Multi-criteria method for hazard and food prioritisation

EFET'S CONFERENCE ON RISK ASSESSMENT AND RANKING OF RISKS IN EUROPEAN FOOD SAFETY SYSTEMS

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Nawel Bemrah, Pauline Kooh, Marie Vallée

Introduction

PrioR: Food Risk Ranking Tool

First report *CIMAP 3: ranking of biological and chemical hazards to optimise food safety**

- Developped a methodology for the ranking chemical and biological hazards and food-hazard pairs
- Proof of concept on a limited number of hazards and pairs

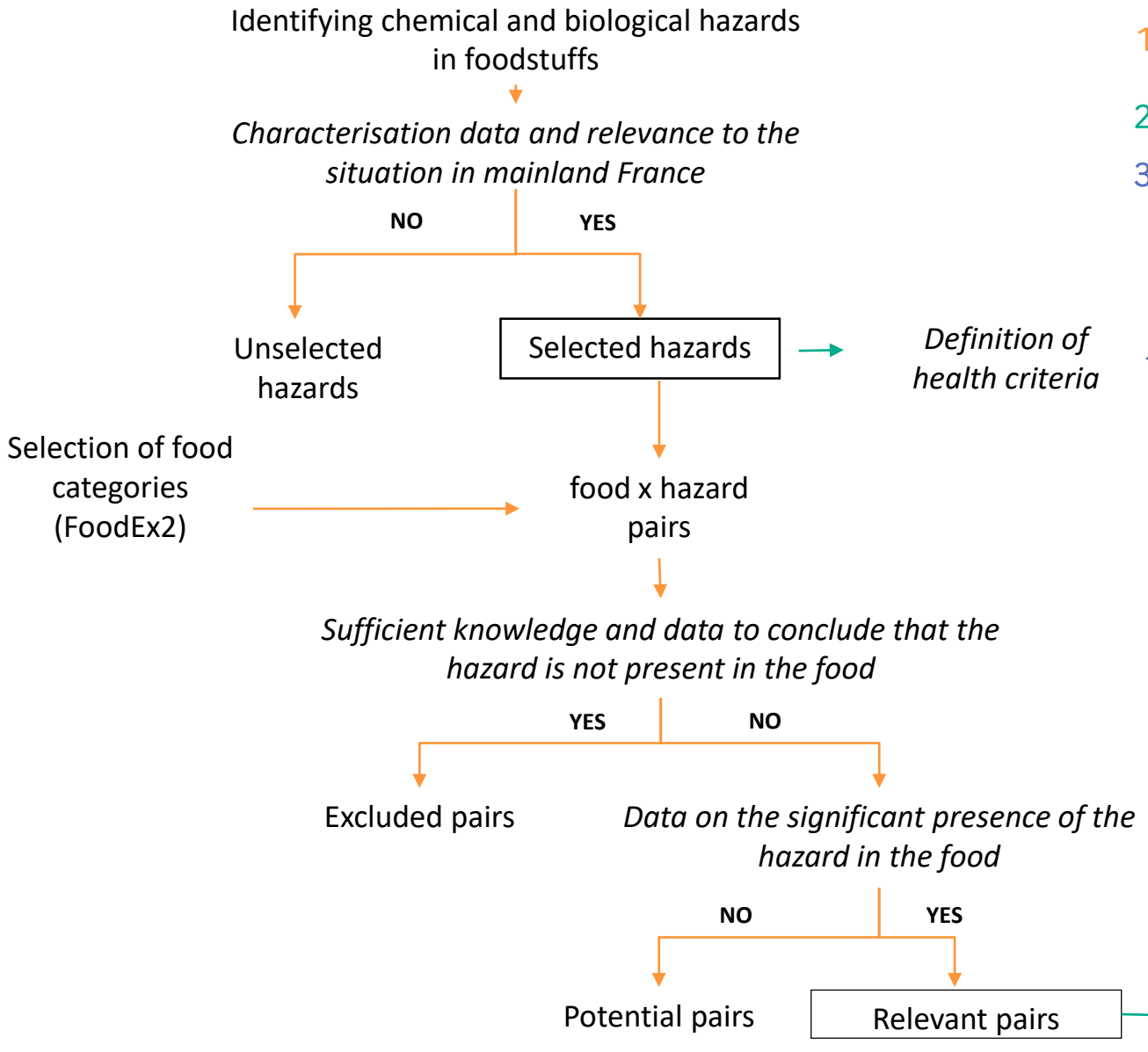
An operational ranking tool

1. Creation of a database containing all the data needed to compile the ranking criteria
2. Input the data into the database
3. Classification of food-hazard pairs into « excluded », « potential » or « relevant » for ranking purposes
4. Input ranking criteria for relevant hazards and food-hazard pairs
5. Development of a user interface

***Opinion on the method available at:**
https://www.anses.fr/fr/system/files/BIORISK2016SA0153Ra.pdf

Methodology

General methodology developed: multi-criteria decision-support model



1. Identification of objects to be prioritised
2. Defining and filling in ranking criteria
3. Aggregation and weighting of criteria

Definition of health criteria → *Regrouping the health criteria* (ELECTRE III) → Ranking of chemical hazards; Ranking of biological hazards

Definition of health criteria → *Regrouping the health criteria* (ELECTRE III) → Ranking of food-chemical hazard pairs; Ranking of food-biological hazard pairs

Selection of biological hazards

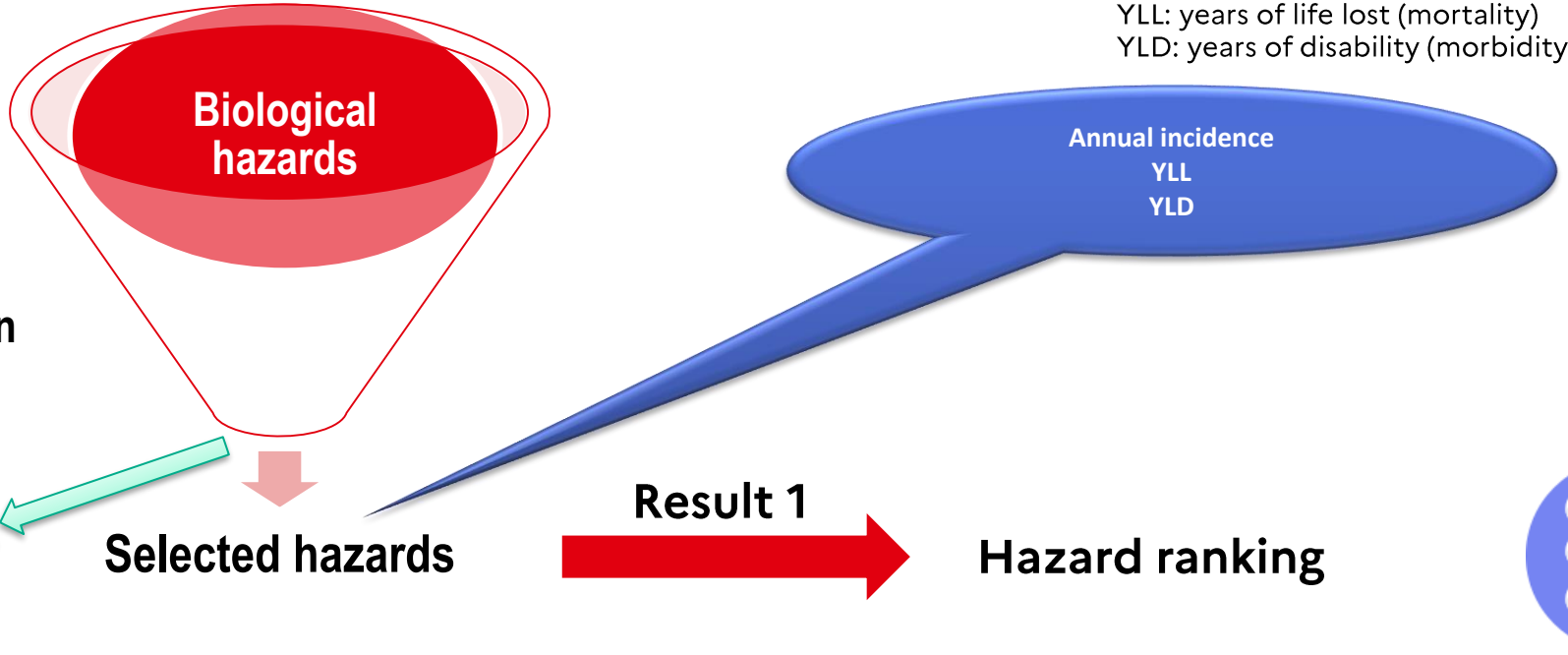
Selection of biological hazards for ranking

Hazard filters

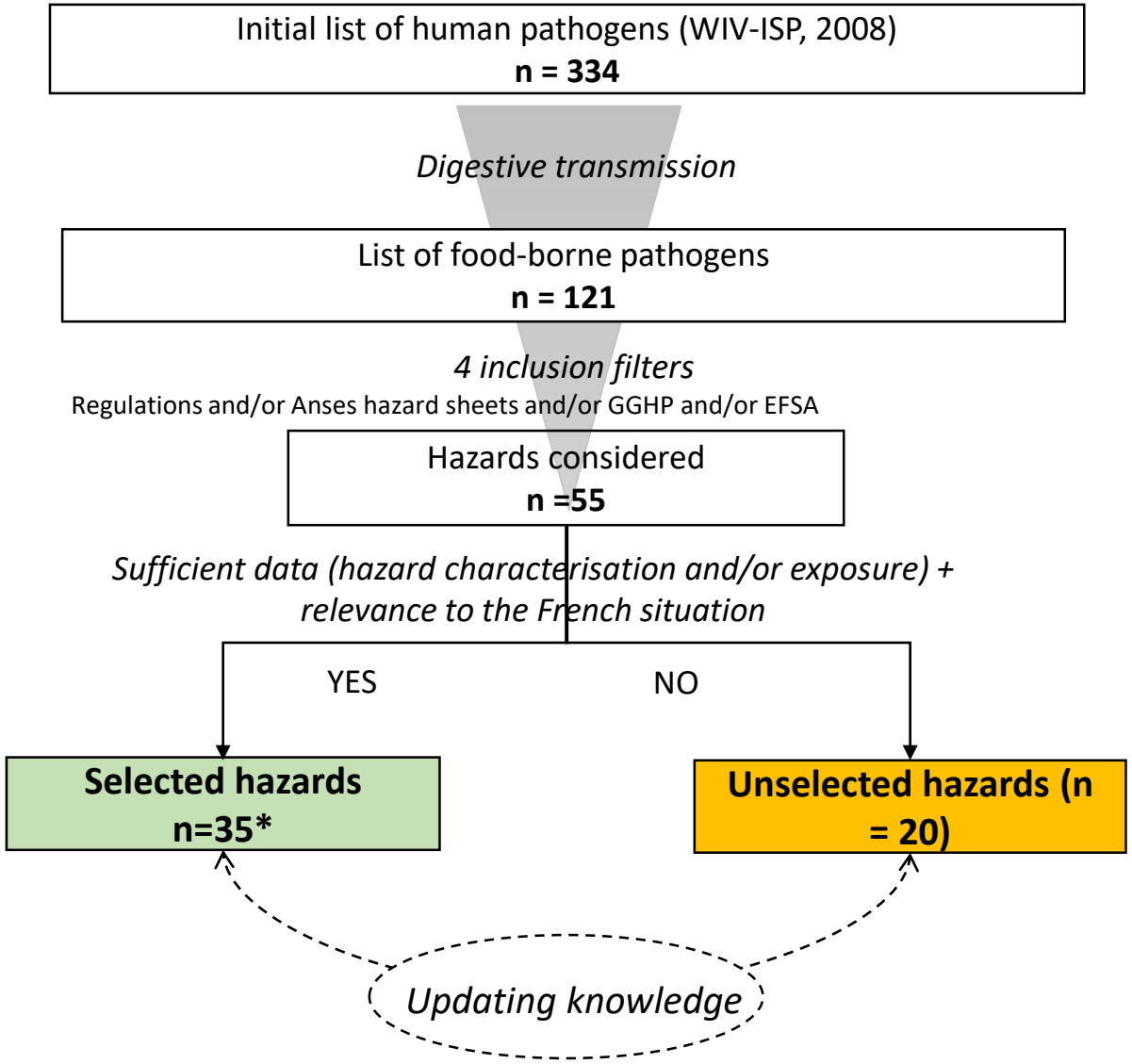
food transmission

regulations and/or hazard sheet

sufficient data (hazard characterisation and/or exposure) + relevance to the French situation



Identification and selection of biological hazards



Dangers	Disease (clinical forms)
Bacteria, toxins and metabolites	
Aeromonas spp.	Opportunistic infection
Bacillus cereus	Emetic poisoning and diarrhoeal toxin infection
Brucella spp.	Brucellosis
Campylobacter spp.	Acute gastroenteritis and complications (Guillain-Barré syndrome, reactive arthritis, irritable bowel syndrome)
Clostridium botulinum	Botulism
	Infant / infant botulism
Clostridioides difficile (syn *Clostridium difficile*)	Intestinal opportunistic infection (diarrhoea)
Clostridium perfringens	Diarrhoeal toxicity and infection
Cronobacter spp.	Systemic infection / infants
Enterohaemorrhagic *Escherichia coli* (EHEC)	Acute gastroenteritis and complications (haemolytic uremic syndrome [HUS], and thrombotic microangiopathy syndrome [TMS]
Histamine	Histamine poisoning
Listeria monocytogenes	Invasive listeriosis
	Perinatal listeriosis / foetuses and newborns
Mycobacterium bovis	Tuberculosis
Non-typical *Salmonella*	Acute gastroenteritis and complications (reactive arthritis)
Shigella spp / Enteroinvasive *Escherichia coli* (EIEC)	Acute gastroenteritis and complications (HUS, reactive arthritis)
Staphylococcus aureus	Emetic poisoning
Non choleric *Vibrio* (*Vibrio cholerae non* O1 / non O139, *Vibrio parahaemolyticus*)	Acute gastroenteritis
Enteropathogenic *yersinia* (*Y. enterocolitica, Y. pseudotuberculosis*)	Acute gastroenteritis
Viruses & ATNC	
Bovine Spongiform Encephalopathy (BSEc) agent	Variant of Creutzfeldt-Jakob Disease
Norovirus + other EAG viruses (astroviruses, enteroviruses, rotaviruses)	Acute gastroenteritis
Hepatitis A virus	Hepatitis
Hepatitis E virus	Hepatitis
Parasites	
Anisakis spp. *and Pseudoterranova* spp.	Gastrointestinal anisakidiosis
Cryptosporidium spp.	Acute gastroenteritis
Cyclospora cayetanensis	Acute gastroenteritis
Diphyllobothrium latum	Diphyllobothriosis
Echinococcus multilocularis	Alveolar echinococcosis
Fasciola hepatica	Fasciolosis
Giardia duodenalis	Acute gastroenteritis / irritable bowel syndrome
Taenia saginata	Teniasis
Toxoplasma gondii	Acquired Toxoplasmosis
	Congenital Toxoplasmosis / foetus and newborns
Trichinella spp.	Trichinellosis

** 31 after consolidation*

GGHP = Guide of good hygien practices

Selection of food-biological hazard pairs

Selection of biological hazards and food/biological hazard pairs for ranking

YLL: years of life lost (mortality)
YLD: years of disability (morbidity)

Hazard filters

food transmission

regulations and/or hazard sheet

sufficient data (hazard characterisation and/or exposure) + relevance to the French situation

Biological hazards

Annual incidence
YLL
YLD

Unselected hazards

Selected hazards
+
Food

Result 1

Hazard ranking

Pairs filter

Significant presence in food

Food-hazard pairs

YLL
YLD
Incidence of disease attributed to food

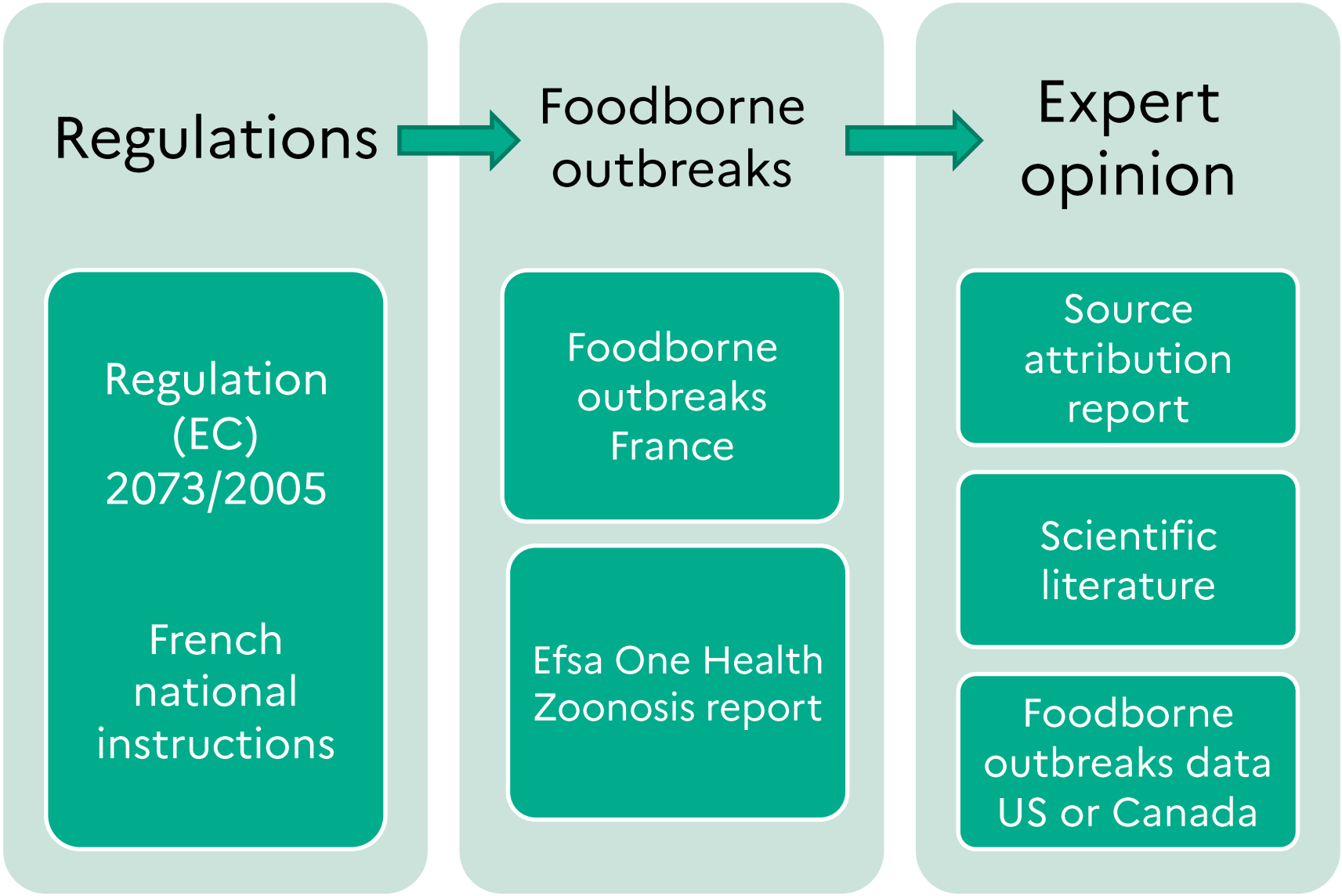
Potential food/hazard pairs

Relevant food-hazard pairs

Result 2

food/hazard pairs ranking

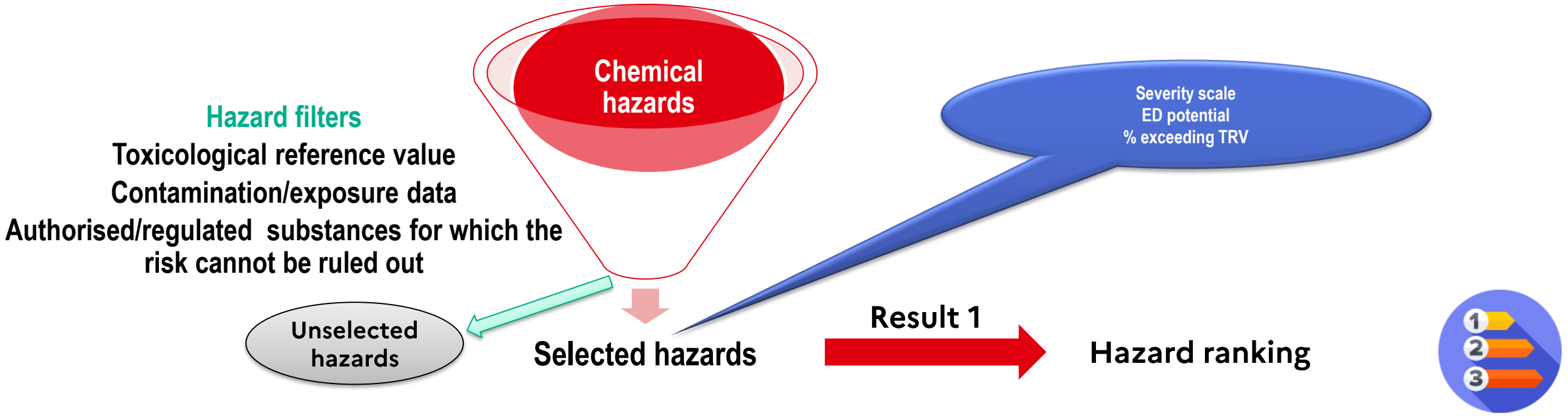
Sources of data for selecting relevant food/biological hazard pairs



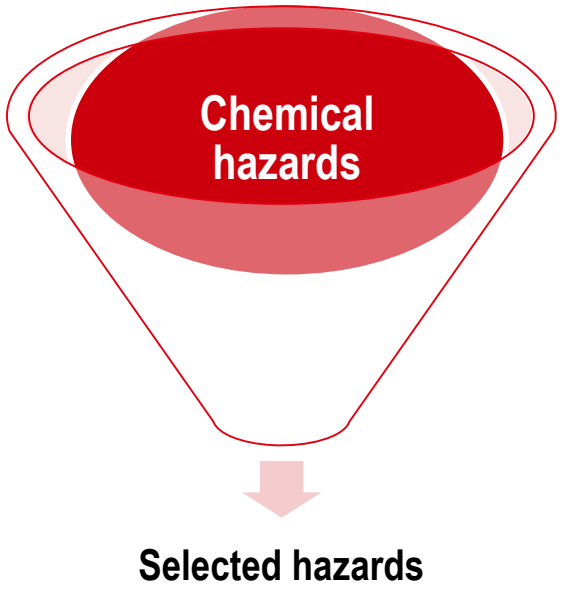
Selecting chemical hazards

Selection of chemical hazards for ranking

ED: Endocrine disruptor
TRV: Toxicological Reference Value



Identification and selection of chemical hazards



List of selected hazards

108 hazards (substances or families of substances) selected

- *Inorganic compounds, including trace metals*
- *Persistent organic pollutants (POPs)*
- *Mycotoxins*
- *Phycotoxins (or marine biotoxins)*
- *Cyanotoxins*
- *Phytotoxin**s***
- *Phyto-oestrogens*
- *Neoformed compounds*
- *Substances derived from MCDA*
- *Pesticide residues*
- *Food additives*
- *Other contaminants*

Selection of food and chemical hazard pairs

Selection of chemical hazards and food-chemical hazard pairs for ranking

EP: Endocrine disruptor
TRV: Toxicological Reference Value

Hazard filters

Toxicological reference value
Contamination/exposure data
Authorised/regulated substances for which the risk cannot be ruled out

Chemical hazards

Unselected hazards

Severity scale
ED potential
% exceeding TRV

Selected hazards
+
Food

Result 1

Hazard ranking

pairs filter

Significant presence in food

Food-hazard pairs

Potential food-hazard pairs

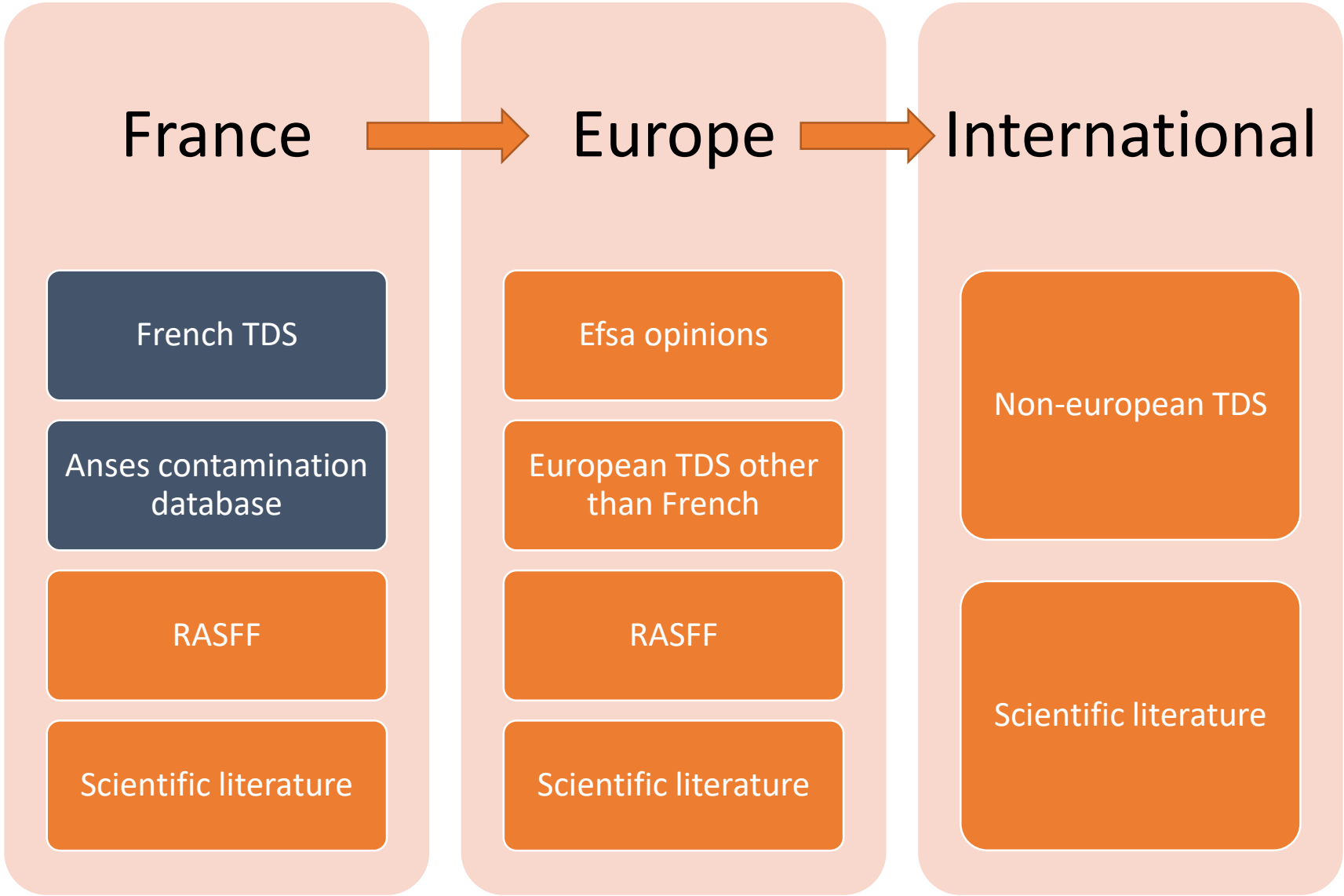
Severity scale
ED potential
% exceeding TRV
% contribution to total exposure

Relevant food-hazard pairs

Result 2

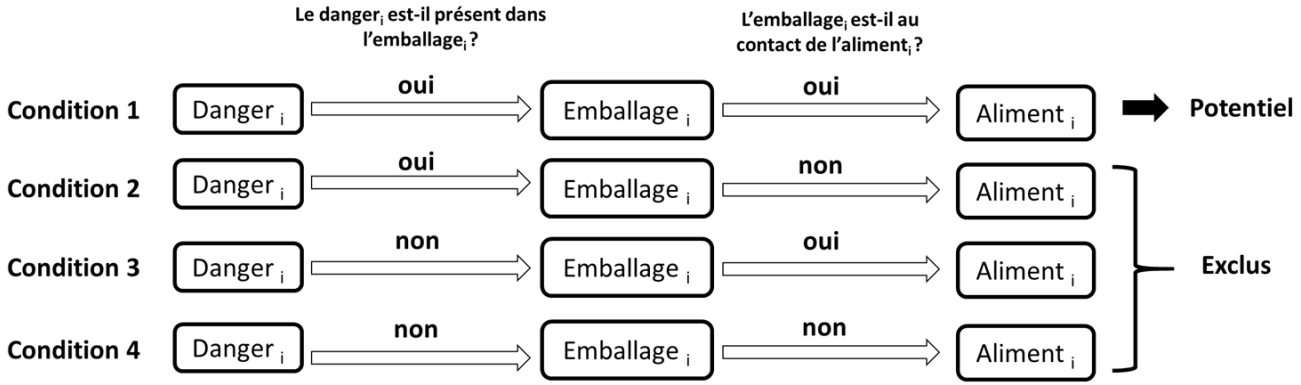
Food/hazard pairs ranking

Sources of data for selecting relevant food-chemical hazard pairs



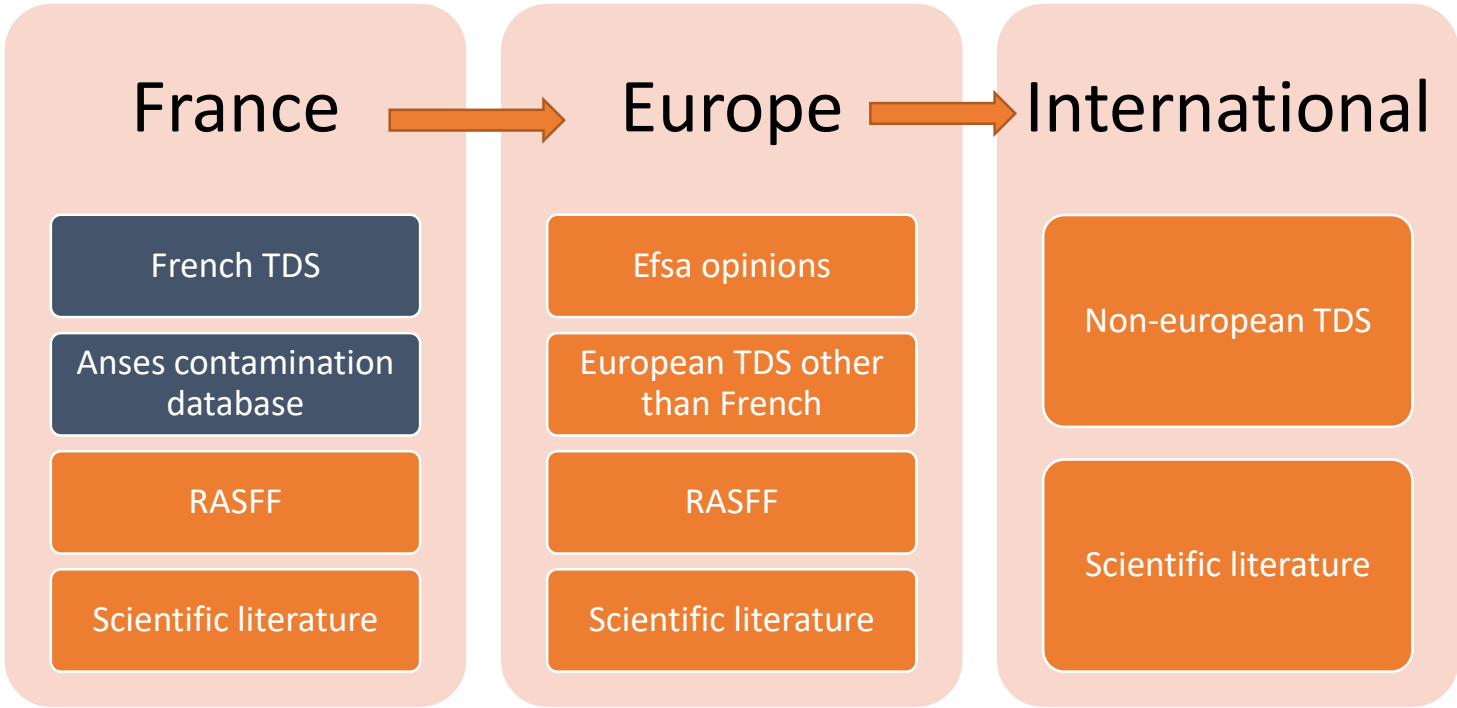
Exclusion and inclusion filters for food-FCM hazard pairs

Pairs excluded if:



is based on knowledge of the uses of food packaging on the market

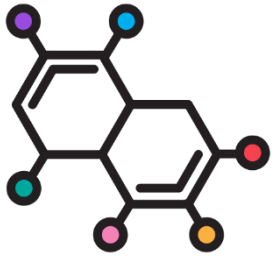
- Relevant pairs if:
- There is proof that the hazard has been detected in the food:



FCM = Food contact materials

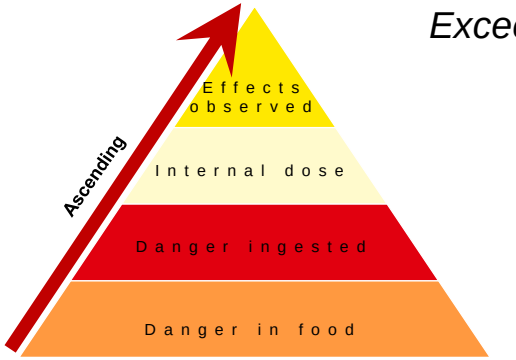
Ranking criteria

Hazard ranking criteria



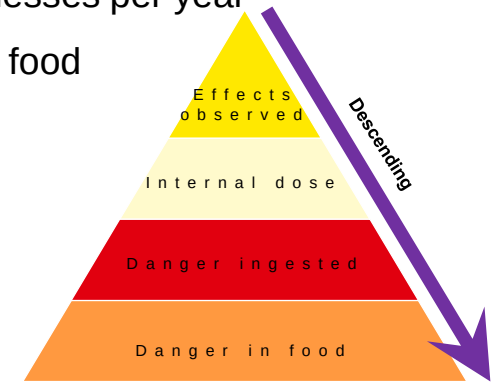
TRV exceeded
(Toxicological reference value)

Exceeding frequency



Incidence

Number of illnesses per year attributable to food



Representation of risk

Severity

Severity scale

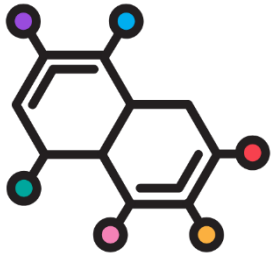
Endocrine Disrupting (ED) potential

Severity

YLL (*years of life lost: mortality)*

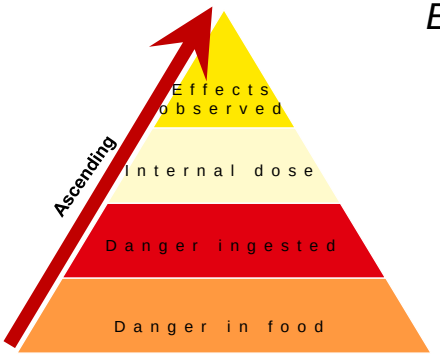
YLD (*years of disability: morbidity)*

Criteria for ranking pairs



TRV exceeded
(Toxicological reference value)

Exceeding frequency



Contribution

Contribution of the food to total exposure to the hazard

Severity

Severity scale

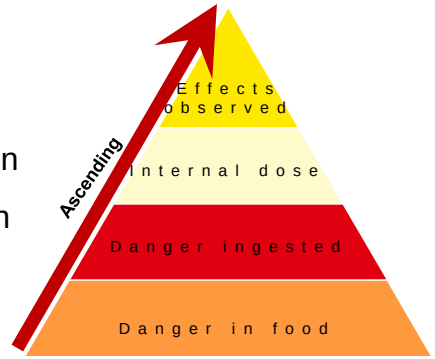
Endocrine Disrupting (ED) potential

Representation of risk

Incidence

Number of illnesses per year per food

- Probability of risk scenario
- Level of contamination
- Prevalence
- Growth during distribution
- Impact of the preparation
- Number of portions
- Morbid dose 50



Severity

YLL (*years of life lost: mortality)*

YLD (*years of disability: morbidity)*

Criteria for ranking food-biological hazard pairs

Macro-criterion: "occurrence

Severity" macro-criterion

Single summary criterion

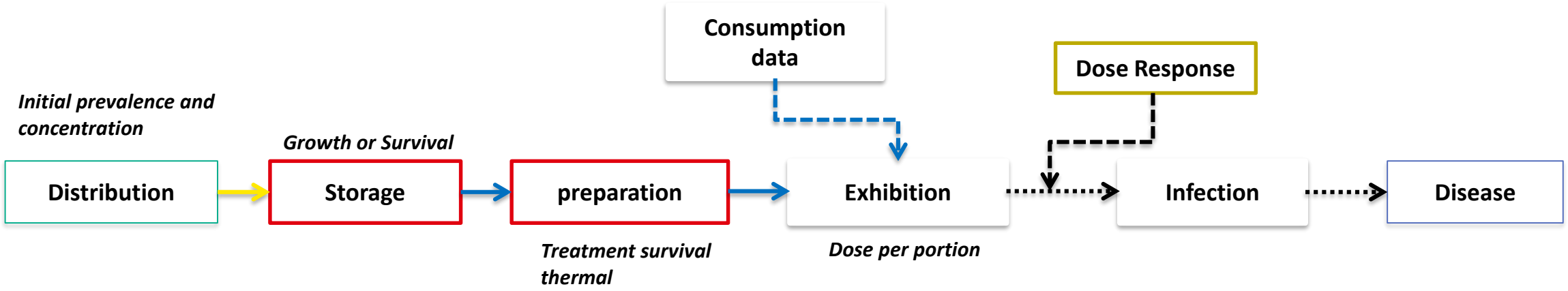
Incidence of food-related disease" criterion

YLL" criterion

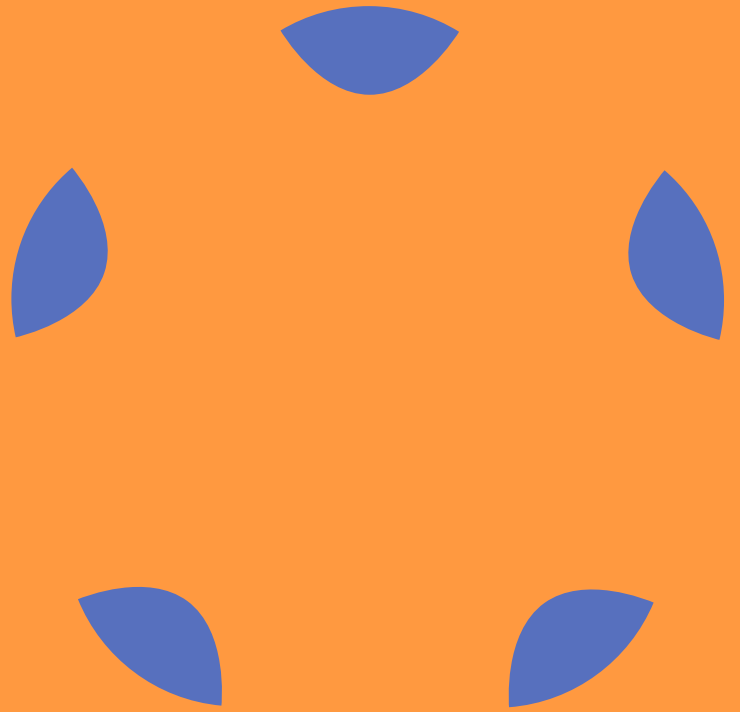
YLD" criterion

- Prevalence of distribution contamination
- Distribution concentration
- Potential for development during storage
- Impact of final preparation
- Number and average size of portions eaten
- Morbid dose 50
- Probability of occurrence of high-risk scenario

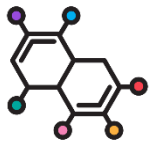
Defined for a high-risk scenario
=
responsible for the highest number of cases



Aggregation of criteria



Ranking



Chemical Criteria

Prepare

Coordination

PRIOR tool

Weight

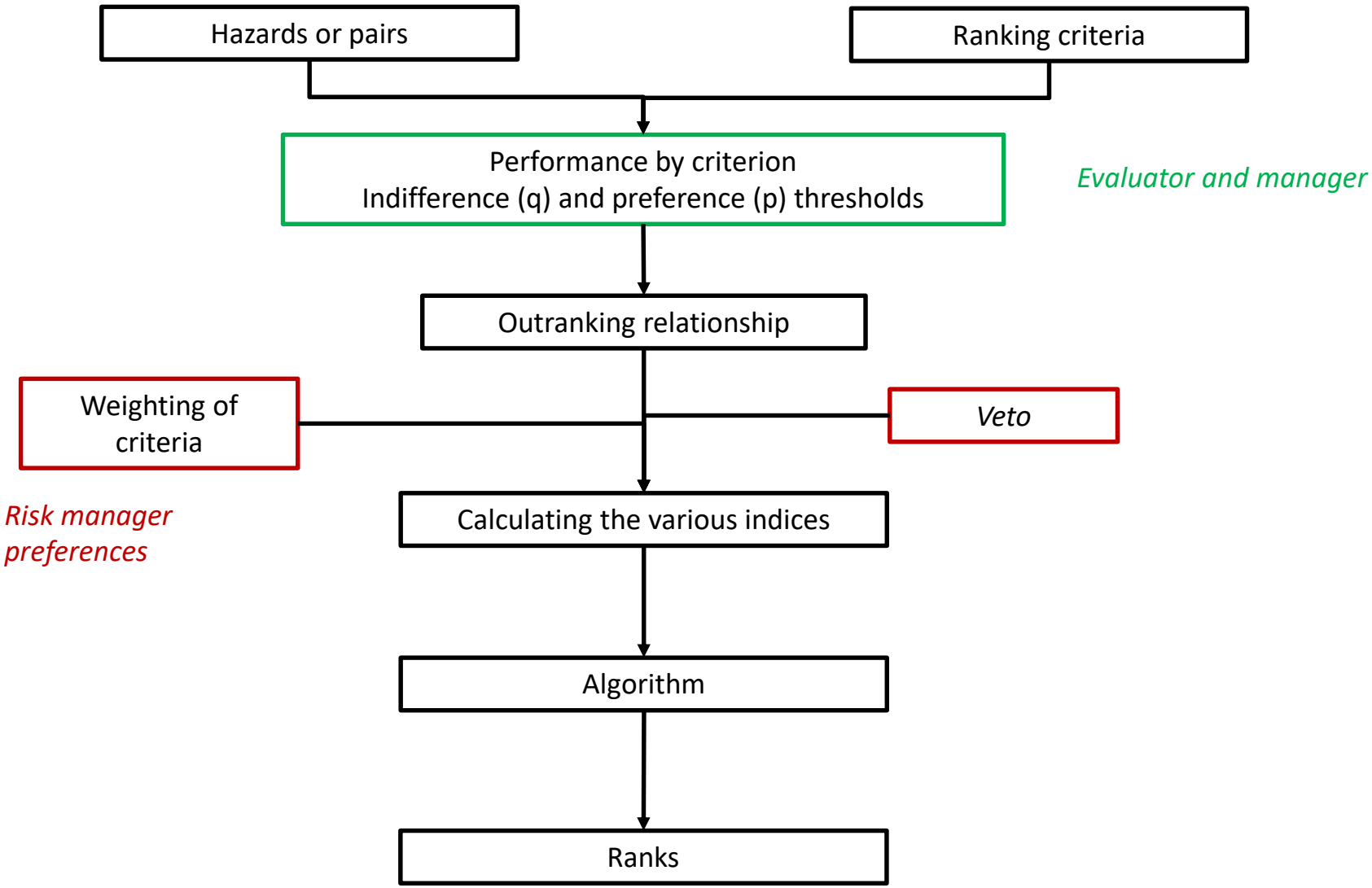
Risk manager

Chemical ranking

Biological ranking

Biological Criteria

ELECTRE III: the main principles



Weighting of criteria

Weight games	YLL/ 1000 cases	YLD/ 1000 cases	Incidence
Weight A	25	25	50
Weight B	50	25	25
Weight C	43	43	14

→ Equivalent weight between severity and incidence

→ Mortality >> morbidity and incidence

→ Severity >> incidence

Weight games	Severity scale	ED potential	VTR exceeded
Weight A	45	10	45
Weight B	43	14	43
Weight C	49	2	49

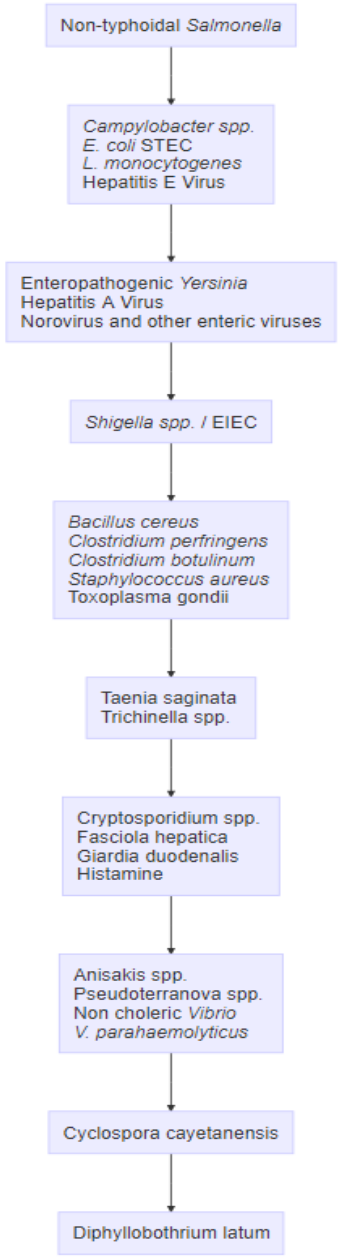
The weights are set by the manager with the assessor.

Ranking of biological hazards

TABLE 4. INCIDENCE AND SEVERITY (YEARS OF LIFE LOST [YLL], YEARS LOST DUE TO DISABILITY [YLD]) OF FOODBORNE ILLNESSES IN MAINLAND FRANCE

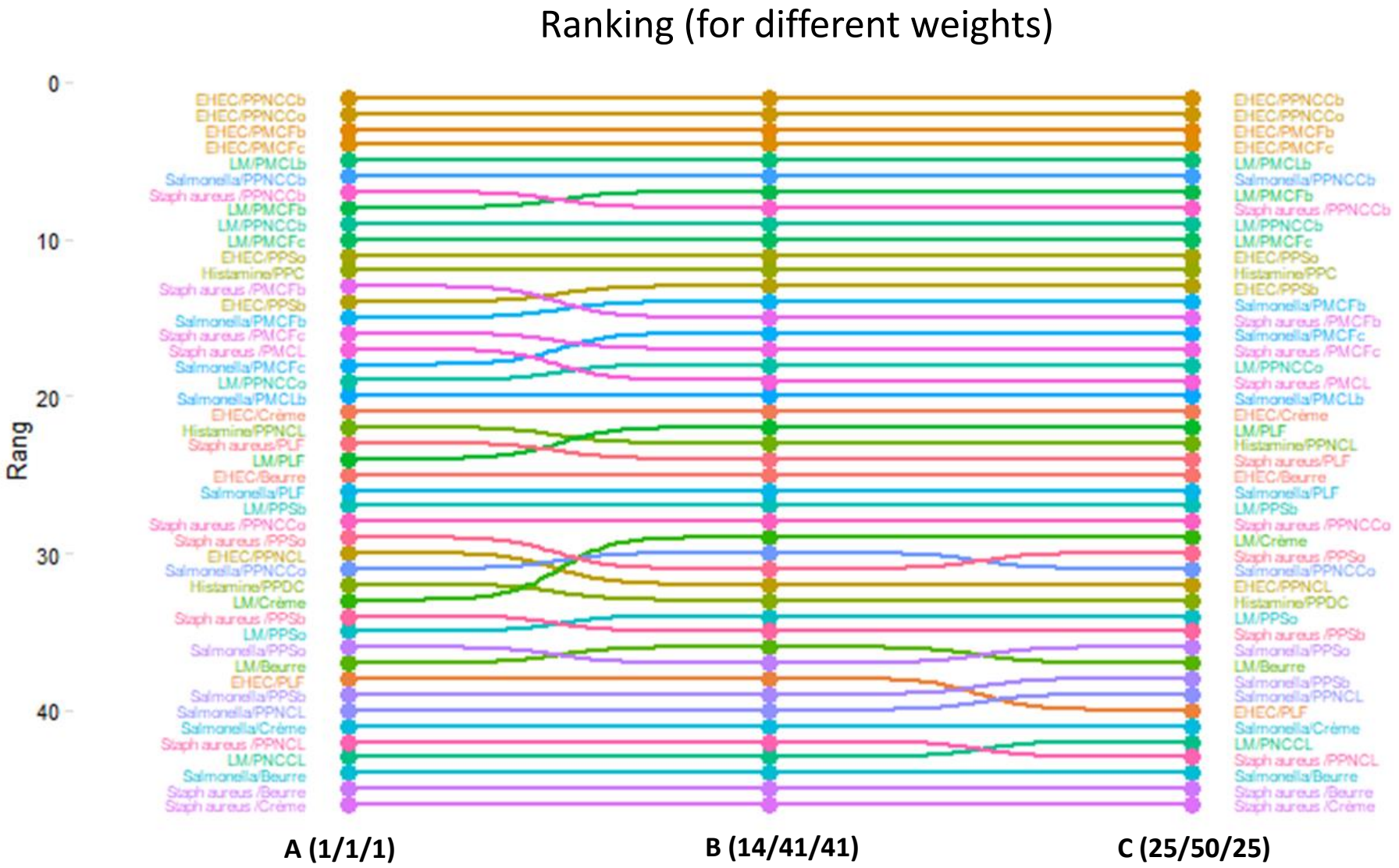
Hazard	*Disease (Clinical Forms)*	*Incidence 2008–2013*	*Incidence 2014–2019*	*YLL/ 1000 cases*	*YLD/ 1000 cases*
Bacillus cereus	Emetic poisoning and diarrheal toxin infection	69468[a]	188274[b]	0[f]	2.3[f]
Campylobacter spp.	Acute gastroenteritis and complications (Guillain-Barré syndrome, reactive arthritis, irritable bowel syndrome)	392177[a]	611815[b]	7.7[g]	4.9[g]
Clostridium botulinum	Foodborne botulism, infant botulism	21[c]	14[c]	2800[d]	100[d]
Clostridium perfringens	Diarrheal toxin infection	119632[a]	173041[b]	0.4[f]	2.8[f]
Shiga toxin-producing *Escherichia coli* (STEC)	Acute gastroenteritis and complications (Haemolytic uraemic syndrome (HUS) and Thrombotic microangiopathy (TMA)	17927[a]	17927[d]	55.2[g]	20.7[g]
Histamine	Histamine poisoning	167[c]	247[c]	0[d]	3[d]
Listeria monocytogenes	Invasive listeriosis, Perinatal listeriosis	402[a]	374[c]	3300[g]	400[g]
Non-typhoidal *Salmonella*	Acute gastroenteritis and complications (reactive arthritis)	183002[a]	201582[b]	15[g]	4[g]
Shigella spp/ Enteroinvasive *Escherichia coli* (EIEC)	Acute gastroenteritis and complications (HUS, reactive arthritis)	3449[a]	5386[b]	22[g]	3[g]
Staphylococcus aureus	Emetic poisoning	73021[a]	52479[b]	0.3[f]	2.3[f]
Non choleric *Vibrio* (*Vibrio cholerae* non O1/ non O139, *Vibrio parahaemolyticus*)	Acute gastroenteritis	0	20[c]	0[d]	3[d]
Enteropathogenic *Yersinia* (*Y. enterocolitica, Y. pseudotuberculosis*)	Acute gastroenteritis	21330[a]	21330[d]	15[d]	4[d]
Norovirus and other gastro-enterititis viruses (astrovi-ruses, enteroviruses, rotaviruses)	Acute gastroenteritis	517593[a]	517593[d]	1.8[h]	0.6[h]
Hepatitis A virus	Hepatitis	2627[a]	3159[b]	58.3[g]	13.7[g]
Hepatitis E virus	Hepatitis	576[c]	2212[c]	377.3[g]	75.5[g]
Anisakis spp. *and Pseudoterranova* spp.	Gastrointestinal anisakidiosis	7[e]	14[e]	0.5[d]	4.1[d]
Cryptosporidium spp.	Acute gastroenteritis	105[c]	189[c]	0.5[d]	4.1[d]
Cyclospora cayetanensis	Acute gastroenteritis	7[c]	8[c]	0.5[d]	4.1[d]
Diphyllobothrium latum	Diphyllobothriosis	3[a]	3[d]	0.5[d]	4.1[d]
Fasciola hepatica	Fasciolosis	5[a]	5[d]	0[h]	9200[h]
Giardia duodenalis	Acute gastroenteritis/irritable bowel syndrome	454[c]	303[c]	0.5[g]	4.1[g]
Taenia saginata	Teniasis	33006[a]	33006[d]	0.5[d]	4.1[d]
Toxoplasma gondii	Acquired toxoplasmosis, congenital toxoplasmosis	11785[a]	11785[d]	2[h]	60[h]
Trichinella spp.	Trichinellosis	11[a]	11[d]	20[h]	80[h]

Audiat-Perrin *et al*. 2024
https://www.liebertpub.com/doi/10.1089/fpd.2023.0105



Example of a set of weights
YLL: 50
YLD:25
Incidence: 25

Ranking of food-biological hazard pairs : example of Raw milk cheeses



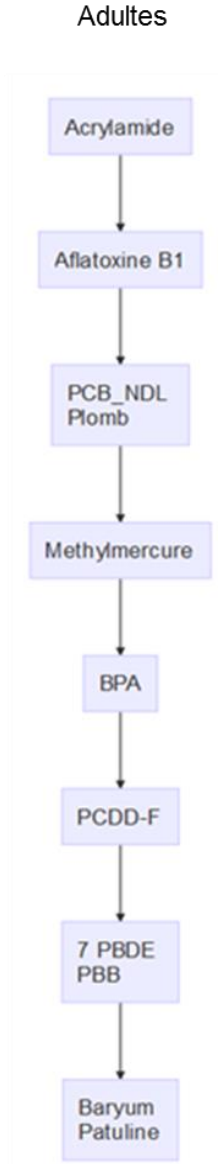
Opinion available at: https://www.anses.fr/fr/system/files/BIORISK2019SA0033.pdf

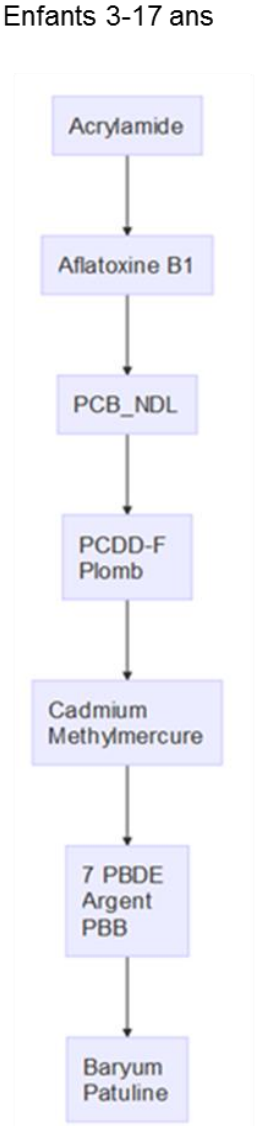
Ranking chemical hazards

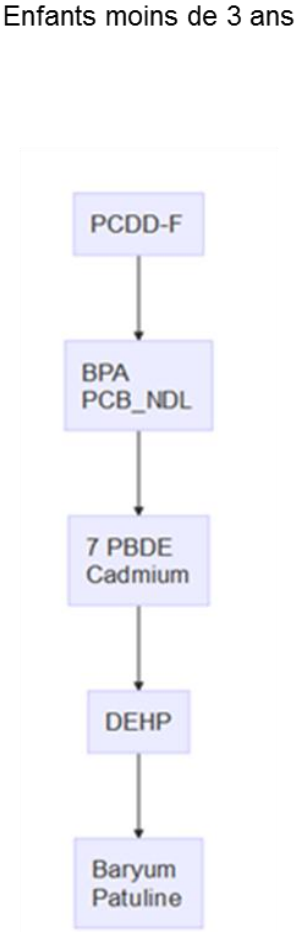
Ranks adult population

Chemical hazards	Final ranking	Confidence level
Acrylamide	1	Medium (B)
Aflatoxin B1	2	Medium (B)
PCB_NDL	3	High (A)
Lead	3	High (A)
Methylmercury	4	High (A)
BPA	5	High (A)
PCDD-F	6	High (A)
7 PBDES	7	High (A)
PBB	7	High (A)
Silver	8	High (A)
Cadmium	8	High (A)
Barium	9	High (A)
Patulin	9	High (A)

+ "children (aged 3-17)" and "children under 3" population ranks





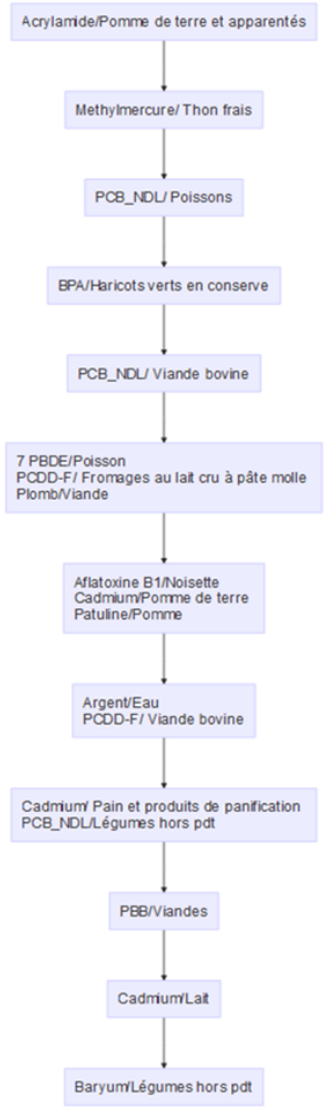


Ranking of food-chemical hazard pairs

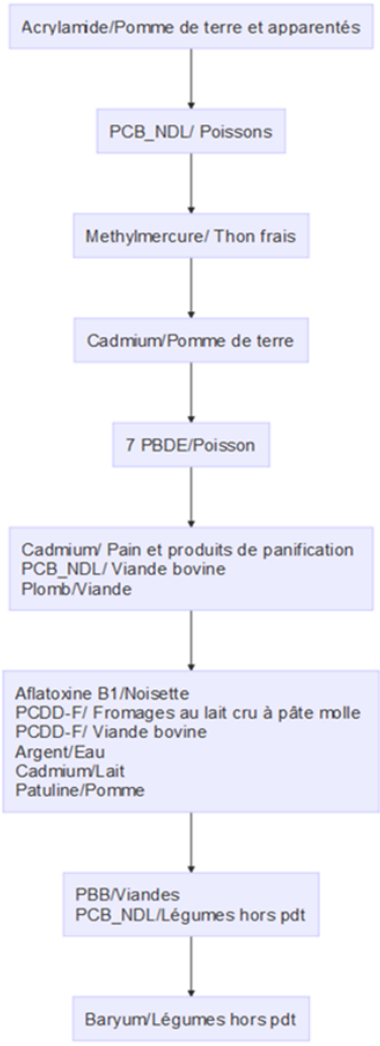
Ranks adult population

Couples	Final ranking	Confidence level
Acrylamide/Potatoes and related products	1	Medium (B)
Methylmercury/ Fresh tuna	2	High (A)
PCB_NDL/ Fish	3	High (A)
BPA/Canned green beans	4	High (A)
PCB_NDL/ Beef	5	High (A)
7 PBDE/Fish	6	High (A)
Lead/Meat	6	High (A)
PCDD-F/ Raw milk soft cheese	6	High (A)
Aflatoxin B1/Hazelnut	7	Medium (B)
Cadmium/Potatoes	7	High (A)
Patuline/Apple	7	High (A)
Silver/Water	8	High (A)
PCDD-F/ Beef	8	High (A)
PCB_NDL/Vegetables excluding potatoes	9	High (A)
Cadmium/ Bread and bakery products	9	High (A)
PBB/Meat	10	High (A)
Cadmium/Milk	11	High (A)
Barium/Vegetables excluding potatoes	12	High (A)

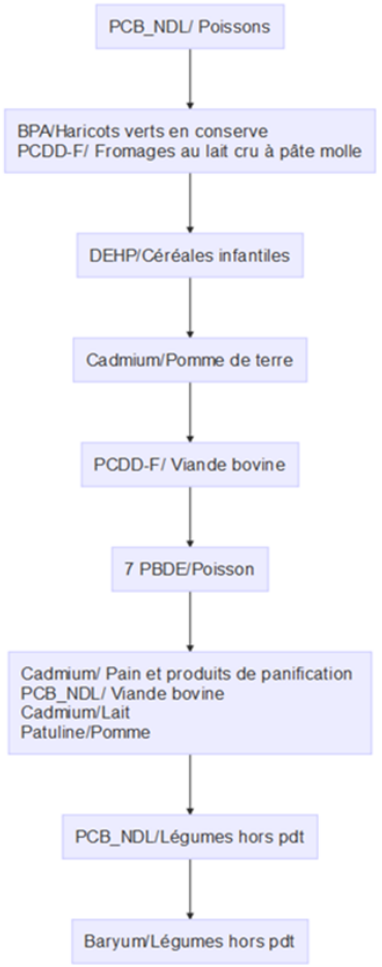
Adultes



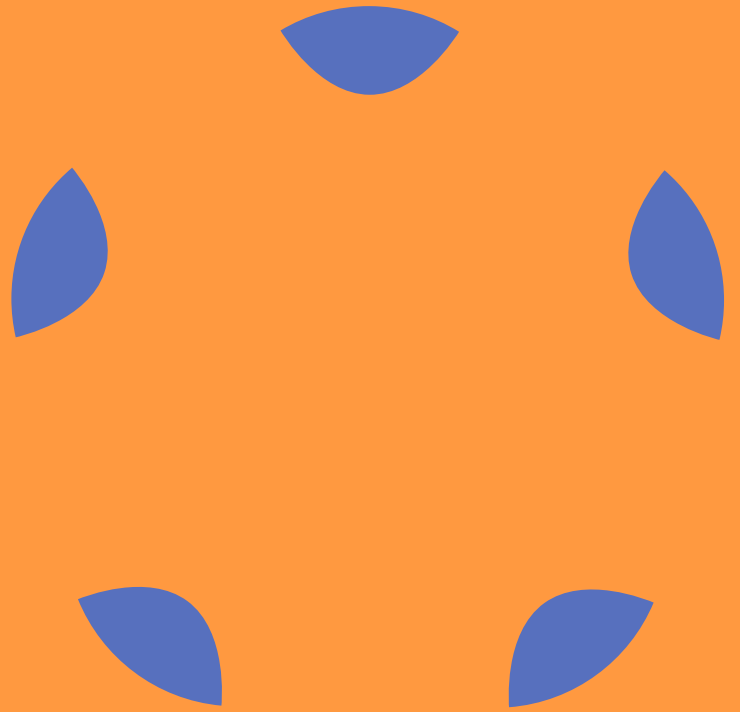
Enfants 3-17 ans



Enfants moins de 3 ans



Conclusion



Conclusion

- Development of an original risk ranking method for hazards and food-hazard pairs (proof of concept and first application on biological hazards)
- Extensive work to inventory and select relevant hazards and the classification of food-hazard pairs into 3 categories (excluded/potential/relevant)
- Criteria information needs an extensive data collection work → time consuming +++
- Consideration of data uncertainty and risk manager's preferences (criteria weight)
- Coming soon :
  - Full risk ranking of chemical hazards
  - Ranking of chemical and biological hazards in bovine meat