Microbial Hazards Risk Ranking

MiRA

WAGENINGEN
UNIVERSITY & RESEARCH

Microbial Hazards Risk Ranking Criteria

- User's input
- Default data input

Severity

DALY/case (HS) (C8)

Likelihood

Hazard-Food Characteristics (HFC)

- Processing survival **(C2)**
- Recontamination **(C3)**
- Post-processing control **(C4)**
  - → IF: growth opportunity
  - → EF: storage/distribution/retail
- Meal preparation **(C5)**

Hazard-Food Association (HFA)

- Outbreak prevalence **(C6A)**
- Food contamination prevalence **(C6B)**
- Sampling prevalence **(C6C)**

Food Consumption (FC) (C7)

Grouping of Risk Ranking Criteria

User's input

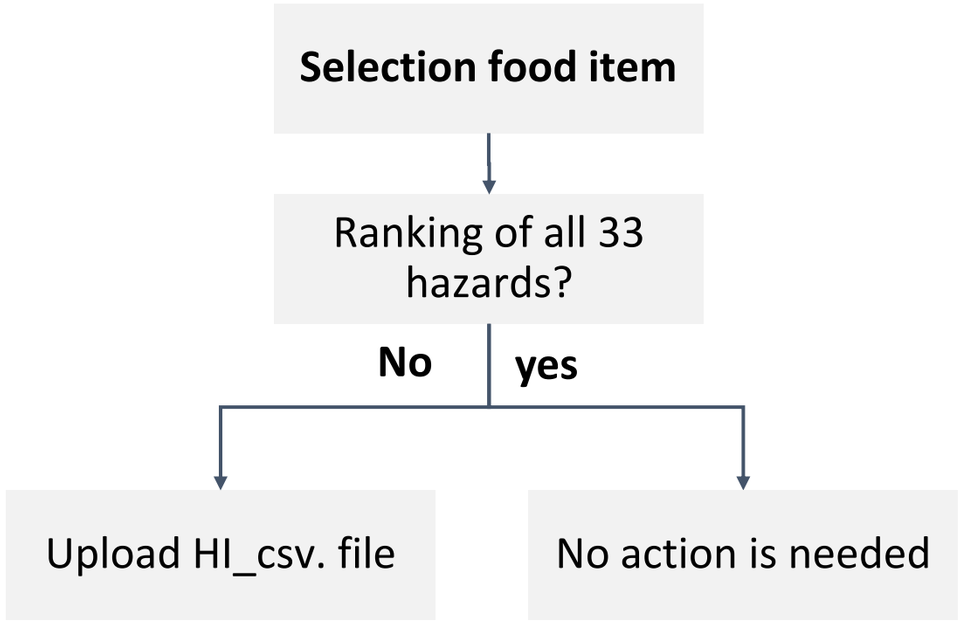
Parameter	Criteria
Food	item Composition Acidity
Factory	**C1** Processing survival **C2** Recontamination
Distribution	**C3** PPE: growth opportunity **C4** PPE: storage, distribution and retail **C5** Meal preparation
Others	Include hazard with no/low evidence

Default data

Parameter	Criteria
C6 Prevalence - Outbreak - Contamination - Sampling	Default value is automatically added into the calculation
C7 Food consumption	
C8 Severity	

Food parameter: Select food item

User's input



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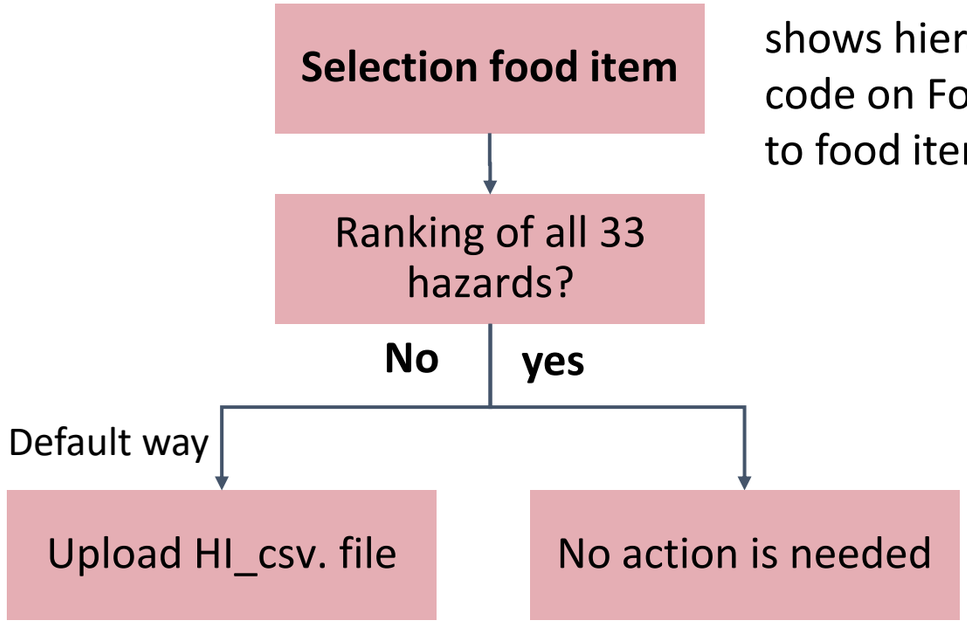

shows hierarchy & code on FoodEx2 next to food item

Provide link to MiID

https://foodmicrobiologywur.shinyapps.io/Microbial_hazards_ID/

Food parameter: select food composition

User's input

Food composition

Factors	Tick relevant
High fat	□ yes
Low Aw (0.5-0.9)	□ yes
Dry product (aw < 0.5)	□ yes
pH < 4.5	□ yes
4.5 < pH < 4.8	□ yes
pH > 10	□ yes
Neutral	□ yes

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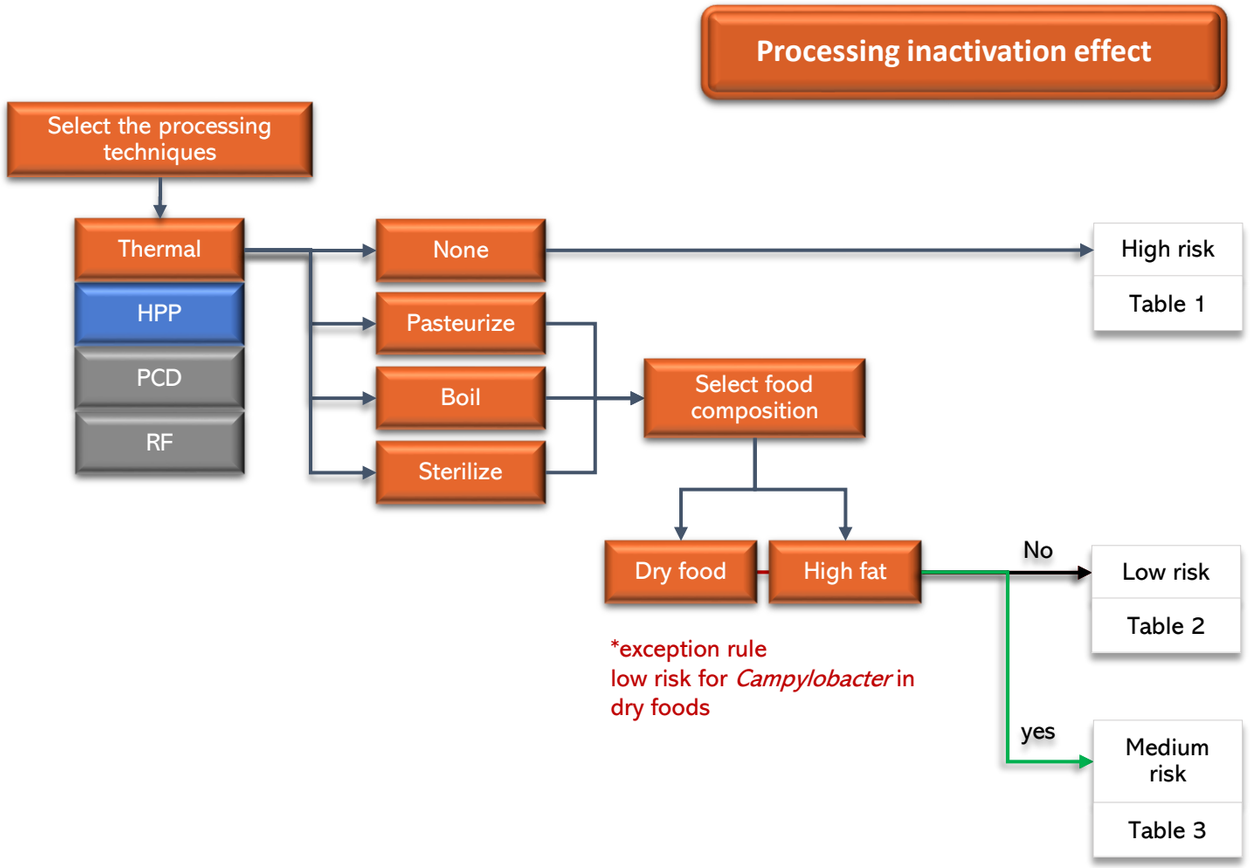
Food composition

This step influences the inactivation efficacy of the selected processing techniques in the next input

1. Check processing techniques of factory parameter
2. Take the corresponding value

Decision tree



Risk value	Score
1E-20	1
1E-18	1
1E-12	1
1E-10	2
1E-8	2
1E-6	2
1E-5	2
1E-4	3
1E-3	3
1E-1	4
1	4

Table 1

Hazard group	No inactivation
Vegetative bacteria	1
Virus	1
Vegetative parasites	1
Parasite cysts	1
Heat-resistant virus	1
Bacterial spores	1
Bacterial toxin	1

Table 2

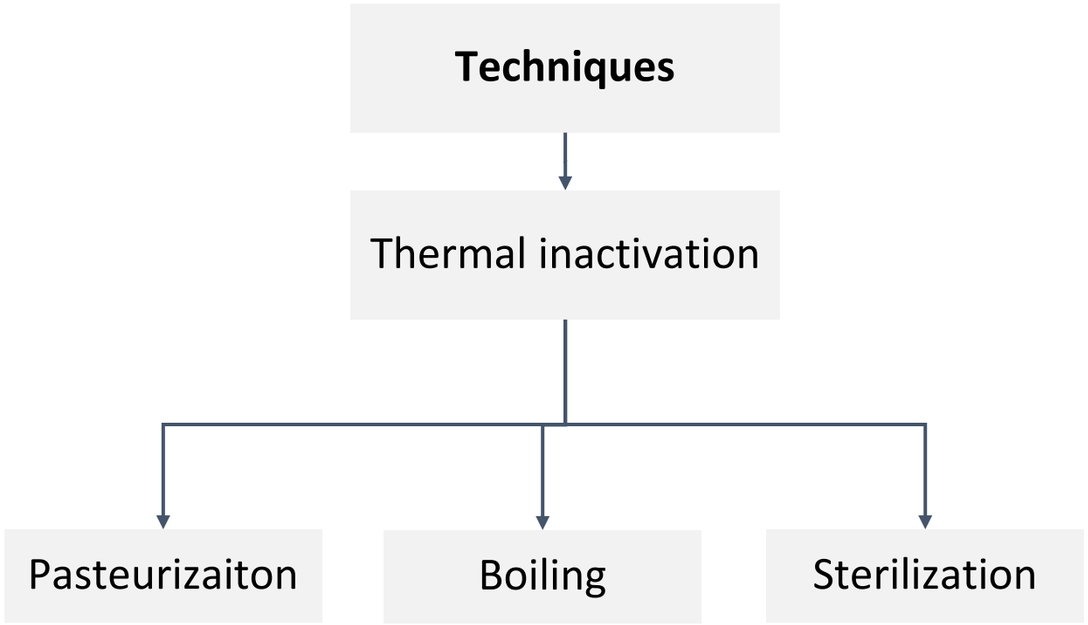
Hazard group	Pasteurization	Boiling	Sterilization
Vegetative bacteria	1E-6	1E-10	1E-20
Virus	1E-6	1E-10	1E-20
Vegetative parasites	1E-6	1E-10	1E-20
Parasite cysts	1E-05	1E-10	1E-20
Heat-resistant virus	1E-03	1E-10	1E-20
Bacterial spores	1	1E-03	1E-12
Bacterial toxin	1	1E-03	1E-12

Table 3

Hazard group	Pasteurization	Boiling	Sterilization
Vegetative bacteria	1E-4	1E-8	1E-18
Virus	1E-4	1E-8	1E-18
Vegetative parasites	1E-4	1E-8	1E-18
Parasite cysts	1E-3	1E-8	1E-18
Heat-resistant virus	1E-1	1E-8	1E-18
Bacterial spores	1	1E-1	1E-10
Bacterial toxin	1	1E-1	1E-10

Factory parameter: processing techniques

User's input



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Techniques + food composition

Factors	Tick relevant
High fat	□ yes
Low Aw (0.5-0.9)	□ yes
Dry product (aw < 0.5)	□ yes
pH < 4.5	□ yes
4.5 < pH < 4.8	□ yes
pH > 10	□ yes
Neutral	□ yes

Step 2_PE: relevant values in column H, I, or J is used. Display information on columns K &L based on the factory parameter selection

When more than 1 factor is relevant, select the highest value

Default	Wet neutral product	Column H
Factors	**Tick relevant**	**Data column**
High fat	□ yes	Column I, display column K
Low Aw (0.5-0.9)	□ yes	Column J, display column L
Dry product (aw < 0.5)	□ yes	Column J, display column L
Acidity	**Tick relevant**	**Data column**
pH < 4.5	□ yes	
4.5 < pH < 4.8	□ yes	
pH > 10	□ yes	
Neutral	□ yes	Column H

Problem:

e.g., high fat AND dry;

Addition: has no meaning

Multiplication: make the value smaller which does not make sense

Solution:

When more than 1 factor is relevant, select the highest value

Factory parameter: Recontamination

User's input

Sources	Tick relevant
Aseptic processing	□ yes
Wet environment	□ yes
Dry environment	□ yes
Addition of dry herbs or spices	□ yes
Addition of dry vitamins	□ yes
Addition of other dry ingredients	□ yes
Human cross-contamination	□ yes

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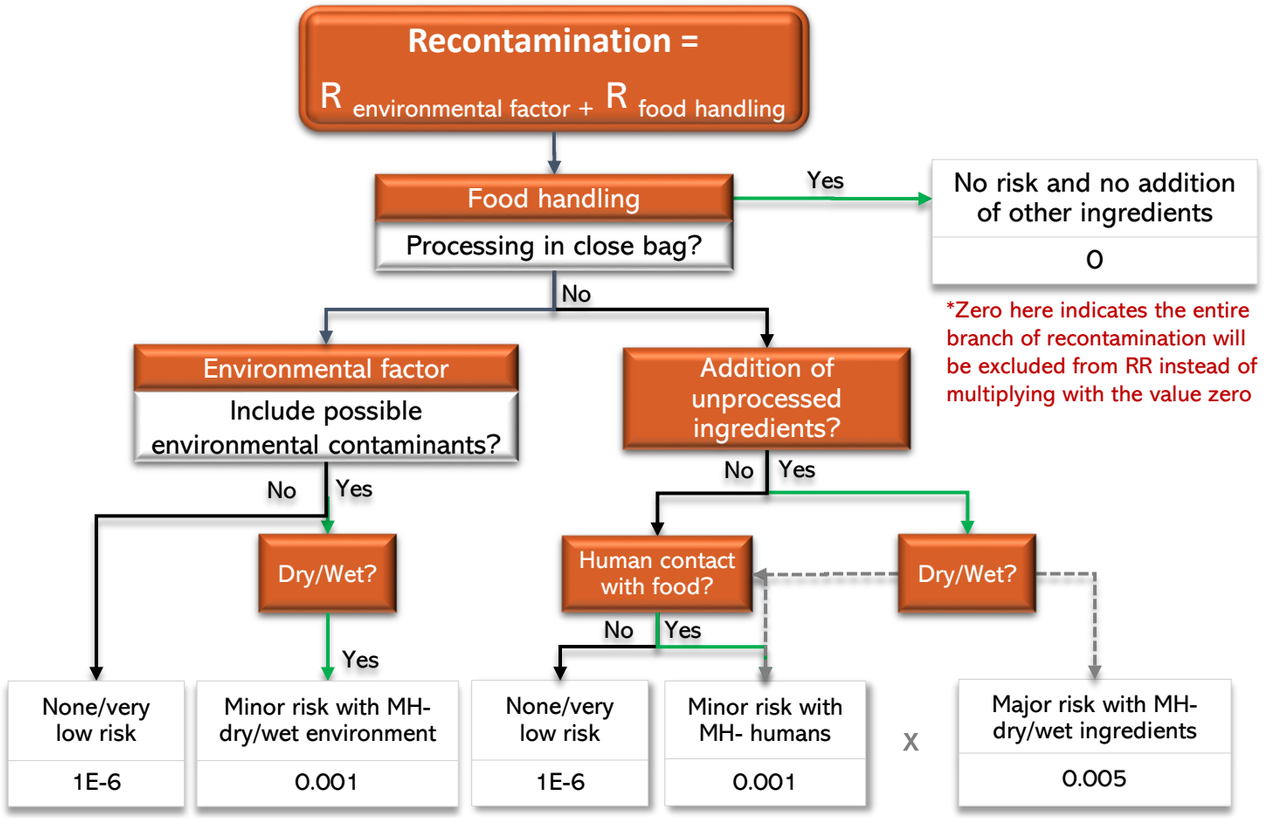
Sources	Tick relevant
Aseptic processing	□ yes
Wet environment	□ yes
Dry environment	□ yes
Addition of dry herbs or spices	□ yes
Addition of dry vitamins	□ yes
Addition of other dry ingredients	□ yes
Human cross-contamination	□ yes

Step 3_RP: pick the relevant columns and **add** the numerical values assigned for EF & RF

Decision tree

Category of dry ingredients	Risk of recontamination for relevant hazard
dry spices	0.5
other dry ingredients	0.05
dry vitamins	0.005

Risk value	Score
1E-6	1
0.005	2
0.05	3
0.5	4
0	0



*Zero here indicates the entire branch of recontamination will be excluded from RR instead of multiplying with the value zero

*Assuming 50% of 100% of unprocessed ingredients may be contaminated

Category of dry ingredients	Risk of recontamination for relevant hazard
dry spices	0.5
others	0.05
dry vitamins	0.005

Recontamination scenario comparision								
	Assign risk values							
Aseptic processing	0							
Environment factor:		**None**	**vitamin or human**	**dry ingre**	**spices**	**addition of all dry options**	**addition of all dry options + human contamination**	
Wet environment Dry environment	1E-6 OR 0.005	1.00E-06	0.005					
Addition of dry herbs or spices Addition of dry vitamins Addition of other dry ingredients Human cross-contamination	1E-6 OR 0.005 OR 0.05 or 0.5	1.00E-06	0.005	0.05	0.5			
	Calculated risk	1.00E-12	5.00E-09	5.00E-08	5.00E-07	1.25E-10	6.25E-13	
						3.34E-03	3.62E-03	root function

Problem: Selection of more options for recontamination category ➔ lower value due to multiplication

Solution: Replace with addition, and it reflects more to the reality

Recontamination scenario comparision								
	Assign risk values							
Aseptic processing	0							
Environment factor:		**None**	**vitamin or human**	**dry ingre**	**spices**	**addition of all dry options**	**addition of all dry options + human contamination**	
Wet environment Dry environment	1E-6 OR 0.005	1.00E-06	0.005					
Addition of dry herbs or spices		1.00E-06	0.005	0.05	0.5			
Addition of dry vitamins Addition of other dry ingredients Human cross-contamination	1E-6 OR 0.005 OR 0.05 or 0.5							
	Calculated risk	1.00E-12	5.00E-09	5.00E-08	5.00E-07	1.25E-10	6.25E-13	
						3.34E-03	3.62E-03	root function

Problem:

Scenario 1: " 0 " in the RP category

Scenerio 2: " 0.005" in the RP category

Final RR: Scenario 1 should be < Scenario 2

But it is the opposite for now.

Solution: addition will solve the problem

Recontamination scenario comparision							
Aseptic processing	**Assign risk values** 0						
Environment factor:		**None**	**vitamin or human**	**dry ingre**	**spices**	**addition of all dry options**	**addition of all dry options + human contamination**
Wet environment Dry environment	1E-6 OR 0.005	1.00E-06	0.005				
Addition of dry herbs or spices		1.00E-06	0.005	0.05	0.5		
Addition of dry vitamins Addition of other dry ingredients Human cross-contamination	1E-6 OR 0.005 OR 0.05 or 0.5						
	Calculated risk	2.00E-06	5.00E-03	5.00E-02	5.00E-01	5.55E-01	5.60E-01

Scenario 1: “ 0 “ in the RP category

Scenerio 2: “ 0.005” in the RP category

Mutiplication:

Scenario 1: “0”* 5

Scenario 2: 0.005 * 5

Addition:

Scenario 1: 0+5 = 5

Scenario 2: 0.005+5 = 5.0005

Distribution parameter – storage/distribute/retail

User's input

Storage/distribution/retail	Tick relevant
Room temperature	□ yes
Refrigeration	□ yes
Frozen	□ yes
Potential temperature abuse	□ yes

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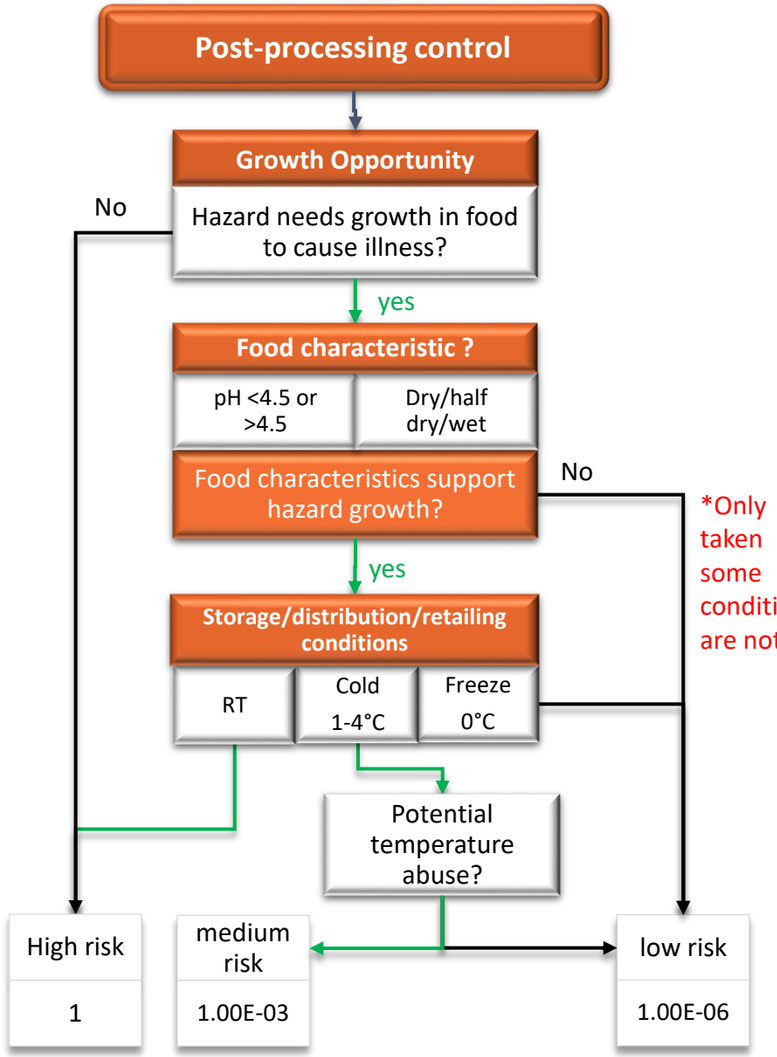
Storage/distribution/retail	Tick relevant	Food composition filled by user	Cardinal parameter
Room temperature	□ yes	Take data in food parameter	Compare with cardinal parameter in Supplementary Table X, & take the estimated likelihood in step 4_ PPC2
Refrigeration	□ yes		
Frozen	□ yes		
Potential temperature abuse	□ yes		

Decision tree

Risk value	Score
1E-6	1
1E-3	2
1	3



*Only yes/no growth in food characteristics is taken into consideration, with exceptions for some strains that can otherwise grow in the conditions they cannot grow are
are not taken into consideration

Distribution parameter – Meal preparation

User's input

Meal preparation	Tick relevant
Ready to eat	□ yes
Ready to heat <70°C	□ yes
Ready to cook > 70°C	□ yes

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Step 5_MP: pick the value in the relevant columns E, F or G

Hazard group	RTE	RTH <70°C	RTC >70°C
Vegetative bacteria	1	1E-2	1E-4
Virus	1	1E-2	1E-4
Vegetative parasites	1	1E-2	1E-4
Parasite cysts	1	1E-1	1E-03
Heat-resistant virus	1	1	1E-02
Bacterial spores	1	1	1
Bacterial toxin	1	1	1

Decision tree

Risk value	Score
1E-4	1
1E-3	1
1E-2	2
1E-1	3
1	4

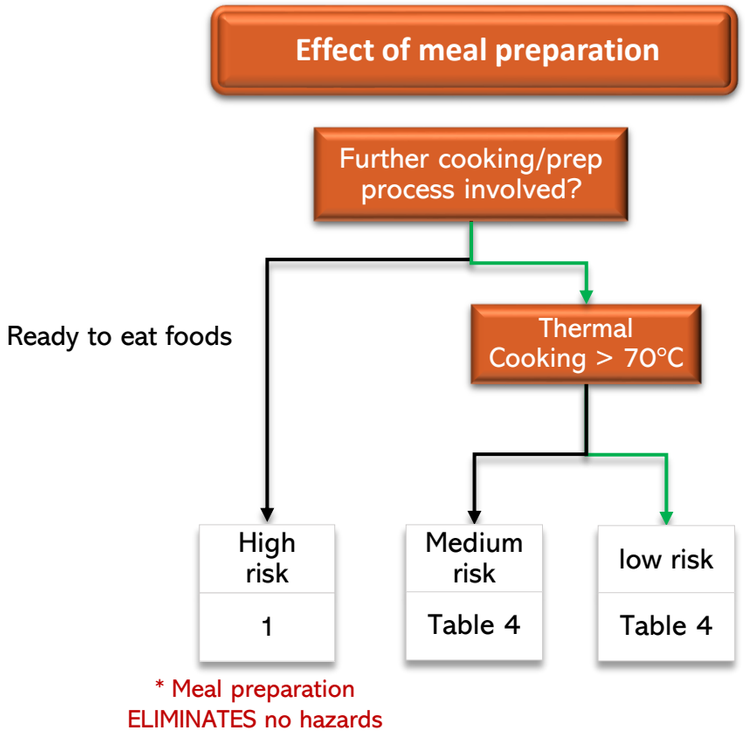

Table 4

Hazard group	Cooking <70C	Cooking >70C
Vegetative bacteria	1E-2	1E-4
Virus	1E-2	1E-4
Vegetative parasites	1E-2	1E-4
Parasite cysts	1E-1	1E-03
Heat-resistant virus	1	1E-02
Bacterial spores	1	1
Bacterial toxin	1	1

Prevalence and Severity data

User's input

Parameter	Criteria
Food	item Composition Acidity

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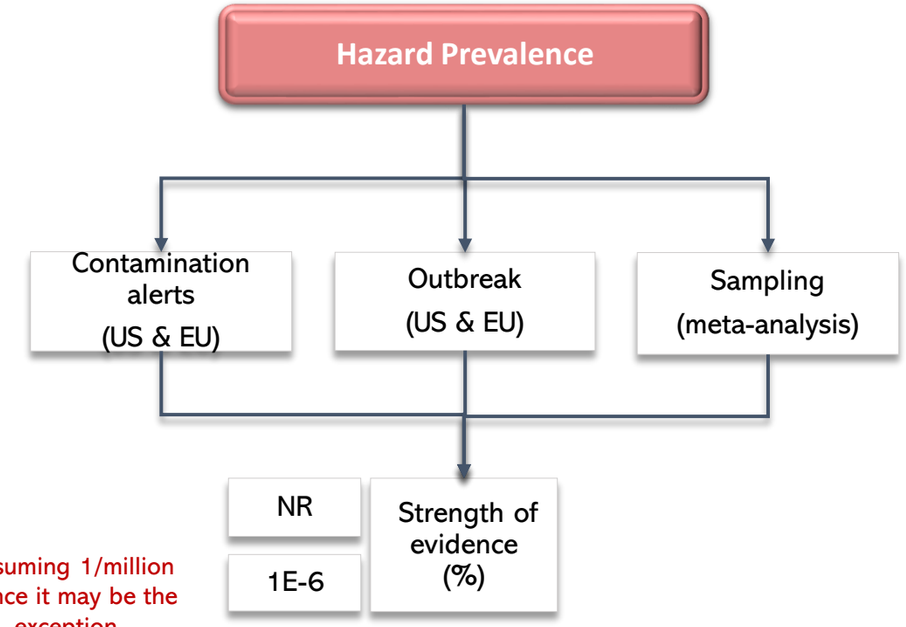
Based on user's input in step 1, display the respective data column in Step 6_HFA4th root, Step 7_FC and Step8_HS values

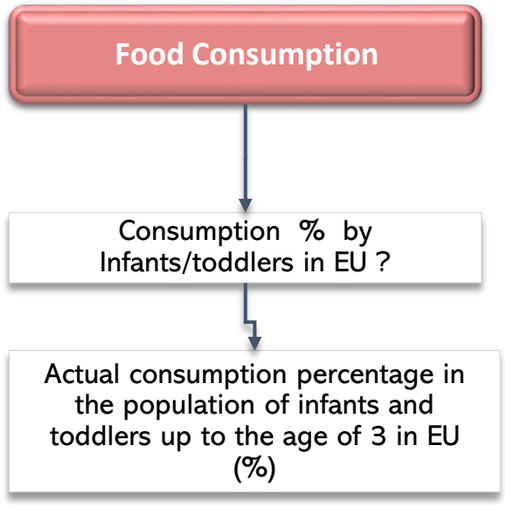
Show total ranking of results in a Table

Show total ranking of results in a plot

Decision tree



*Assuming 1/million chance it may be the exception

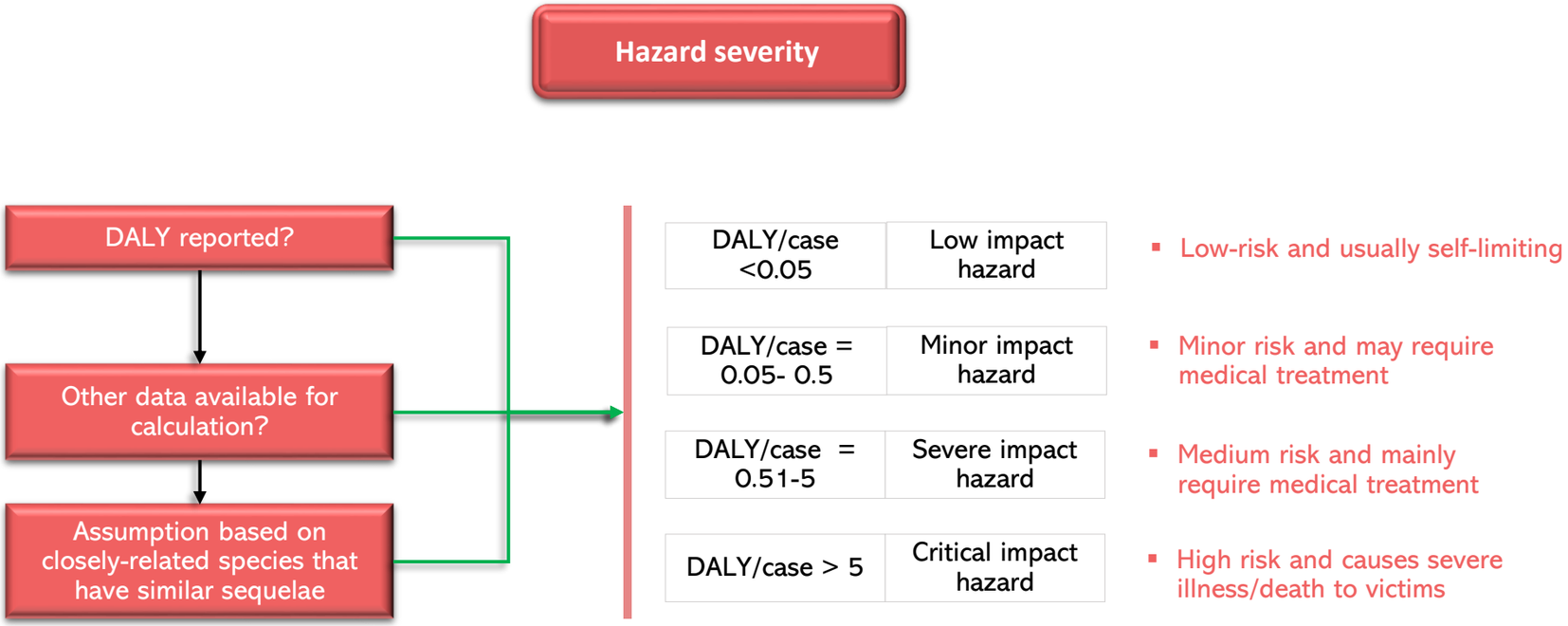


Prevalence percentage	Risk value	Score
NR	0.000001	1
< 1%	<0.01	2
1-10%	0.011-0.1	3
10.1 - 40%	0.101 - 0.4	4
> 40%	> 0.4	5

Consumption percentage	Risk value	Score
NR	0.000001	1
< 1%	<0.01	2
1-10%	0.011-0.1	3
10.1 - 40%	0.101- 0.4	4
> 40%	> 0.4	5

Decision tree

Risk value (DALY/case)	Score
< 0.05	1
0.05-0.5	2
0.51-5	3
> 5	4



Parameter set up in MCDA PROMETHEE

Table 6: Parameters used to run PROMETHEE II on R Software

Parameters	C2+3	C4	C5	C6	C7	C8	Justification
Indifference	0	0	0	0	0	0	The indifference threshold is zero as the criteria values are considered as real numbers (without uncertainty).
Preference	2.5e-5[a]	1[b]	1[c]	0.056[b]	0.47[c]	8.47[b]	The preference threshold reflects where a difference between 2 scores makes a real added value in the decision. The first choice was the difference between the 75th and 25th percentiles. However when this difference equaled zero, the second choice was to increase this percentile range and if still zero, to take the maximum value
Type of preference	“V-shape”	“V-shape	“V-shape	“V-shape	“V-shape”	“V-shape”	“V-shape” to generate a proportional preference
Weight	1/6	1/6	1/6	1/6	1/6	1/6	We assume that the 7 criteria had the same weight on the final risk

a: difference between the 75th and 25th percentiles
b: the difference between the penultimate and the second percentiles
c: the maximum value

Final ranking of Microbiological hazards

Criteria input

Table 4: Risk ranking Criteria and Parameter.

Criteria (C)	Description	Parameter
C1[a]	Food item Food composition	**Food**
C2 **C3[b]**	Processing survival Recontamination	**Factory**
C4 **C5**	PPE: growth opportunity PPE: storage, distribution, and retail Meal preparation	**Distribution**
C6[n]	Outbreak Food contamination Sampling[a]	**Prevalence**
C7	Food consumption of infants and toddlers	**Consumption**
C8	DALY/case per hazard	**Severity**
Optional	Include hazard with no/low evidence	**Others**

[a]-excluded in ranking; [b]- addition of risk values. [n] = 4. Outbreak and food recall data in the EU and USA

Ranking output

$$\text{Total Risk} = (C2 + C3^{b})^{*}\ C4^{*}\ C5^{*}\ (C6n)^{*1/n}\ ^{*}C7^{*}\ C8$$