Risk Assessment and Foodborne Viruses

Is it Cold out There?

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Munich GERMANY 4-6 May IAFP'S EUROPEAN SYMPOSIUM ON FOOD SAFETY 2022

INSTYTUT BIOTECHNOLOGII PRZEMYSŁU ROLNO-SPOŻYWCZEGO im. prof. Wacława Dąbrowskiego PAŃSTWOWY INSTYTUT BADAWCZY

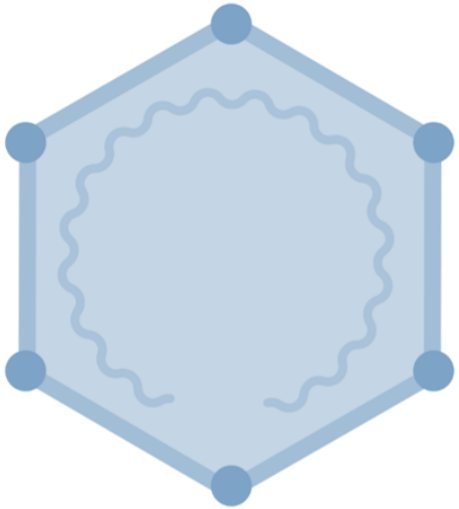
EU-FORA

Presentation structure

- Foodborne Viruses Characteristics & Transmission routes
- Major foodborne viral hazards
- Current situation in Europe and Globally
- Risk Assessment
- Comparison of CRA and MRA
- Microbial Risk Assessment
- Quantitative Microbial Risk Assessment
- Quantitative Viral Risk Assessment
- Challenges in Viral Risk Assessment
- The Future of MRA
- QVRA Future

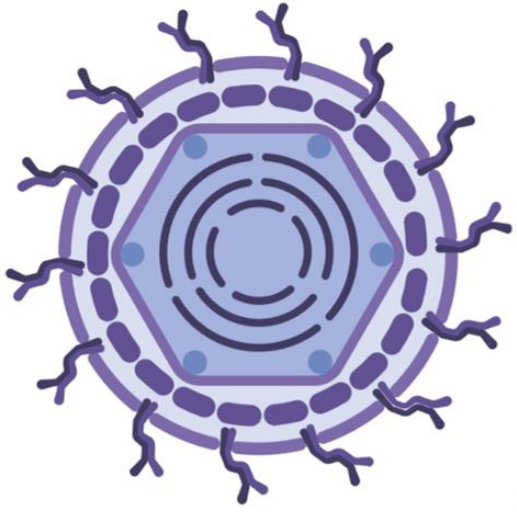
Foodborne Viruses

- Sub-microscopic size 0.02-0.4 µm (bacteria 0.5-5 µm)
- DNA or RNA / ss or ds
- Obligate intracellular parasites



Simple

Non-enveloped genome with a single protein coat (most foodborne viruses)



Complex

Consisting of a segmented genome, encapsulated in a complex protein capsid and enveloped by a membrane (less resistant)

Foodborne Viruses

- No growth in food → vehicle of transmission
- Specificity
- Replication cycle → intracellular propagation and virion shedding
- Routes of transmission:
  - **Faecal-oral**
  - **Zoonotic**
  - Blood products
  - Respiratory
  - Sexual intercourse
  - Vectors

Contact with infected animals or their products

Faecal material from an infected individual is inadvertently consumed
Majority of Foodborne viruses

Upward trend in viral transmission

Pre-Harvest

Environmental Contamination

- Sewage in sea or irrigation water
  (Shellfish, Leafy vegetables, Soft fruits e.g. berries)

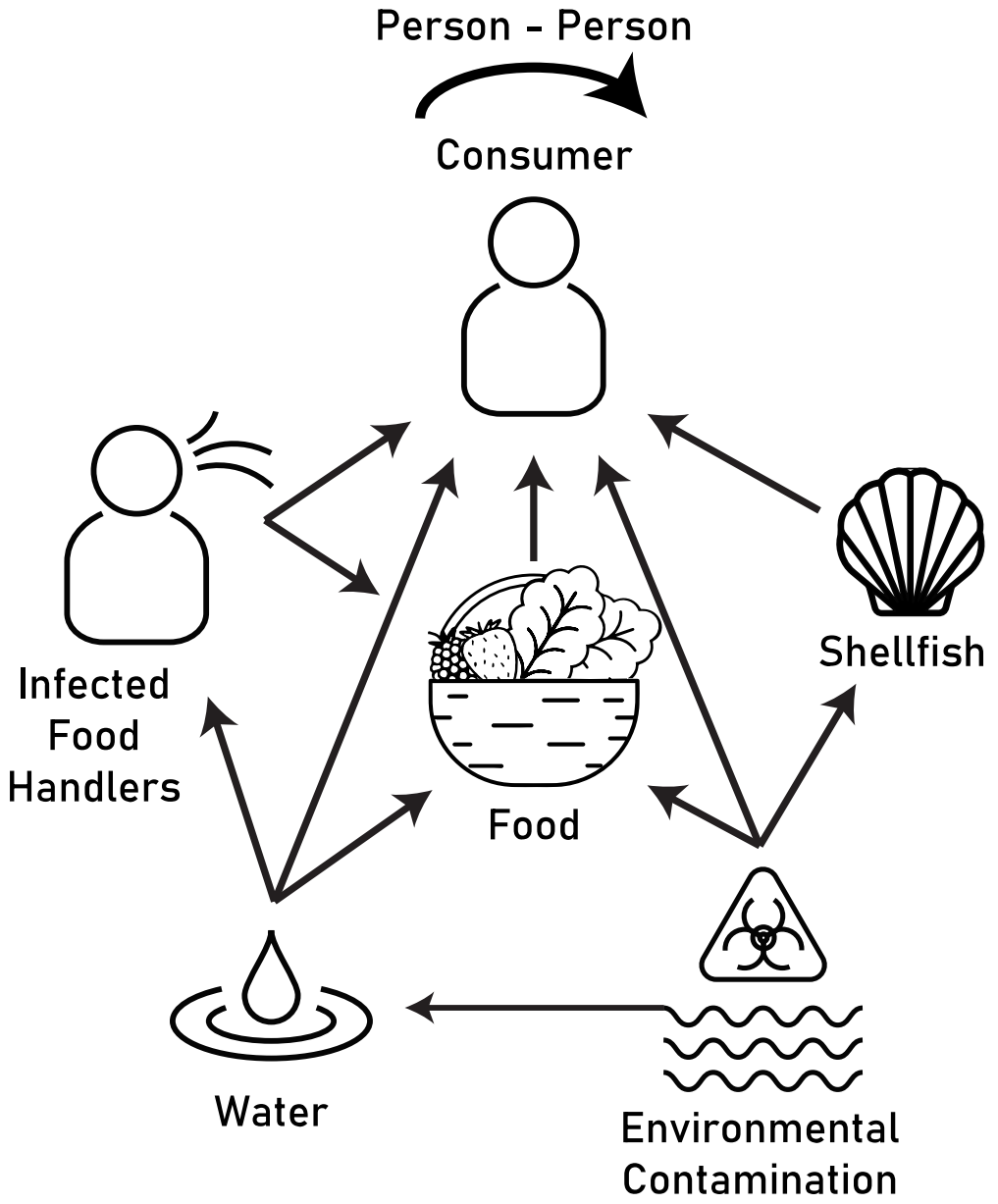
Post-Harvest

Infected Food Handlers

- Asymptomatic
- Poor hygienic practices

Water

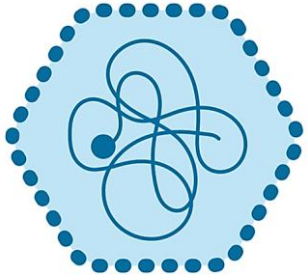
- Contaminated drinking water
- Used in food washing & processing



High Priority ranked Foodborne Viruses

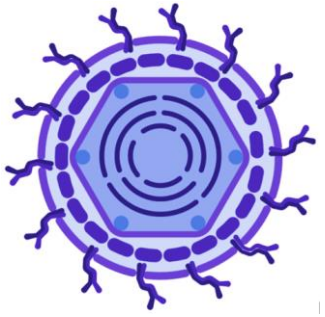
NoV

- Gastroenteritis
- High incidence
- Most common foodborne virus



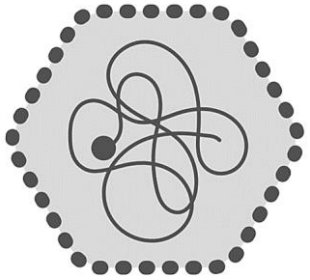
HAV

- Hepatitis
- Sometimes foodborne
- Severe infection
- Vaccine available



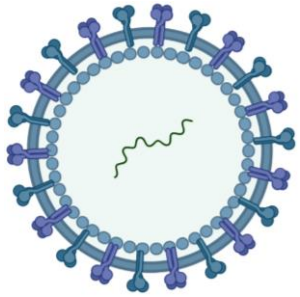
HRV

- Gastroenteritis
- Sometimes foodborne
- Severe infection in nfants/children
- Vaccine available



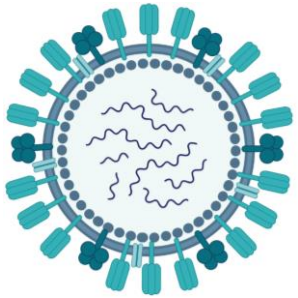
HEV

- Hepatitis
- Potential public health impact
- **Emerging** hazard
- Plausible foodborne transmission
- Potential Zoonosis (Pigs)



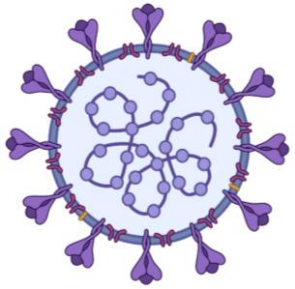
Nipah Virus

- Neurological
- Bat virus
- Foodborne transmission
- **Emerging**



HPAI H5N1

- Respiratory
- Potential public health impact
- **Emerging** hazard
- Zoonosis
- Plausible foodborne transmission
- Main risk from direct exposure (Poultry)



SARS Covid

- Respiratory
- Potential public health impact
- **Emerging**
- Foodborne transmission

SCIENTIFIC REPORT

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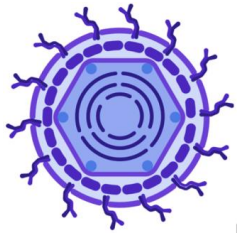
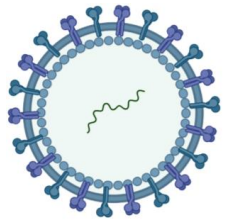
The European Union One Health 2020 Zoonoses Report

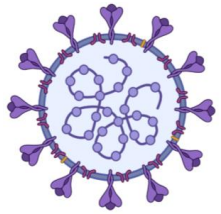
European Food Safety Authority
European Centre for Disease Prevention and Control



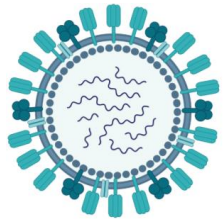
155 Outbreaks



3,008 Cases



211 Hospitalisations

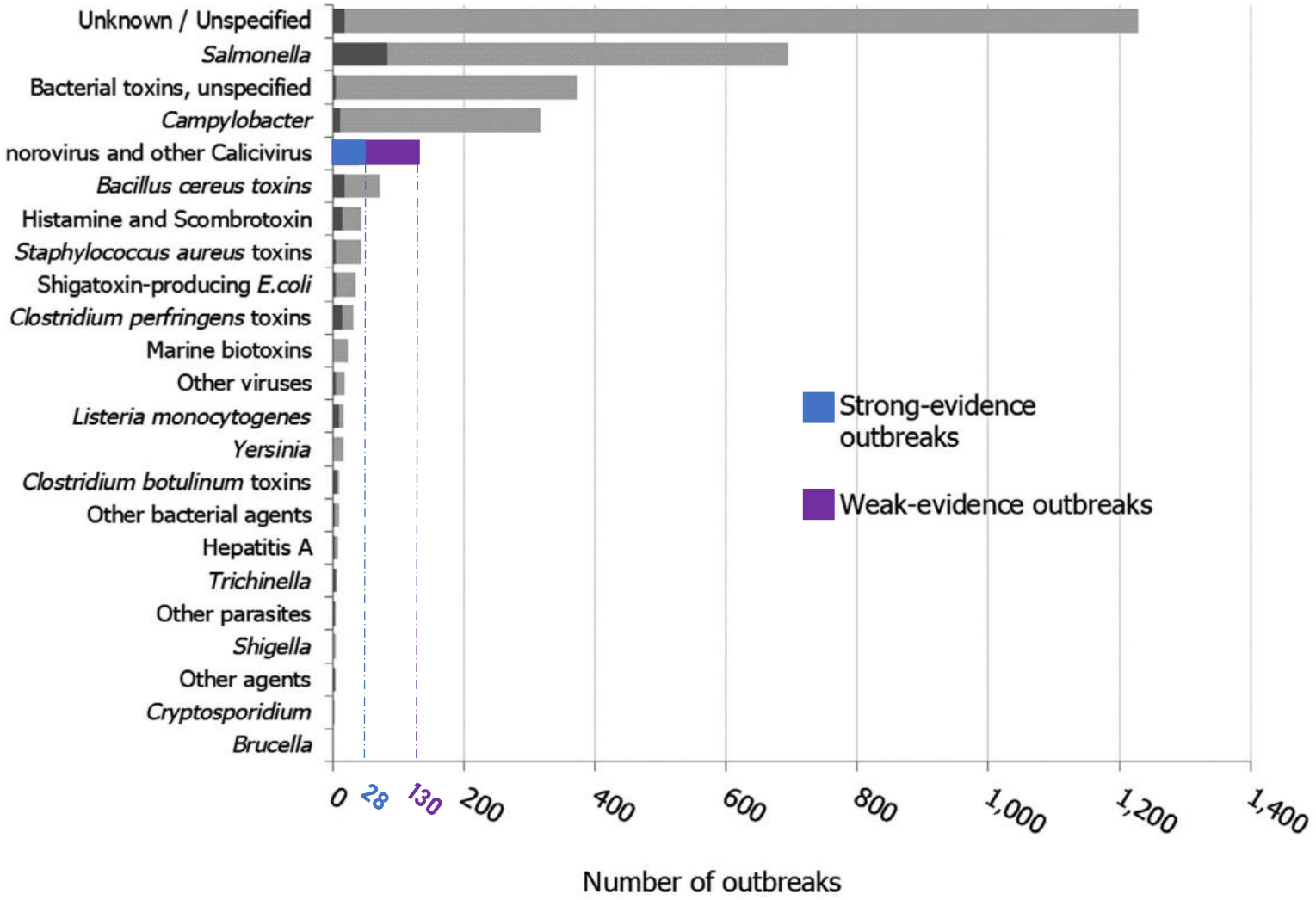


1 Death

Foodborne Viruses Outbreaks

European Zoonosis Report 2020

Foodborne outbreaks per causative agent in EU MS 2020

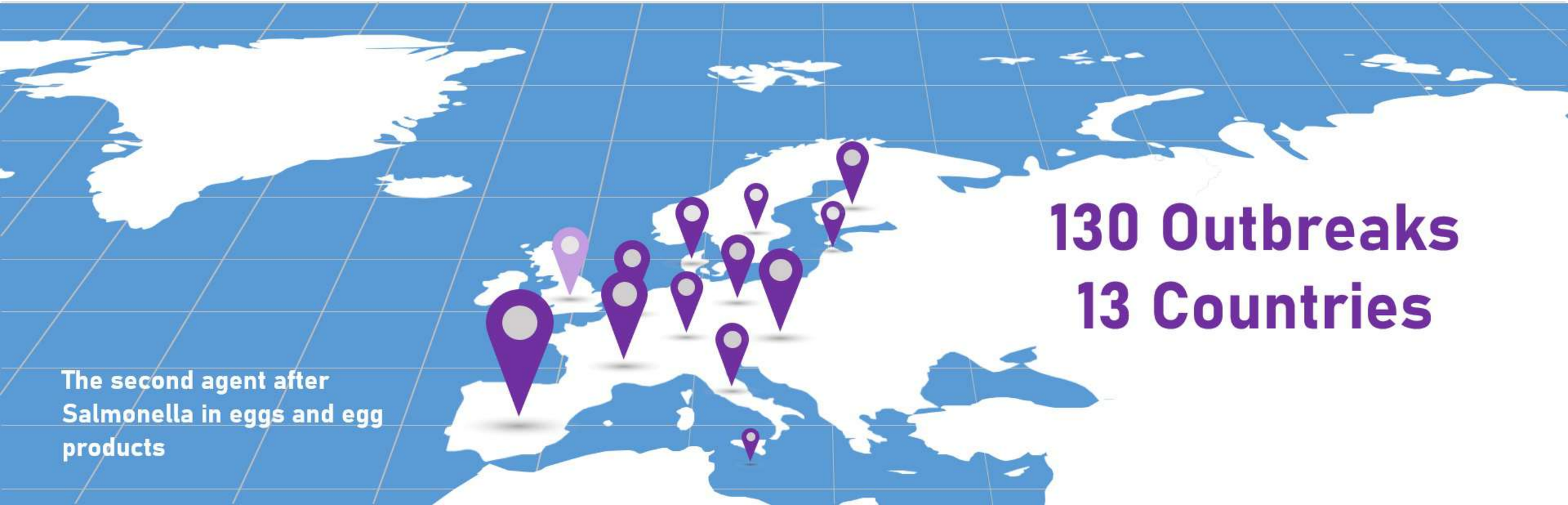


28 Strong-evidence

130 Outbreaks

Foodborne outbreaks of Norovirus and Calciviruses in EU MS 2020

Among the most frequently implicated pairs of causative agents and food vehicles, **Norovirus** and other calicivirus in **'crustaceans, shellfish, molluscs and products thereof'**



Foodborne outbreaks of Norovirus and Calciviruses in EU MS 2020

Among the most frequently implicated pairs of causative agents and food vehicles, **Norovirus** and other calicivirus in **'crustaceans, shellfish, molluscs and products thereof'**

Norovirus

Outbreaks

- 20.4 cases on average
- 6 outbreaks with more than 100 cases
- 1 death

Implicated Foods

- Crustaceans, shellfish, molluscs & products thereof
- Highly manipulated food (mixed food, bakery products and buffet meals)

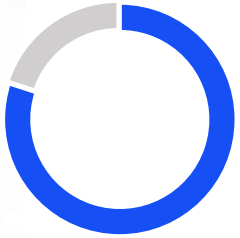
WHO ESTIMATES OF THE GLOBAL BURDEN OF FOODBORNE DISEASES

FOODBORNE DISEASE
BURDEN EPIDEMIOLOGY
REFERENCE GROUP
2007-2015

World Health Organization

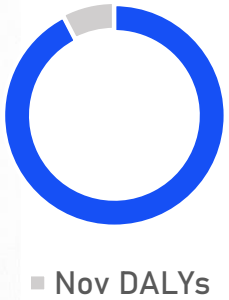
Norovirus Burden

- Most common gastrenteritis cause worldwide



1 out of 5 cases in developed countries

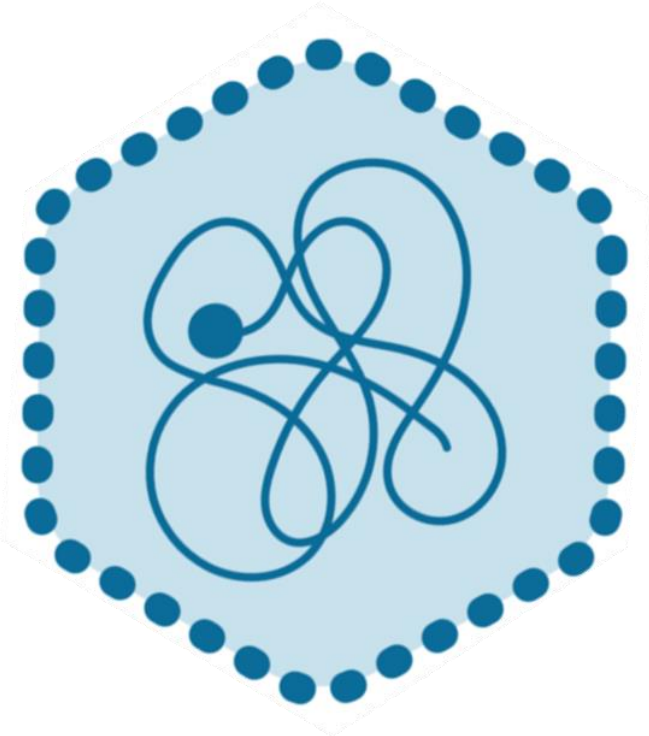
- 124,803,946 cases annually
- 34,929 deaths annually



2,496,078 DALYS
7.6% of total DALYs

178 million $ annual cost to health services
60 billion $ annual cost in healthcare and lost productivity

Hepatitis A



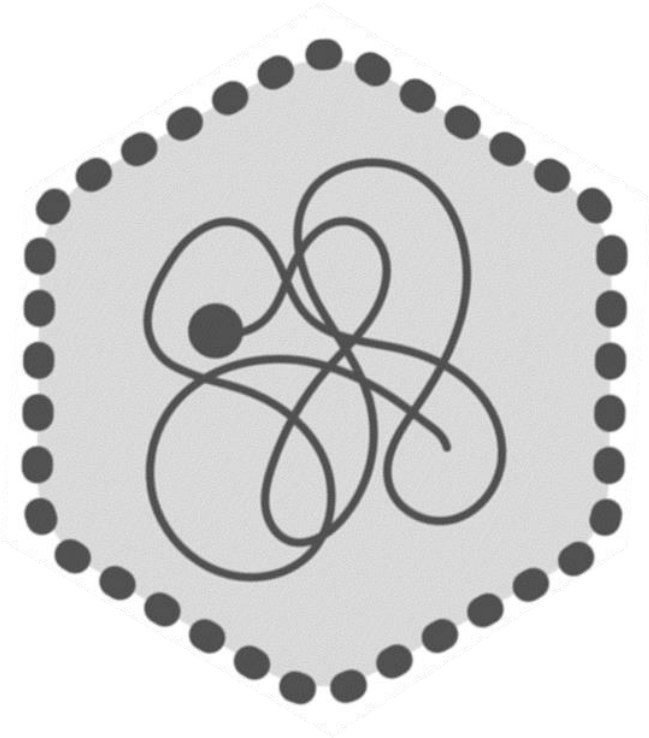
Outbreaks

- 29.4 cases on average
- 1 outbreak in Czechia with 131 cases & 91 hospitalisations
- 1 outbreak in Germany with 41 cases & 9 hospitalisations
- 13 million cases globally
- 27,000 deaths globally
- 1.3 million DALYS

Implicated Foods

- Leafy Vegetables
- Soft Fruit (Berries)
- Fresh or Frozen Berries

Hepatitis E



Outbreaks

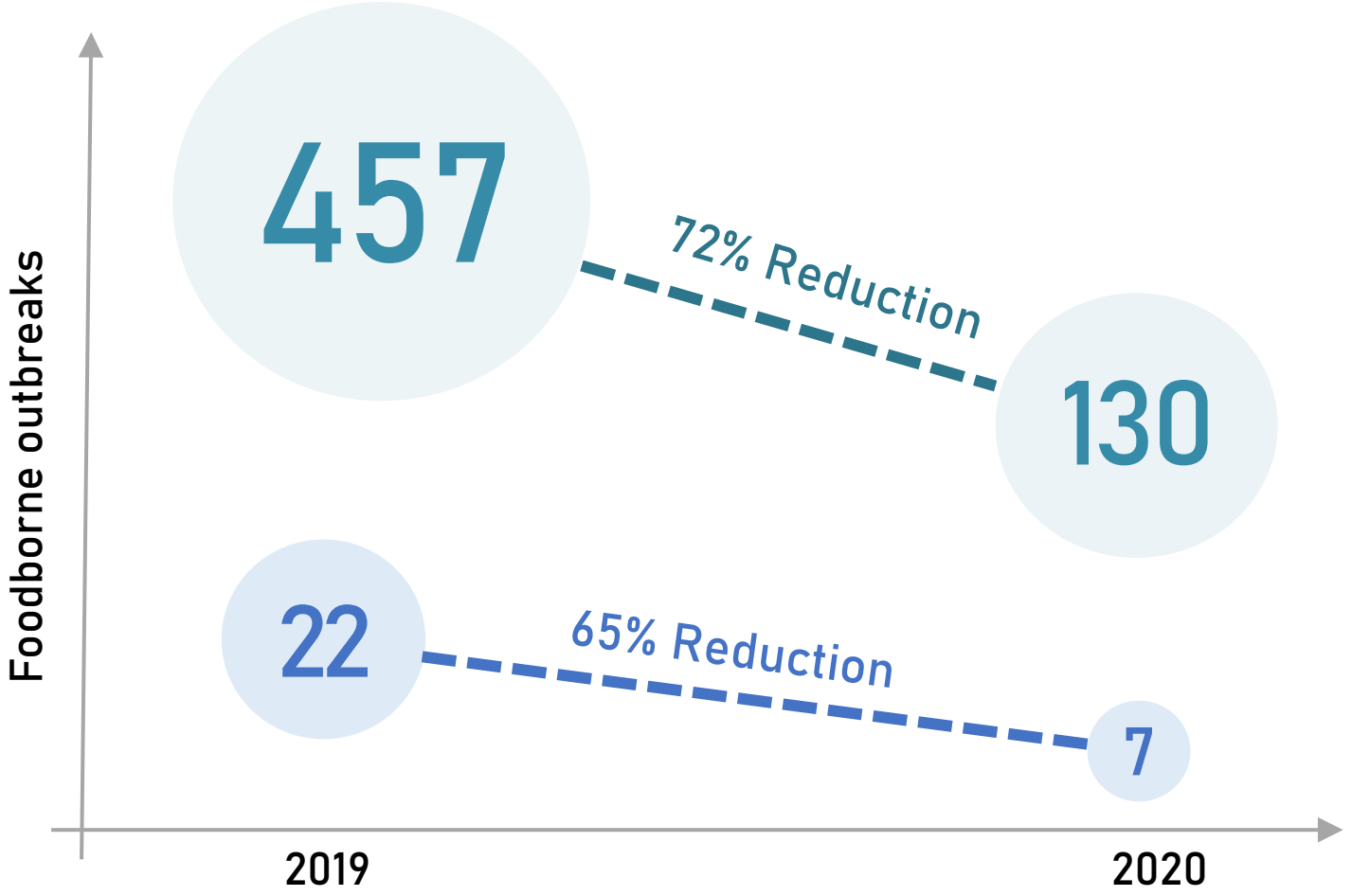
- Outbreaks and cases of Hepatitis E were all reported by Germany
- Potential Porcine Zoonotic disease
- Emerging Hazard

Implicated Foods

- Raw or Undercooked Pork and products thereof

Viral Foodborne Outbreaks & Covid-19

- Social restriction measures and closure of eating establishments
- Safety and hygiene measures
- Impact on the healthcare system



Cases in 2020 were underreported

Risk Assessment

Knowledge generated from risk assessment is intended to drive the decisions made by risk managers and the information shared by risk communicators.

First application by NASA after the Apollo 1 - 1967 fire

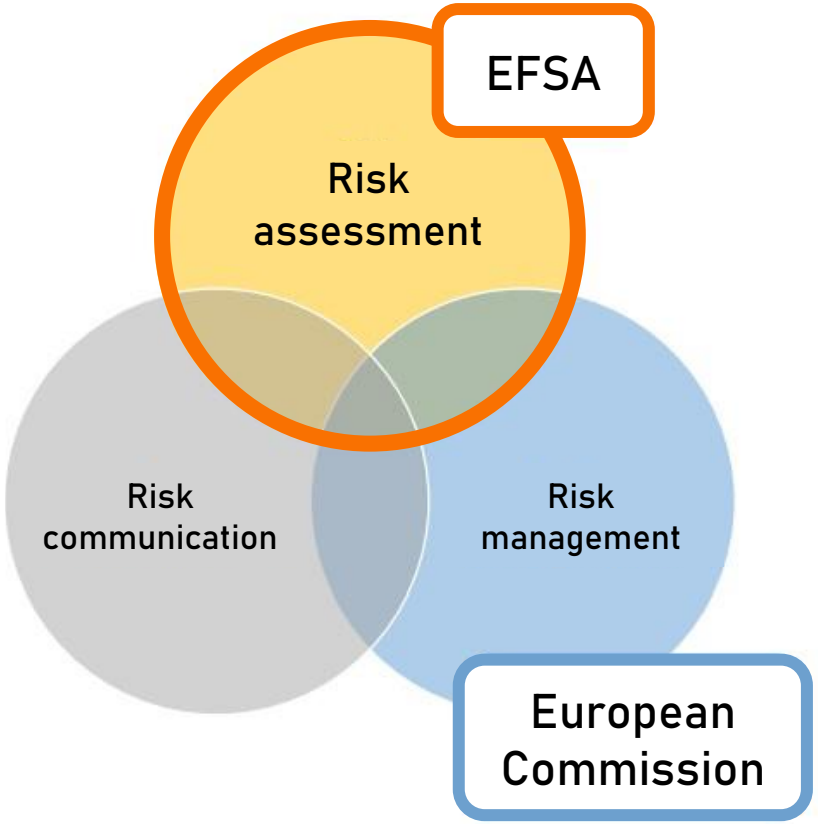
Higher resolution answers to questions of food safety

Food Safety?

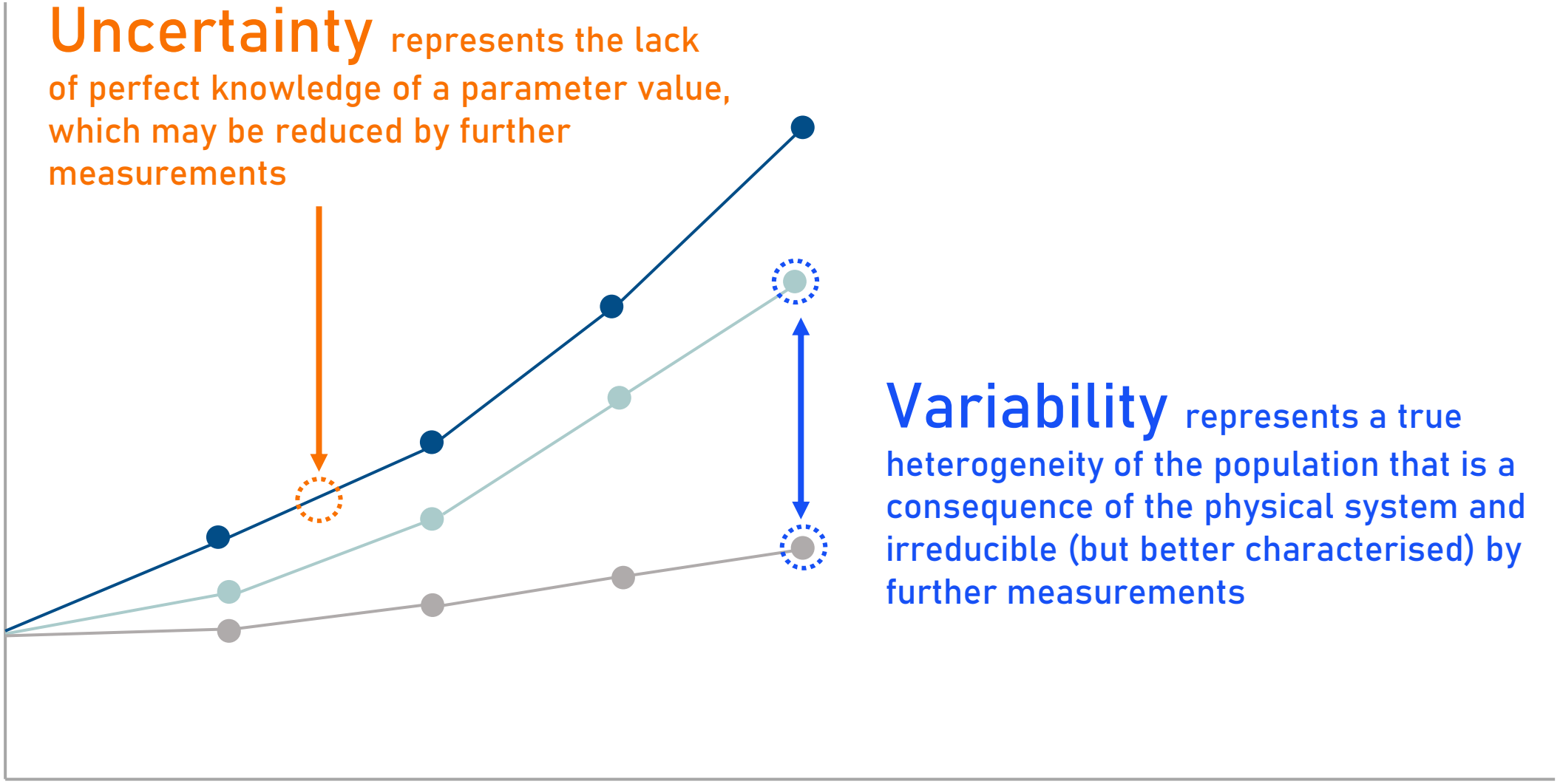
Discrete variable → Continuous variable

(Yes/No) (How Safe?)

Include Variability & Uncertainty for inputs and final output



Uncertainty represents the lack of perfect knowledge of a parameter value, which may be reduced by further measurements



Variability represents a true heterogeneity of the population that is a consequence of the physical system and irreducible (but better characterised) by further measurements

International Guidelines for RA

- WHO & FAO
  - Microbiological risk assessment: guidance for food no.36
  - Principles and Methods for the Risk Assessment of Chemicals in Food (International Programme on Chemical Safety - IPCS)

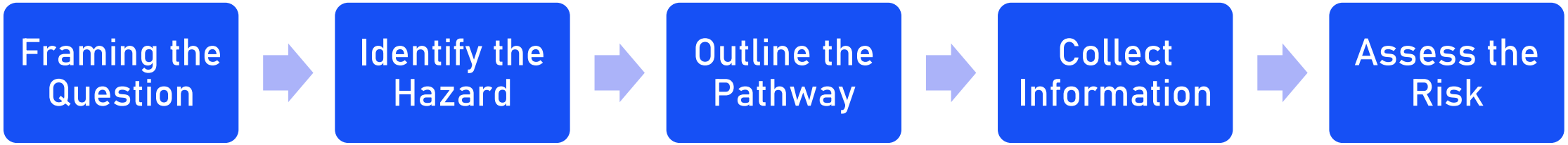
- EFSA
  - microbiological risk assessment (EFSA Journal 2016)
  - Opinion of the Scientific Committee on a request from EFSA related to an harmonized approach for Risk Assessment of Substances Which are both Genotoxic and Carcinogenic

- USDA
  - Microbial risk assessment guideline pathogenic microorganisms with focus on food and water

- EPA
  - Foundations and Frameworks for Human Microbial Risk Assessment

	Chemical RA	Microbial RA
Acute vs Lifetime	Chronic toxicity (mainly)	Acute Illness (sequale)
Exposure Assessment	Bioaccumulation, population characteristics	Growth/Survival in food and hosts
Hazard Characterisation	Toxicological studies	Interaction between food, host and pathogen
Threshold	Threshold dose–response models (except genotoxic carcinogens)	Non-threshold models (Single cell effect)
Risk Characterisation	Exposure and HBGV or MOE (genotoxic compounds)	Risk metrics e.g. DALY's,
Uncertainties & Variabilities	• Duration of exposure in experimental animal studies • Route-to-route extrapolation • Dose–response curve • Interspecies and intraspecies differences • Concentration below LOD or LOQ	• Genetic variability of microbial strains • Events along and within the food chain (predictive microbiology models)

Microbial Risk Assessment (MRA)



Qualitative

Descriptive analysis of the pathways and qualitative risk estimates

The risk assessor assigns a qualitative descriptor (low-medium-high)

- Urgent need
- Numerical data not available
- Lack of resources/skills
- Groundwork for QMRA

Quantitative

Mathematical description of the pathway and numerical risk estimates

- *Deterministic*
  Inputs = point value estimates (e.g. mean value)
  Output = one result
- *Stochastic*
  inputs= Probability Distributions
  Output= Probability Distribution

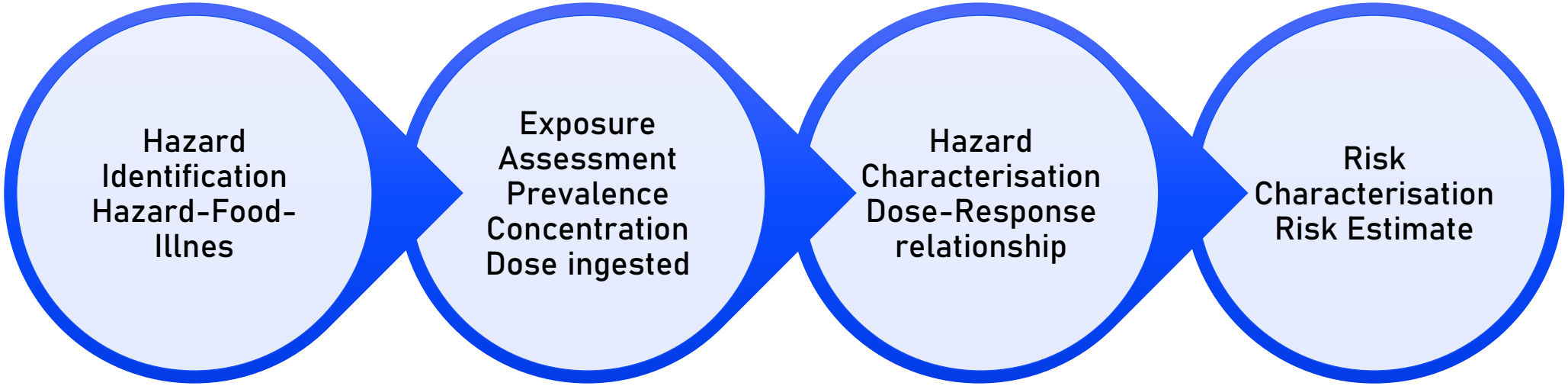
Semi-Quantitative

The risk assessor describes the probabilities and consequences by numerical values/categories

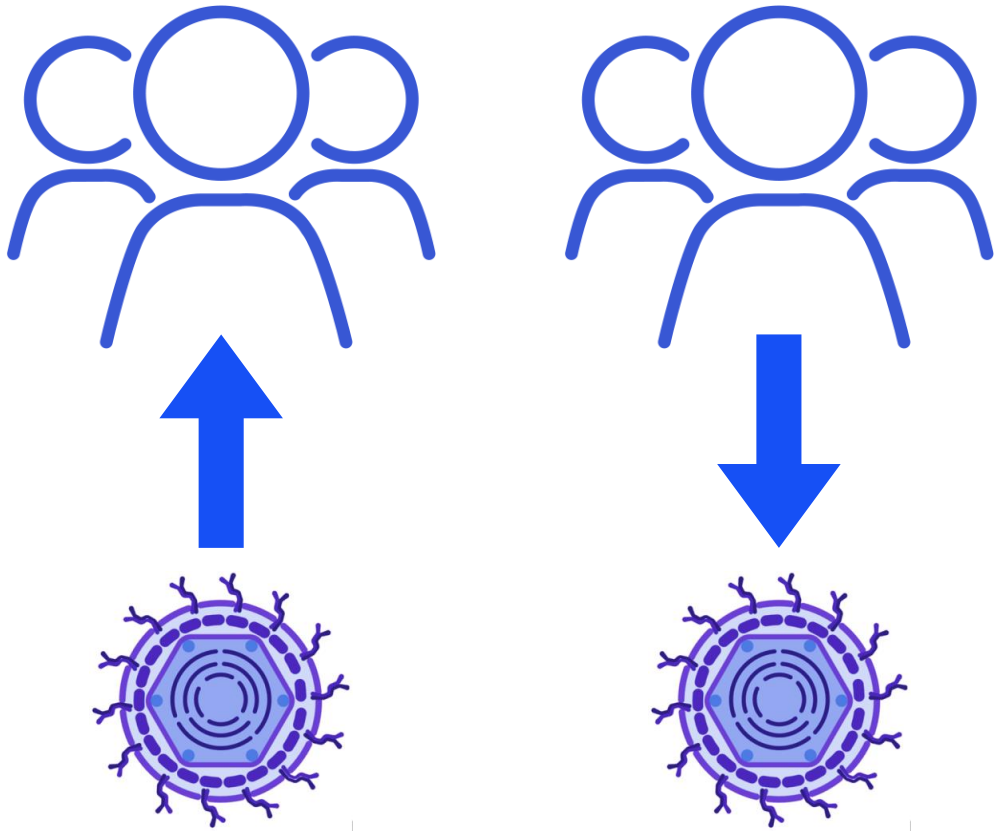
- Lack of quantitative information
- Risk ranking

QMRA

- Mathematical models are used to describe viral prevalence and concentration, and fate in foods as a result of transport, handling and processing.
- Stability of viruses in food
- Response to processing
- Transfer & Spread via cross-contamination



Quantitative Microbial Risk Assessment Approaches



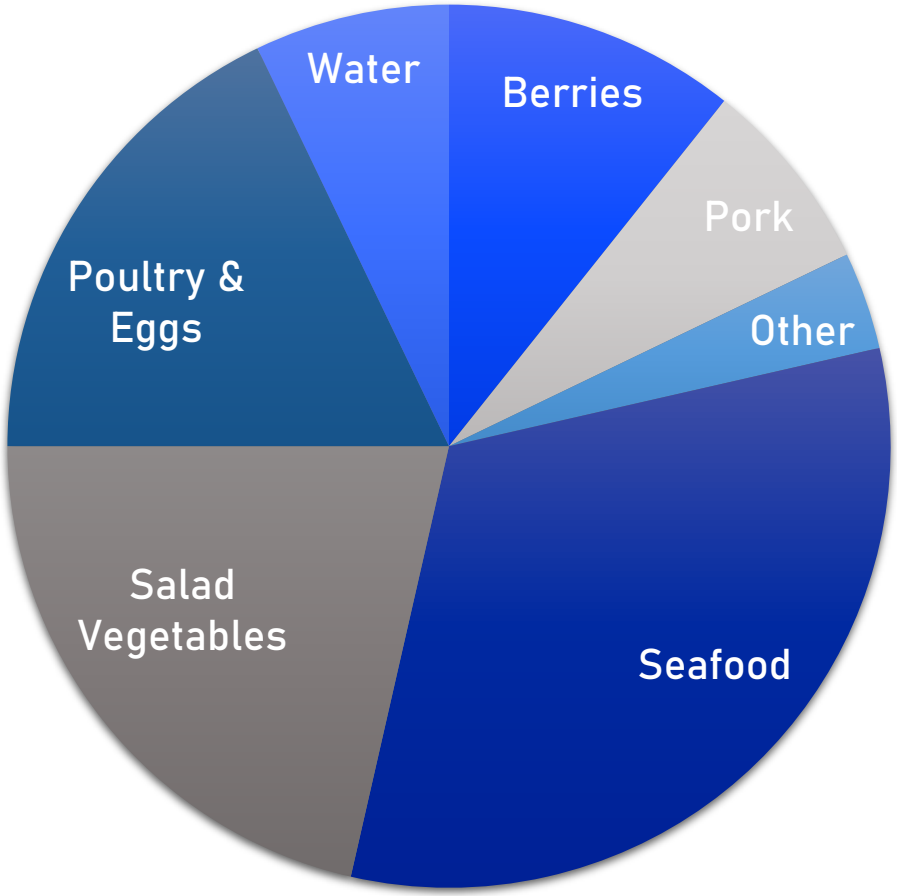
Bottom-Up
Food chain based

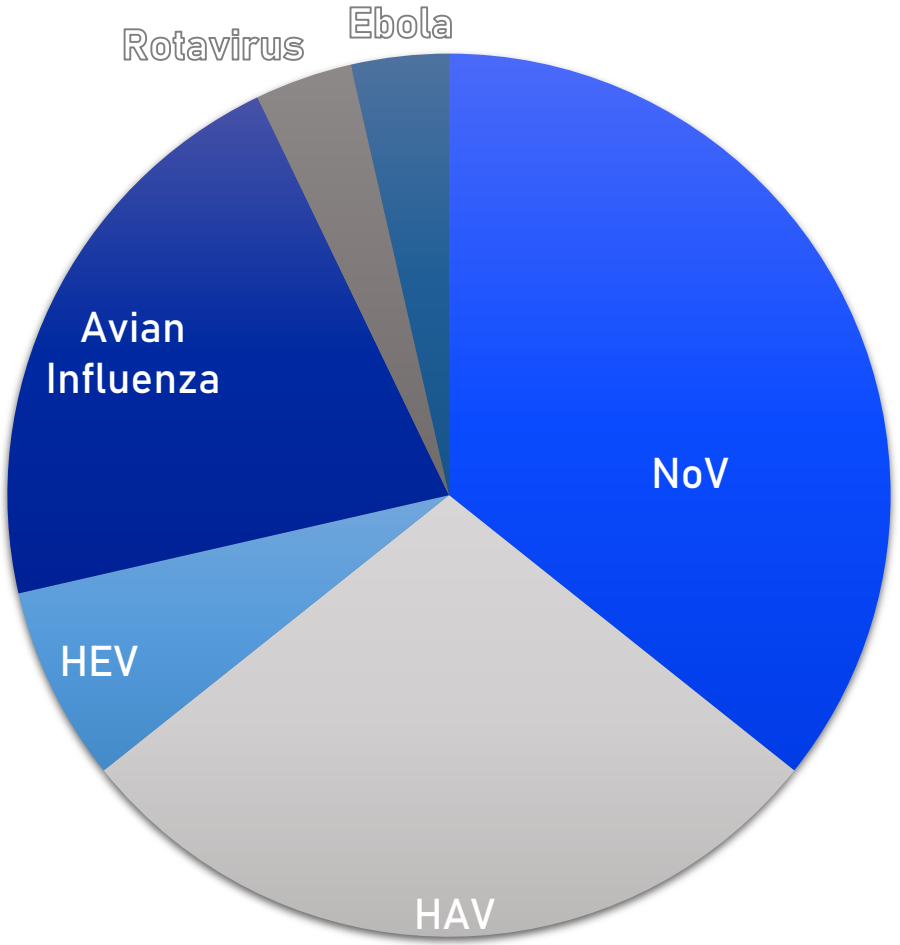
Top-Down
Epidemiology based

QMRA	QVRA
Bacteria	Viruses
Effects have long latency periods or may be poorly established at low doses. Single cell variability	Effects may be fulminant or have a latency period whiles shedding virions.
Growth/Survival in food and host	No growth in food. Bioconcentration in bivalve molluscs. Replication in host's cells
Interaction between food, host and pathogen	Interaction between food, host and pathogen.
Host immunity and susceptibility influences the onset of an infection	Host immunity and susceptibility influences the onset of an infection

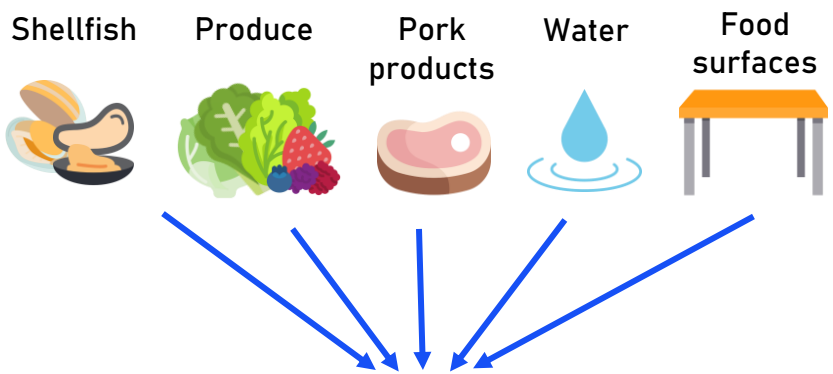
- Persistence in many environments/reservoirs and survival on fomites & in water, soil, and foods
- Resistance to processing, intrinsic factors (aw, pH), commonly used sanitisers and gut acidity
- Preservation of infectivity for long periods of time. Shedding by asymptomatic carriers e.g. 10^{7}-10^{11} HRV viral particles/g of stool 1-100 viral particles suffice to produce illness

Viral Risk Assessments
Is it Cold out There?





Viral Detection



Viral Concentrate

Extracted Nucleic Acids

- Monoplex RTqPCR
- Viability PCR
- Multiplex RTqPCR
- Digital RTqPCR
- Next-Gen Sequencing (NGS)

Challenges

- High degree of genetic variability for NoVs → need to select appropriate RT-PCR primers & probes
- Presence at low levels in contaminated foods, most foodborne viruses cannot readily be enriched by culture methods
- Need to sample and test large volumes of food
- Need to extract and concentrate viruses prior to detection
- Matrix-associated inhibition and interfering substances

Molecular detection does not necessarily indicate the presence of infectious viruses

Viral Risk Assessment Challenges

Hazard Identification

Data Gaps

- Genetic diversity
- Emergence of novel viral strains
- Persistence of virus infectivity on foods,
- Epidemiological data (underreporting, asymptomatic carriers)

Exposure Assessment

- Quantification of infectious viruses
- Detection issues (no/limited enrichment & culturing ability)
- Infectivity status of detected viruses
- Distinction between infectious (viable) and non-infectious (non-viable)
- Sampling plans (Uneven distribution in foods)
- Complicated pathways (Require Data for all steps)
- Virus inactivation/survival kinetics (and validation)
- Susceptibility to disinfectants
- Reliance on surrogates

Viral Risk Assessment Challenges

Hazard Characterisation

- High Variability of health outcomes
- Differences in host immunity
- Inability to discriminate between infectious and non-infectious viral agents
- Issues with dose response modelling
- Extrapolation of Dose-Response results to the general population.

Risk Characterisation

- Overestimation of risk for the general population

QVRA Future

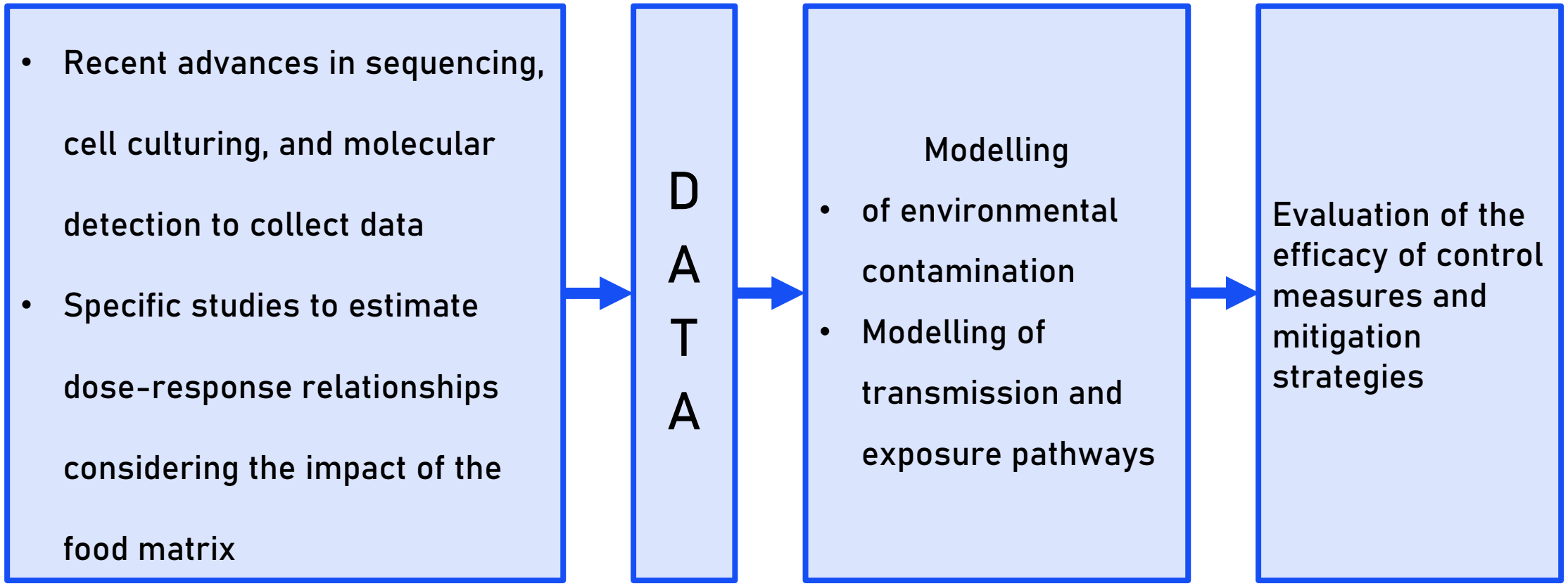
- Whole Genome Sequencing
- Next Generation Sequencing

  - Risk-ranking phenotypes,
  - Surveillance, Outbreaks & R.A.
  - Minimise the need for culturing

- Omics

  - Describing behaviour variability due to heterogeneity in physiological states and stress responses
  - Response at the strain level
  - Decipher complex food ecosystem dynamics
  - Biomarker identification
  - Improve quality and accuracy of HC
  - Describing the ‘state of the dose’
  - Omics-based virulence profiles

The future of Microbial risk assessment: Next steps and new generation techniques



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Munich GERMANY 4-6 May IAFP'S EUROPEAN SYMPOSIUM ON FOOD SAFETY 2022

INSTYTUT BIOTECHNOLOGII PRZEMYSŁU ROLNO-SPOŻYWCZEGO im. prof. Wacława Dąbrowskiego PAŃSTWOWY INSTYTUT BADAWCZY

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