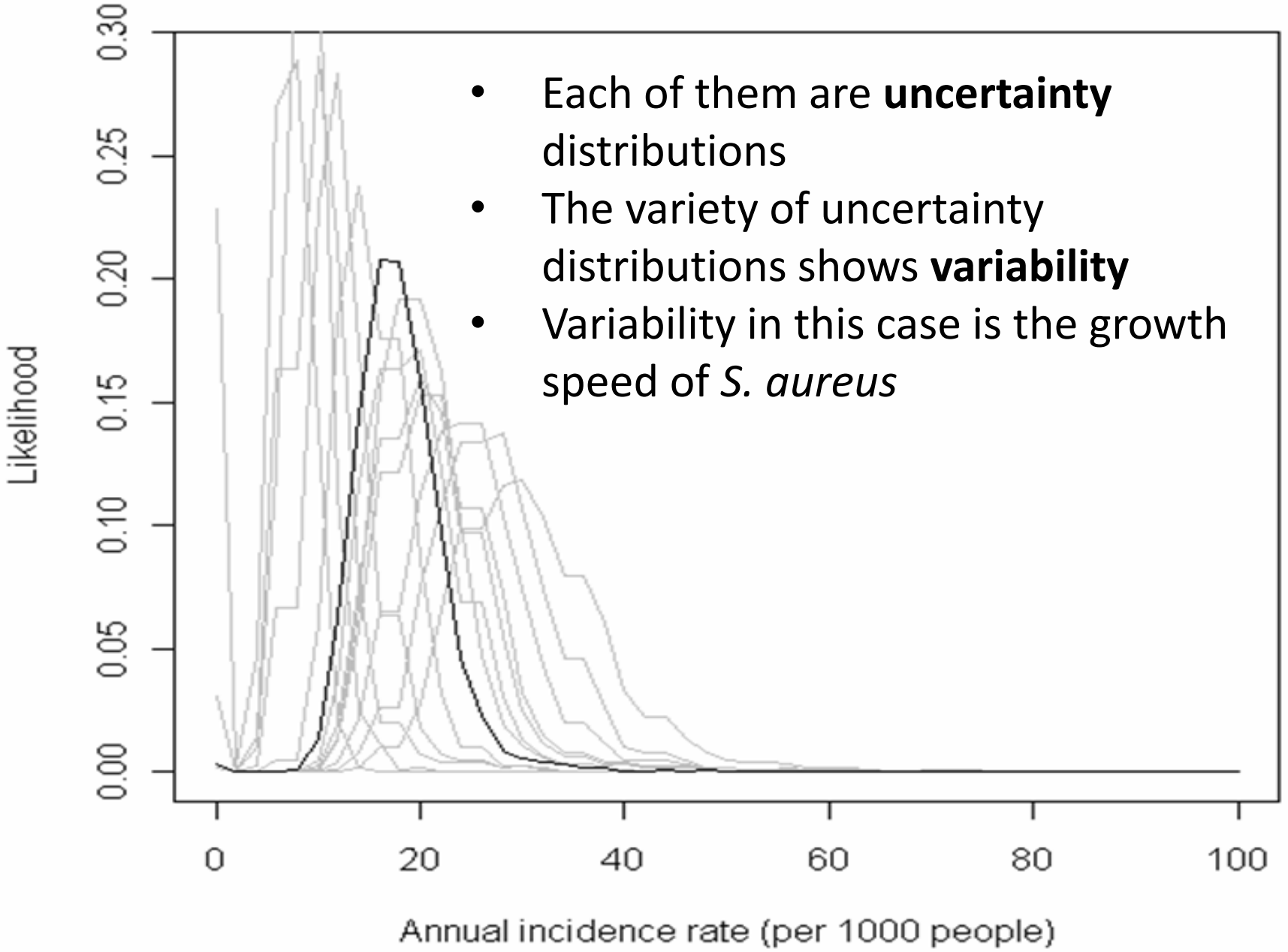
- Integration of previous three steps to obtain a **Risk Estimate**
- A qualitative or quantitative estimate of the **likelihood and severity** of the adverse effects which could occur in a given population
- Degree of confidence: **uncertainty and variability**
- Influence of the estimates and assumptions by **sensitivity analyses**

Uncertainty and variability

- *"**Variability** is a phenomenon in the physical world to be measured, analysed and where appropriate explained. By contrast, **uncertainty** is an aspect of knowledge"*

Sir David Cox

Uncertainty and variability



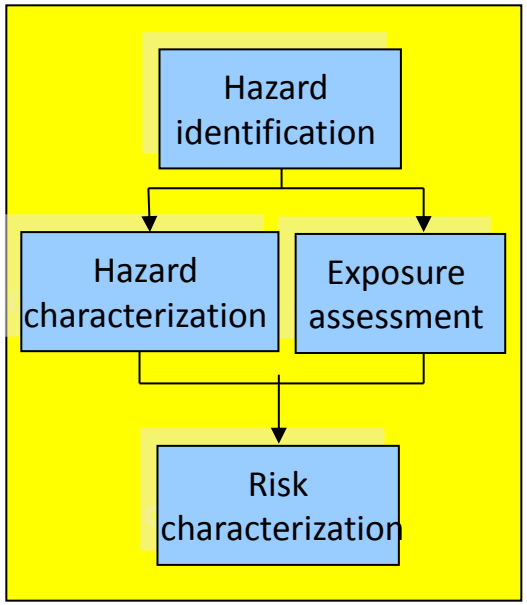
- Each of them are **uncertainty** distributions
- The variety of uncertainty distributions shows **variability**
- Variability in this case is the growth speed of *S. aureus*

Uncertainty

- Assessor's lack of knowledge about the parameters that characterise the physical system that is being modeled
- Level of ignorance, degree of belief
- Sometime reducible through further measurement or study
- In our (food safety risk assessor) case;
  - Prevalence of pathogens/ antibodies in foods
  - Temperature of foods
  - Cooking and consumption behavior (could be dealt as variability if you know well)
  - Time from production to processing/ consumption

Variability

- A function of the system
  - In our (food safety risk assessors) case;
    - Variety in virulence
    - Variety in speed of bacteria multiplication
    - System of the value chain
    - Amount of foods passing through value chains
    - Seasonal variety
- Inter-individual variability
  - Height
  - Weight
  - Sex



Documentation

- Systematic documentation for communication to risk manager
- Reporting the limitations is important in transparent process of the decision making
- Description of the model for other risk assessors to repeat and critique the work

Types of Risk assessment

- Qualitative risk assessment
  - Qualitative statement (Negligible, low, medium, high, extremely high etc.)

- Quantitative risk assessment
  - Deterministic risk assessment
    - Single point estimates
  - Stochastic risk assessment
    - Probability distribution

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- Monte Carlo simulation
- Key distributions

What is Monte Carlo simulation?

- Imagine this EcoHealth work;
  - Probability that vegetable A on farm is contaminated with *Salmonella* came from pig waste: 30% (P_A)
  - Probability of reduction of *Salmonella* prevalence by washing at home: 90% (P_B)
  - After washing, contaminated vegetable contains 20 *Salmonella*/g (CFU)
  - A person ingests 50g of salad of vegetable A at a time (Cons)
  - In the country, this salad is consumed once a week (Rate)
  - Dose-response (DR) relationship known
  - What is the probability of salmonellosis due to consumption of vegetable A as salad?

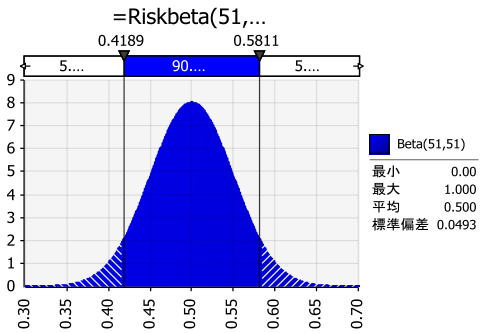
Probability of illness = P_A x (1-P_B) x CFU x Cons x DR x Rate

Deterministic model = 0.3 x (1-0.9) x 20 x 50 x DR x 1/7

Stochastic model assigns distributions for each parameter → Then how we calculate?

Then how the distribution of a risk is made?

- Assign stochastic distributions to each variable
- Pick up values randomly from each distribution based on the probability and calculate a risk
- Repeat the risk calculation automatically 5000-10,000 times until the results become stable (Monte Carlo simulation)



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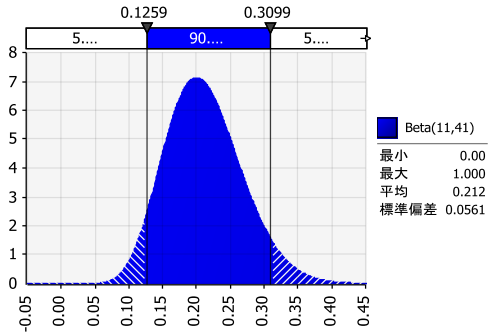

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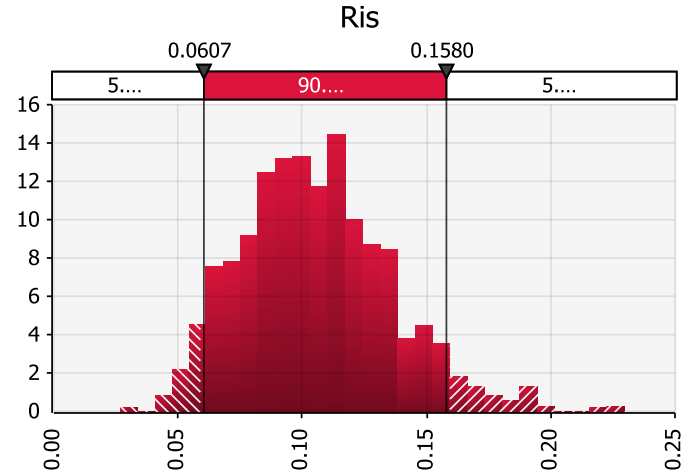


Outline

- Food safety in informal market
- Types of Risk Analysis (Codex, OIE, HACCP)
- Monte Carlo simulation
- Key distributions

Types of data

Head or tail
0 or 1
Healthy or diseased
Binomial data

Animal breed
Districts
Categorical data

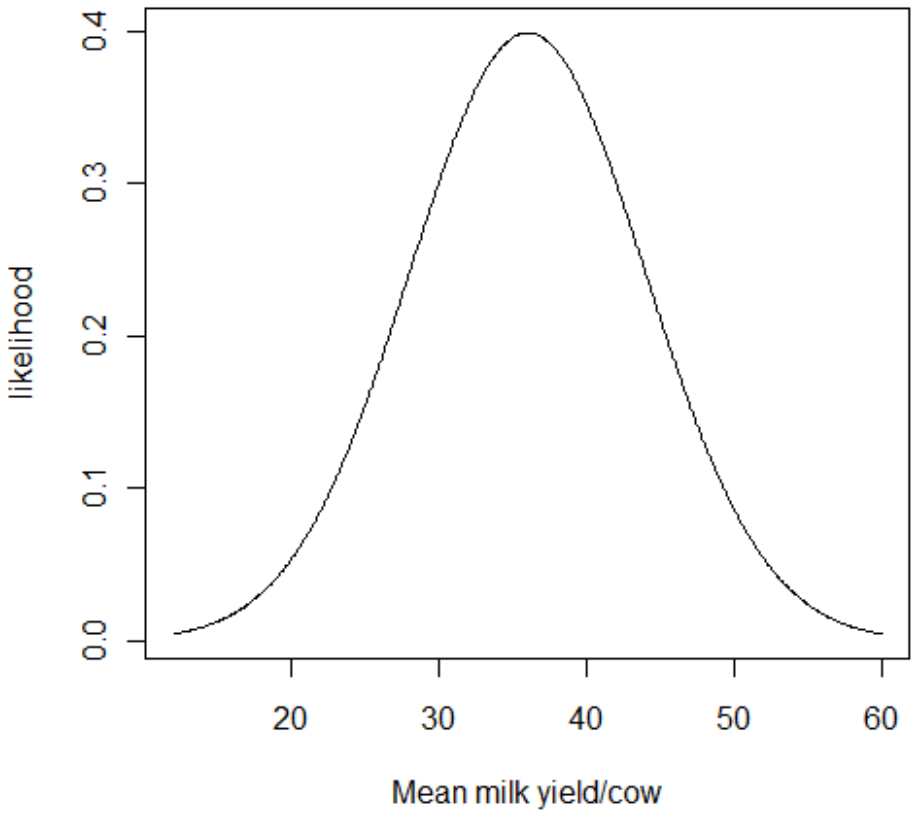
Bacteria load
Number of animals
Count data

Milk yield
Body weight
Continuous data

Parametric and non-parametric statistics

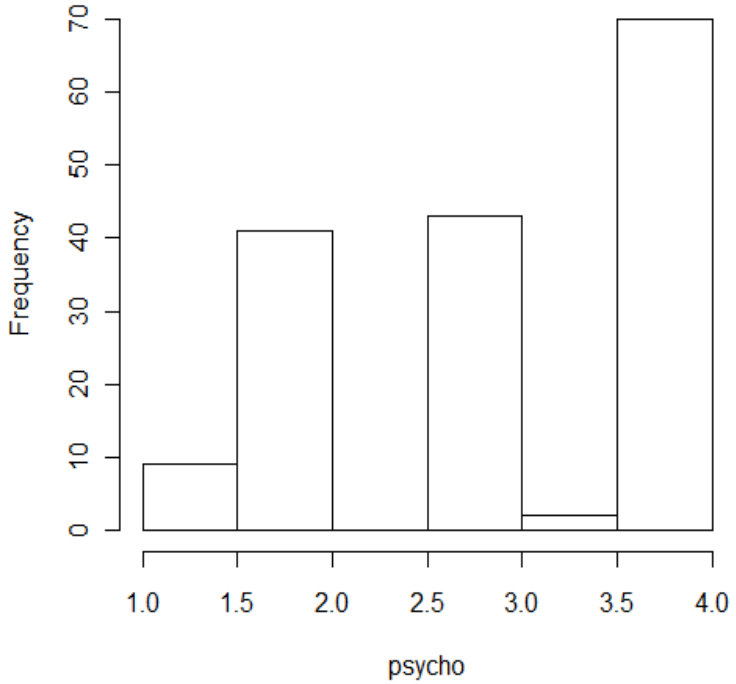
Parametric

E.g. Milk yield



Non-parametric

E.g. Rank of psychological stress during FMD outbreak among vets



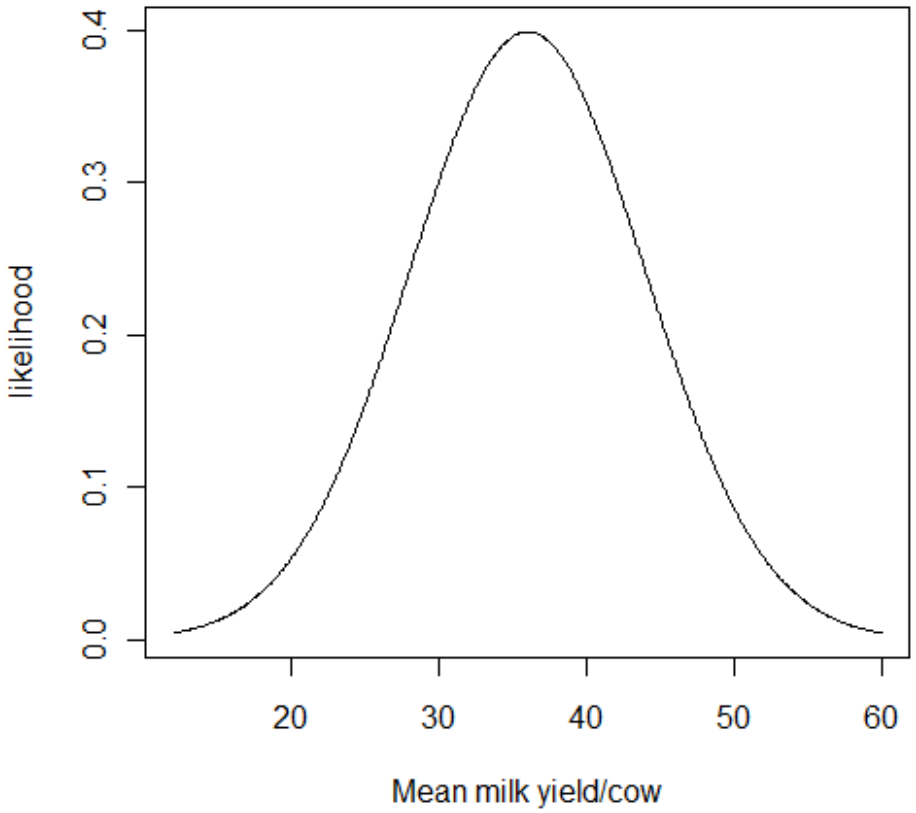
Parametric and non-parametric statistics

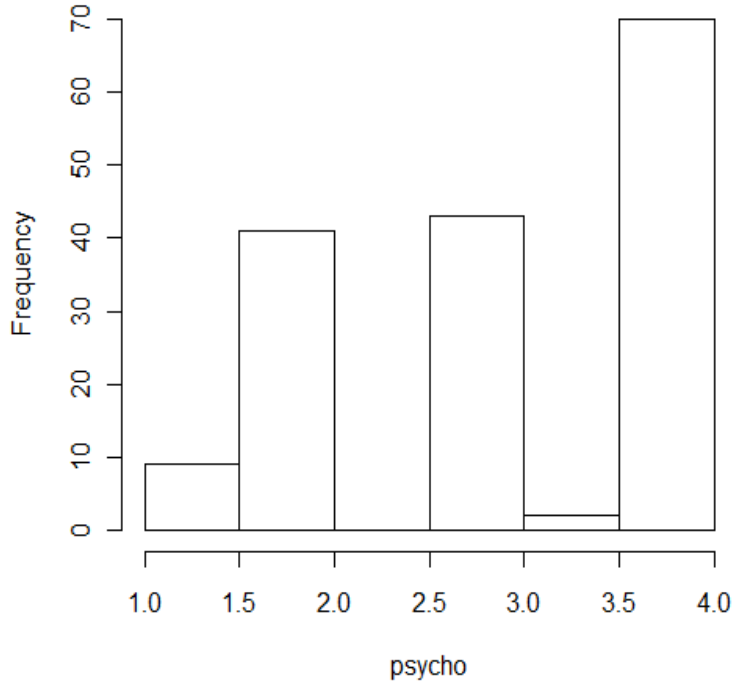
Parametric tests

Make assumptions about the underlying distribution of the observations and the **parameters** which define that distribution

Non-parametric tests

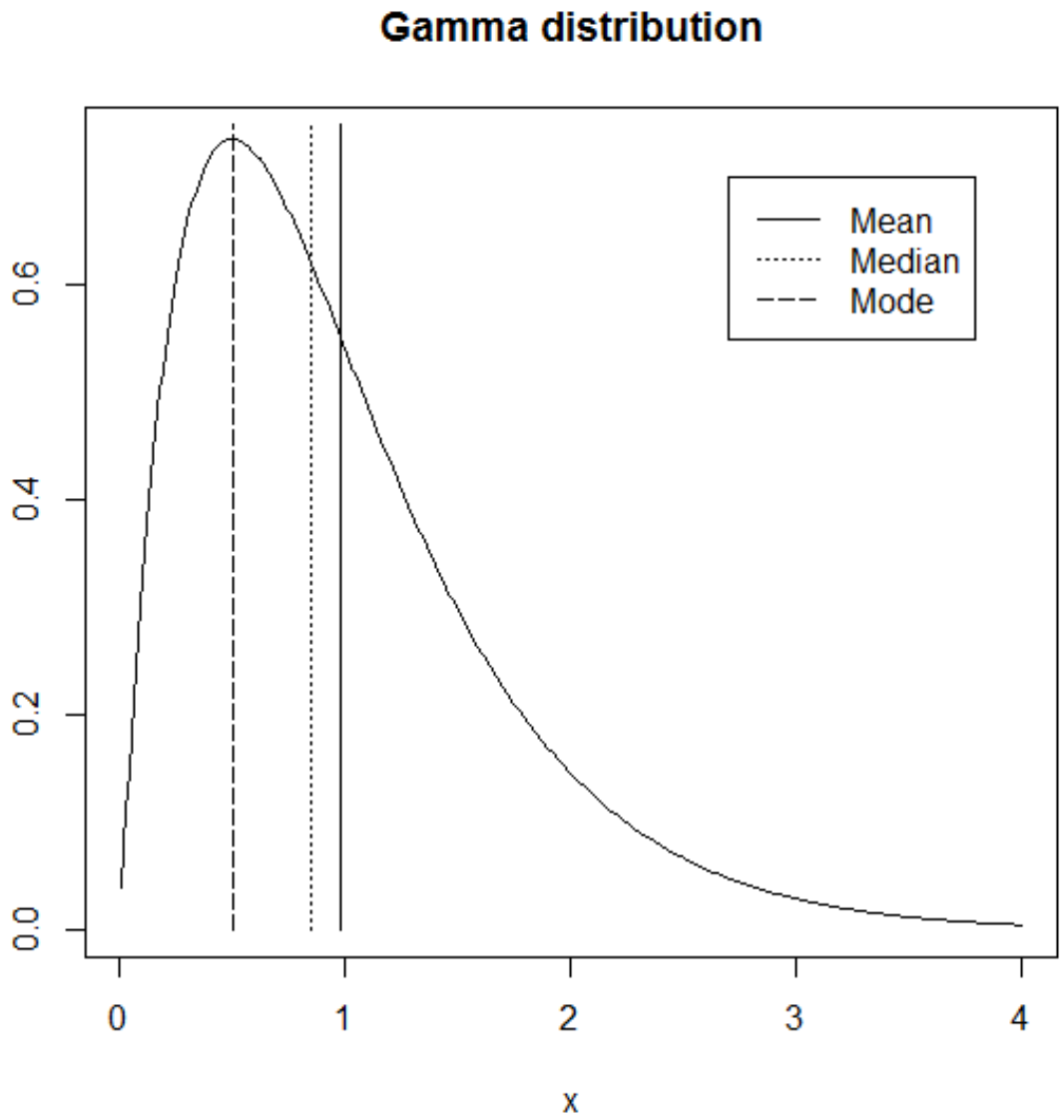
Does **not** make any distributional assumptions about the data





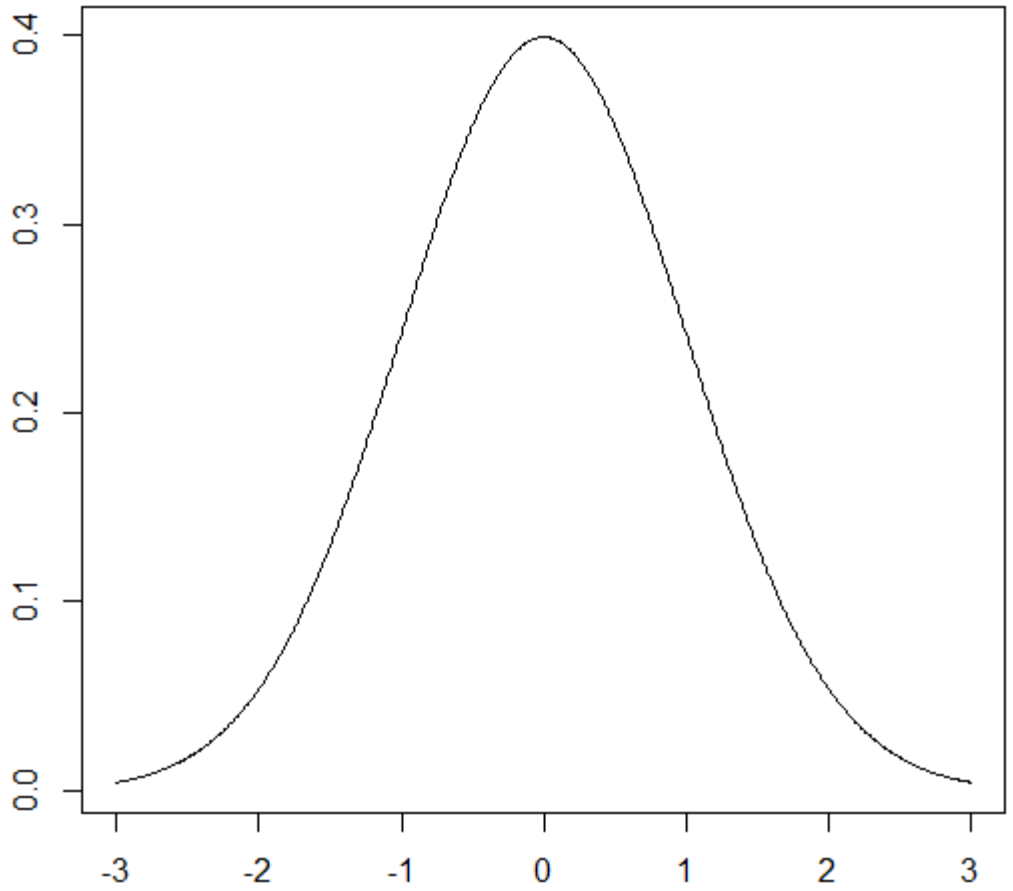
Mean, median and mode

- Mean
  - Arithmetic mean
- Median
  - Central value of the observations which have been arranged in rank order
- Mode
  - The most commonly occurred observation in a set of observations



Normal distribution

- Continuous data
- Two parameters
  - Mean
  - Standard deviation
- Mean, mode and median are same



Probability density function

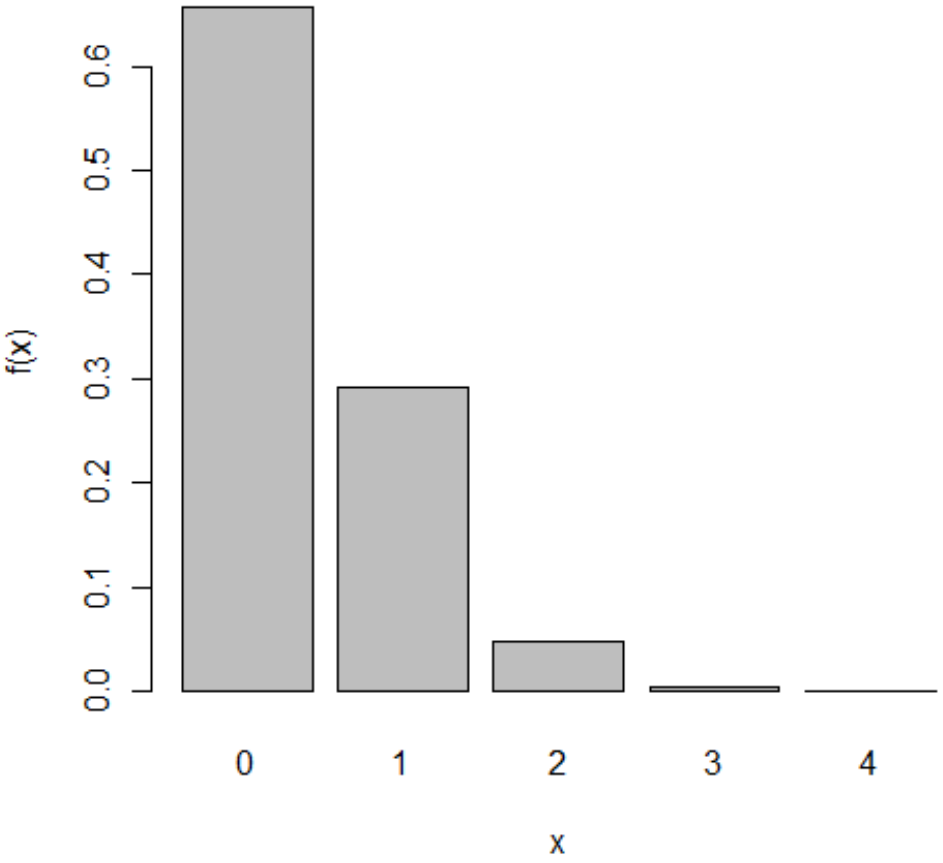
$$f(z) = \frac{1}{\sqrt{2\pi}} e^{-z^2/2}$$

Where $z = \frac{y - \bar{y}}{s}$

Where y is any value from the distribution,
$\bar{y}$ is a mean, s is standard deviation

Binomial distribution

- Two parameters
  - Trial, probability
- Logit-link
- (E.g.) 10% chicken carcasses is known to be contaminated with *Campylobacter*
- You sampled four carcasses
- How many were contaminated?



Probability mass function

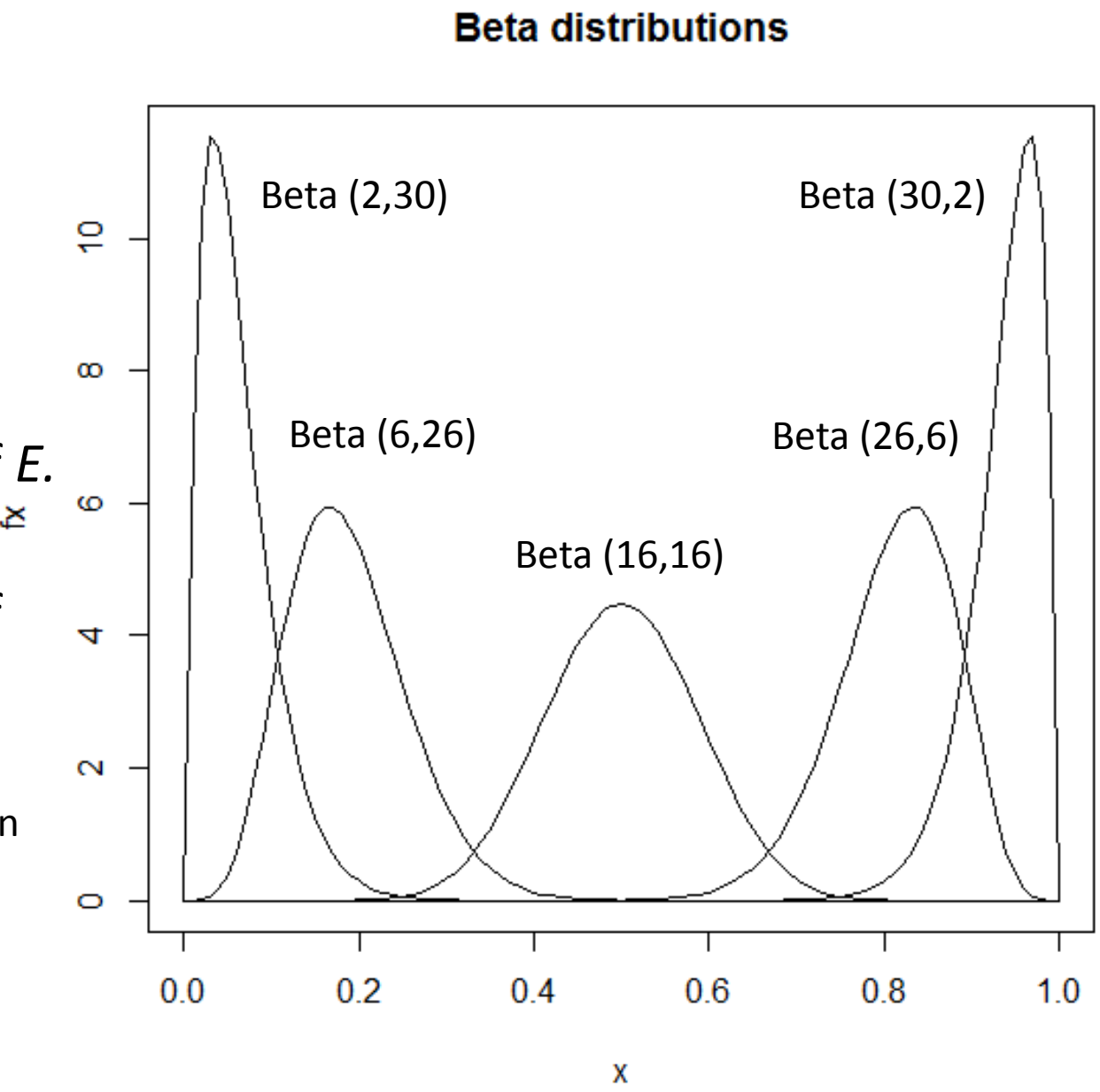
$$\binom{n}{x} p^x (1-p)^{n-x}$$

Where x success in n trials
Probability *P* of success

- Binomial/ Binary response data
- Two parameters
  - Trial
  - Success
- (E.g.) Prevalence of *E. coli* in foods
- (E.g.) Prevalence of brucellosis among cattle herds

Probability density function for Beta (a, b)

$$f(x) = \frac{x^{a-1}(1-x)^{b-1}}{\int_0^1 t^{a-1}(1-t)^{b-1}dt}$$

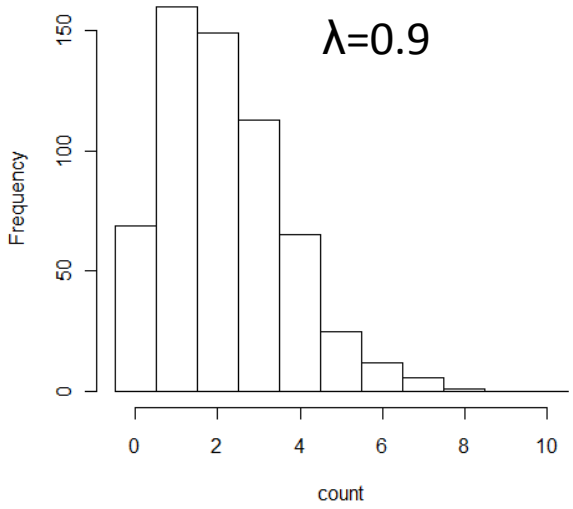


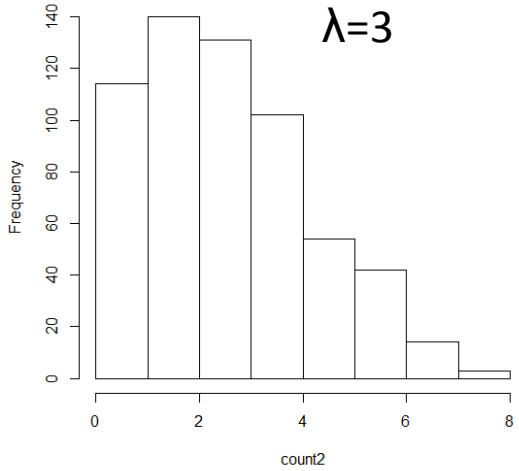
Poisson distribution

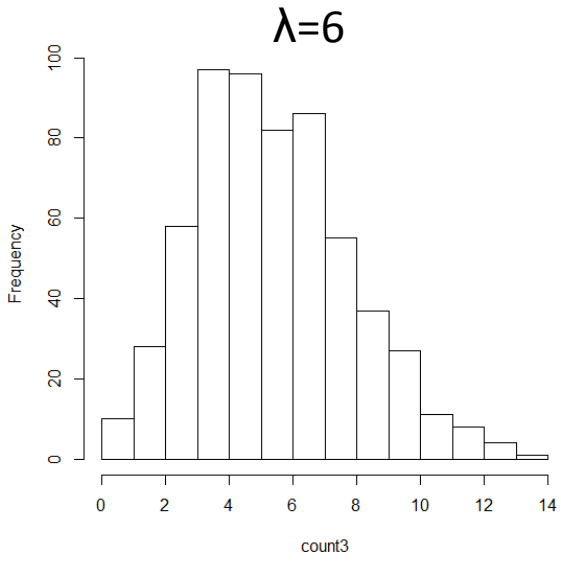
- Count data
- One parameter
  - Shape
- Log-link
- (E.g.) Number of customer per day

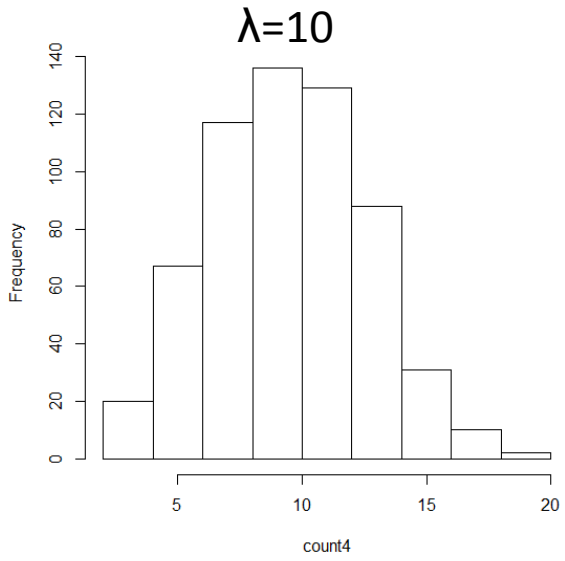
Probability mass function

$$f(x) = \frac{e^{-\lambda t}(\lambda t)^x}{x!}$$









Gamma distribution

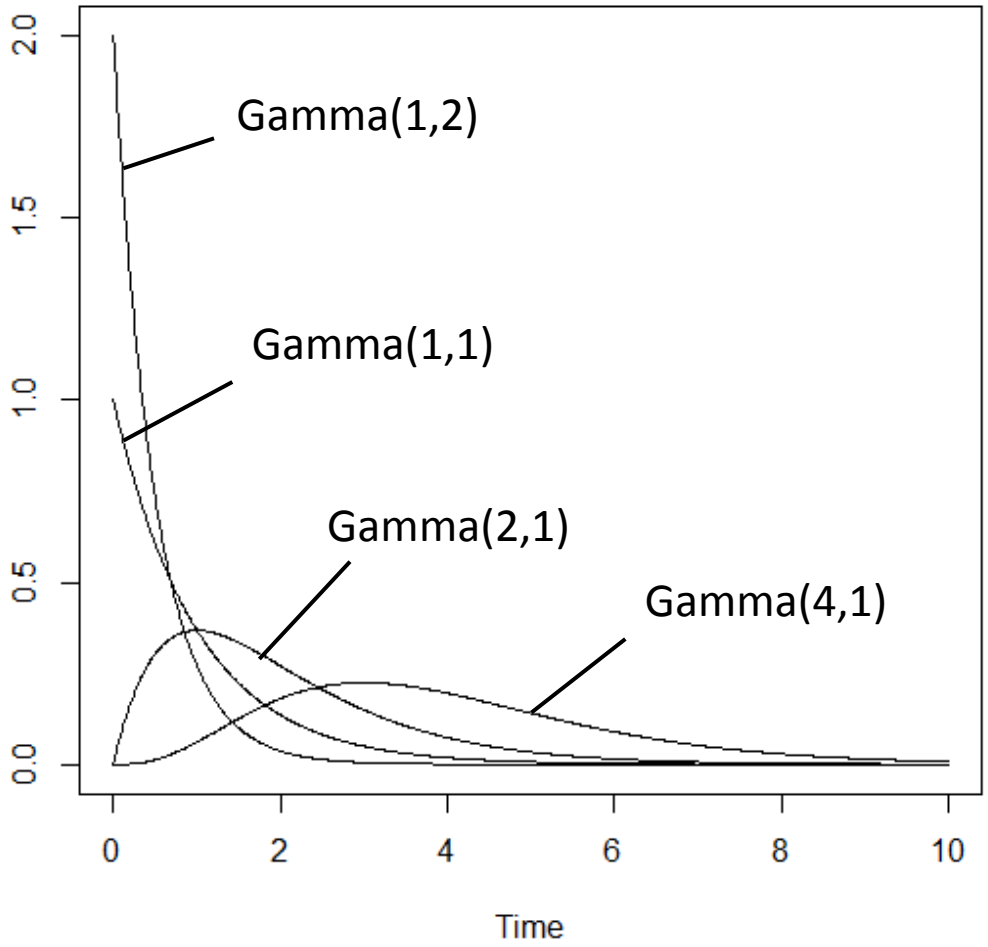
- Gamma (α,β)
- Two parameters
  - Number of events α
  - Time between events β
- Mean: αβ
- Variance:αβ ^{2}

Probability density function

$$f(x) = \frac{\beta^{-\alpha} x^{\alpha-1} \exp(-x/\beta)}{\Gamma(\alpha)}$$

When

$$\Gamma(n) = \int_0^\infty t^{x-1} e^{-t} dt$$

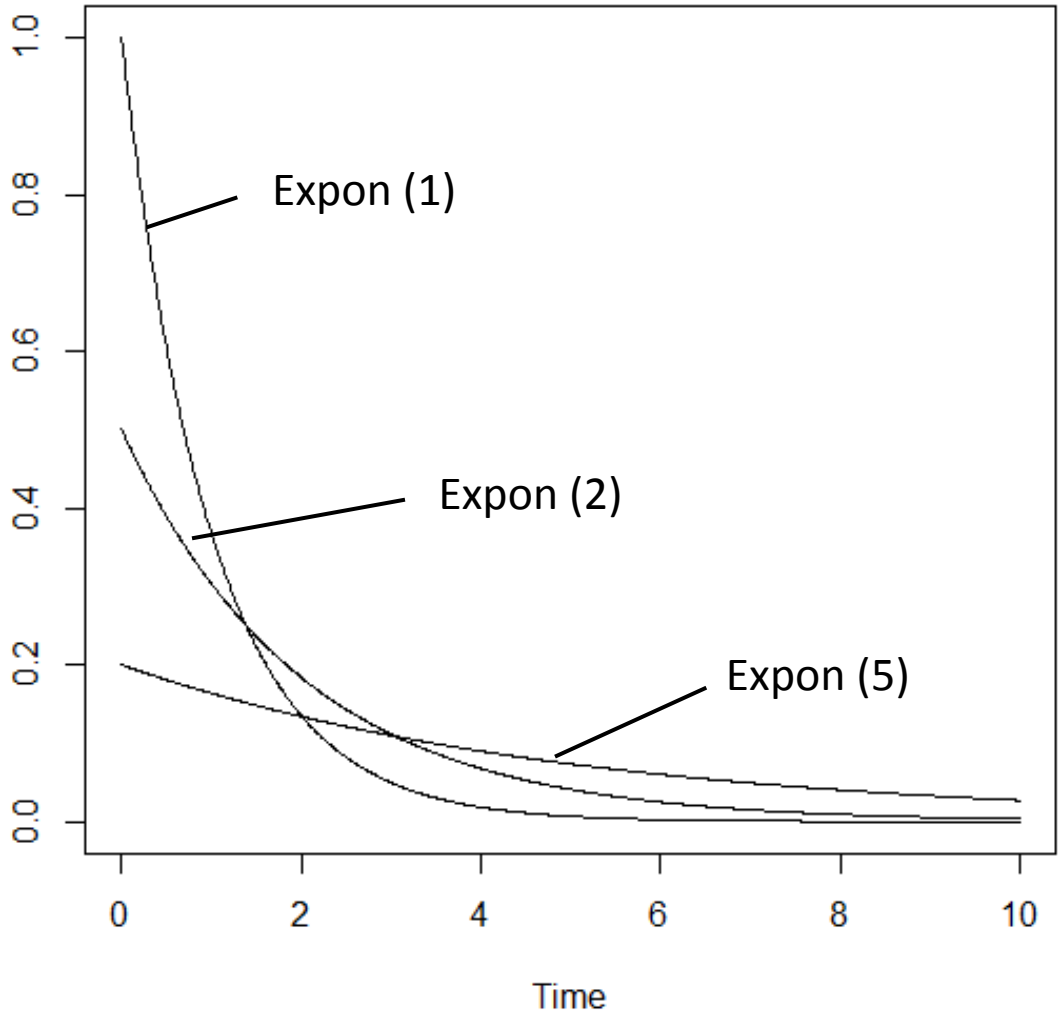


Exponential distribution

- Exp(β)=Gamma (1, β)
  - Special case of Gamma distribution when α=1
- Time between successive occurrences

Probability density function

$$f(x) = \frac{e^{-x/\beta}}{\beta}$$



Key parametric distributions

- Normal distribution
- Binomial distribution
- Beta distribution
- Poisson distribution
- Gamma distribution
- Exponential distribution

There are more parametric distributions but they are key ones to relate other distributions used for food safety risk assessment

Any questions?