What is the impact of different factors on the exposure?

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efsa
European Food Safety Authority

EVIDENCE FOR EXPOSURE ASSESSMENT

Factors impacting the prevalence and concentration of *L. monocytogenes* in RTE foods

Inputs:

- Baseline survey (2010-2011)
- EU monitoring data: *official monitoring although harmonized to some extend, variable across Member States – difficult to be systematically used*
- Literature review

Activity 1: an extensive literature search and study selection with data extraction on *Lm* in a wide range of RTE foods

- NP/EFSA/BIOCONTAM/2015/04–CT1
- 3/11/2015-2/10/2016


EXTERNAL SCIENTIFIC REPORT

Closing gaps for performing a risk assessment on *Listeria monocytogenes* in ready-to-eat (RTE) foods: activity 1, an extensive literature search and study selection with data extraction on *L. monocytogenes* in a wide range of RTE food

EVIDENCE FOR EXPOSURE ASSESSMENT

- Prevalence of *L. monocytogenes*
- Proportion of samples on the market >100 CFU/g
- Sparseness of data
- Varying stability in the associations between model outcomes & factors varied
- Several influential factors included in multivariate analysis, but not always stable
- Impact evaluated on the basis of Odds ratio
- Fish and meat products

Results of prevalence I (EFSA baseline survey)

(a) **Fish**

- Cold smoked > hot smoked
- Sliced > non sliced
- Products with ≥ 2 inhibitors > samples with no inhibitors

Results of prevalence I (EFSA Baseline study)

(b) **Meat**

- Pâté > cold meat products ≈ sausages
- Sliced > non sliced

Proportion of samples with *L. monocytogenes* > 100 CFU/g:

- Animal species "all other species" > avian
- Remaining shelf life

EVIDENCE FOR EXPOSURE ASSESSMENT

Results of prevalence II (literature)

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EXTENSIVE LITERATURE REVIEW

Risk factors

- Processing environment, HACCP, food safety education
- Manufacturing & preparation practices (lethal step)
- Product characteristics (pH, a_w, etc.)
- Storage conditions (time-T)

EVIDENCE FOR EXPOSURE ASSESSMENT

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INTERVENTION STUDIES

- Scarcity of reports with naturally contaminated samples and industrial setting
- Disassembly and thorough cleaning/disinfection of production machines caused drastic reduction of *L. monocytogenes*

EVIDENCE FOR EXPOSURE ASSESSMENT

Growth, survival and inactivation of *L. monocytogenes* in food and in the food chain

- Cardinal secondary models (growth and G/NG interface)
- Cardinal models with stochastic terms describing the strain variability in growth limits/growth rates
- Impact of food microflora and food structure on *L. monocytogenes* growth
- Impact of pre-culture conditions and shifts in the food (micro-)environment on lag time of *L. monocytogenes*
- Single cell modelling: impact of cell heterogeneity lag time and generation time of individual cells
- Inactivation modelling (thermal and non-thermal)

Cardinal models

$\mu_{max} = \mu_{opt}.CM_2(T).CM_1(pH).SR(a_w).\xi$

Indicative components of the model

1. $CM_2(T)$: temperature term

$$\tau(T) = \left(\frac{(T - T_{min})^2 \cdot (T - T_{max})}{(T_{opt} - T_{min}) \cdot [(T_{opt} - T_{min})(T - T_{opt}) - (T_{opt} - T_{max})(T_{opt} + T_{min} - 2T)]} \right)$$

2. $CM_1(pH)$: pH term

$$\frac{(pH - pH_{min})^2 (pH - pH_{max})}{(pH_{opt} - pH_{min}) \left[(pH_{opt} - pH_{min})(pH - pH_{opt}) - (pH_{opt} - pH_{max})(pH_{opt} + pH_{min} - 2pH) \right]}$$

3. $SR(a_w)$: a_w term

$$SR(a_w) = \begin{cases} 0 & , \ a_w \le a_{w\,min} \\ \left(\frac{a_w - a_{w\,min}}{a_{w\,opt} - a_{w\,min}} \right) & , \ a_{w\,min} < a_w < a_{w\,opt} \\ 0 & , \ a_{w\,opt} \le a_w \le a_{w\,max} \end{cases}$$

Stochastic terms for strain variability

$$\psi = \sum_i \frac{\phi_{x_i}}{2 \prod_{j \neq i} \left(1 - \phi_{x_j}\right)}$$

$$\phi(T) = \left(\frac{T_{opt} - T}{T_{opt} - T_{min}} \right)^3$$

$$\phi(pH) = \left(\frac{pH_{opt} - pH}{pH_{opt} - pH_{min}} \right)^3$$

$$\phi(a_w) = \left(\frac{a_{w\,opt} - a_w}{a_{w\,opt} - a_{w\,min}} \right)^3$$

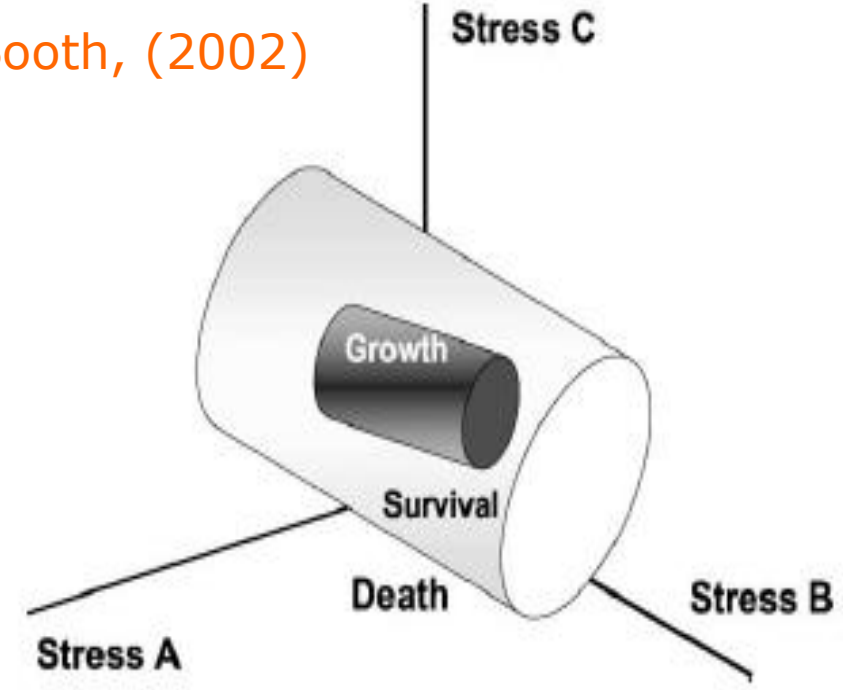
4. Interaction term (ξ)

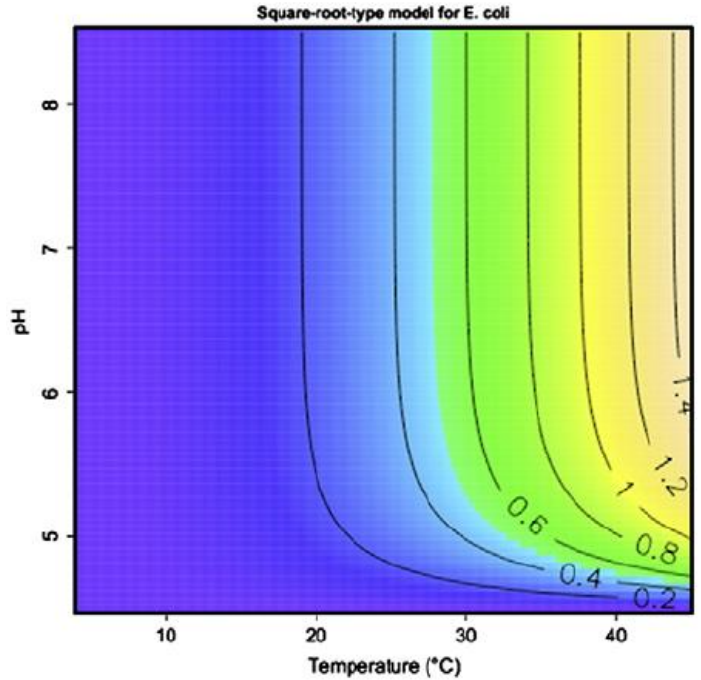
$$\xi = \begin{cases} 1 & , \ \psi \le 0.5 \\ 2(1 - \psi), & 0.5 < \psi < 1 \\ 0 & , \ \psi \ge 1 \end{cases}$$

EVIDENCE FOR EXPOSURE ASSESSMENT

Growth, survival and inactivation of *L. monocytogenes* in food and in the food chain

Booth, (2002)





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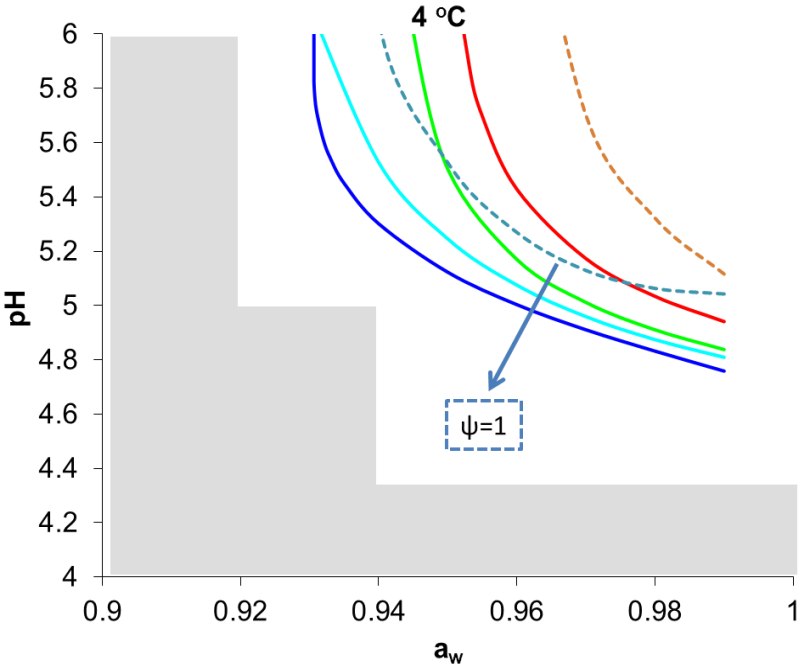
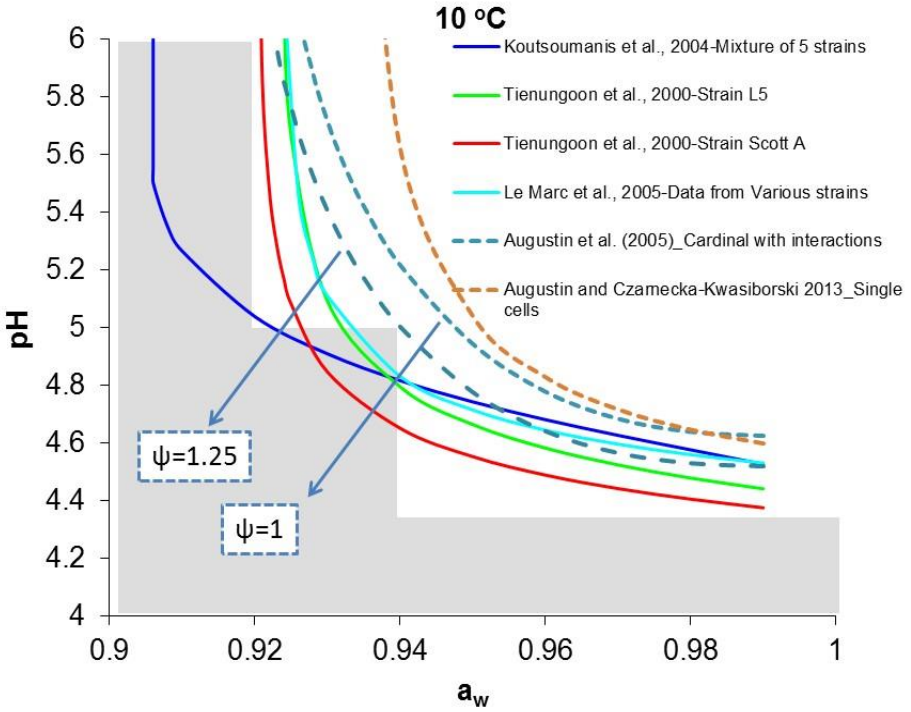
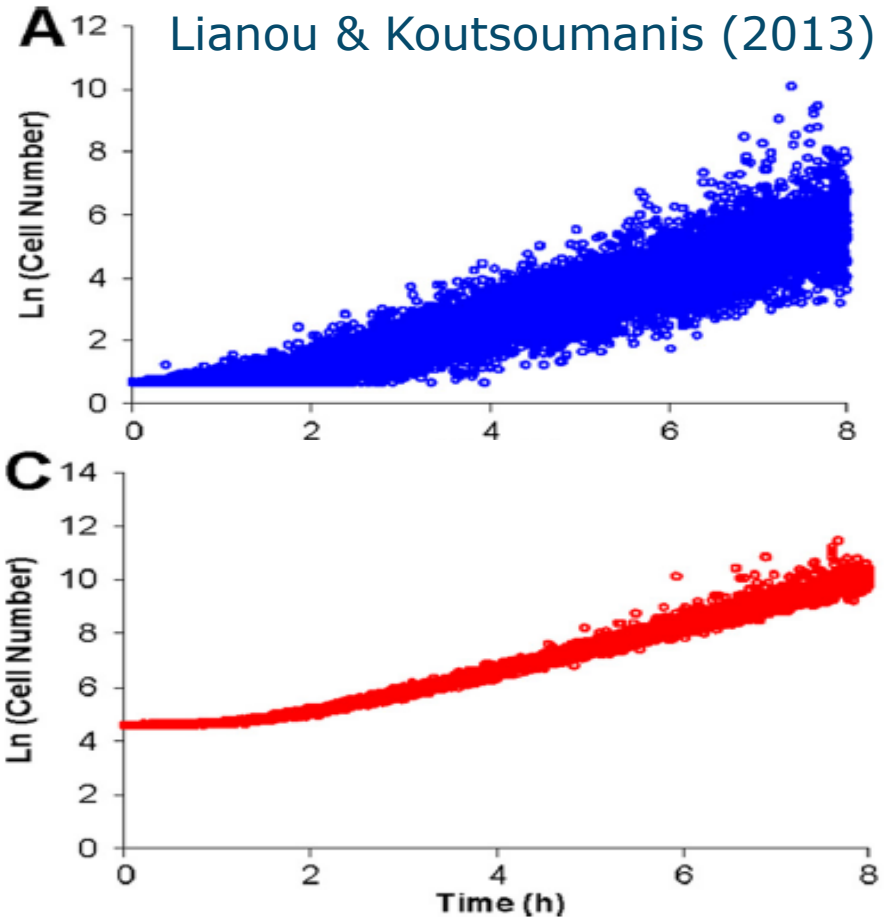
Growth, survival and inactivation of *L. monocytogenes* in food and in the food chain



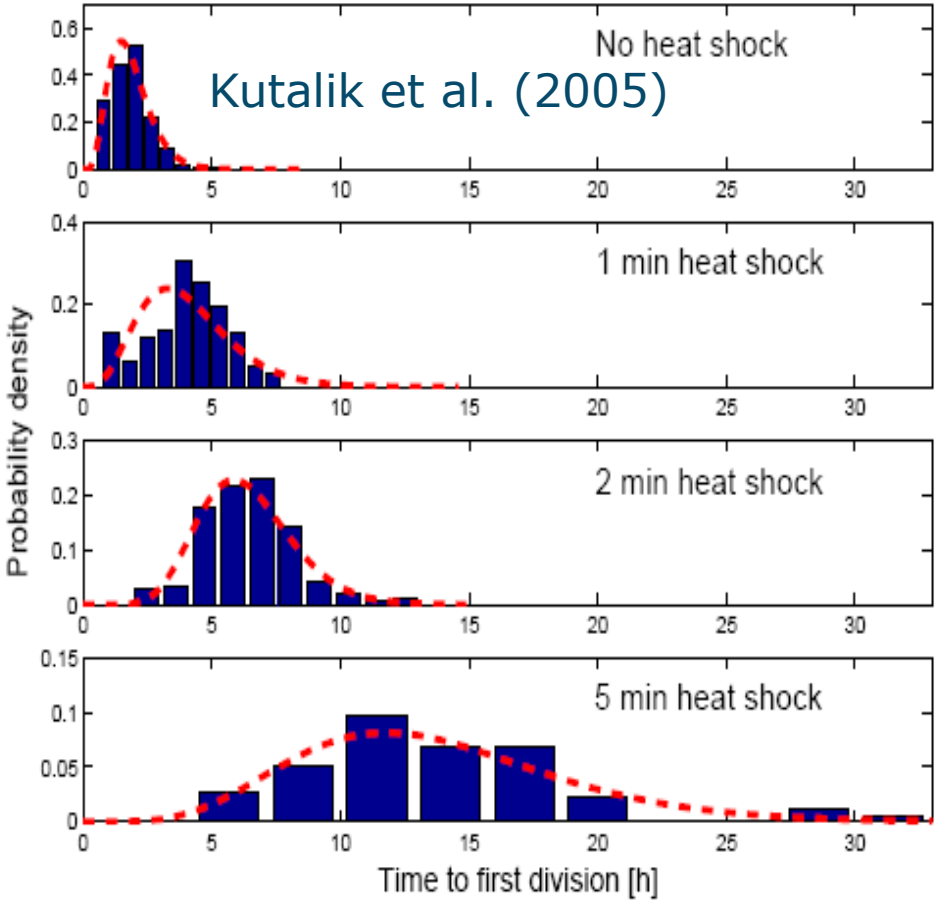


INDIVIDUAL CELL HETEROGENEITY & STOCHASTIC BEHAVIOUR

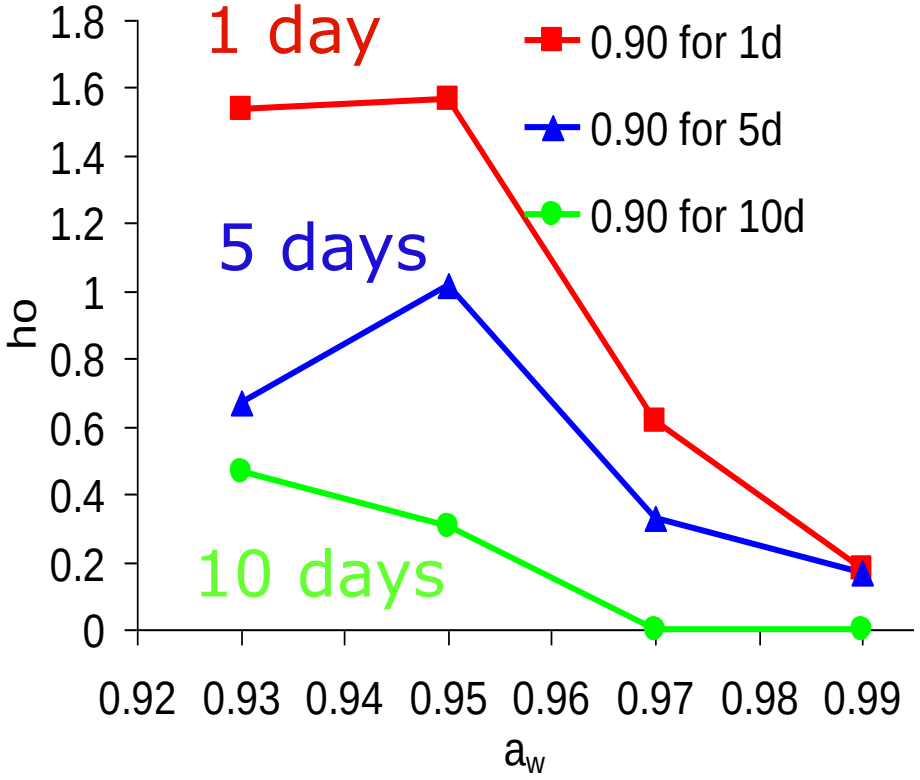
Lianou & Koutsoumanis (2013)

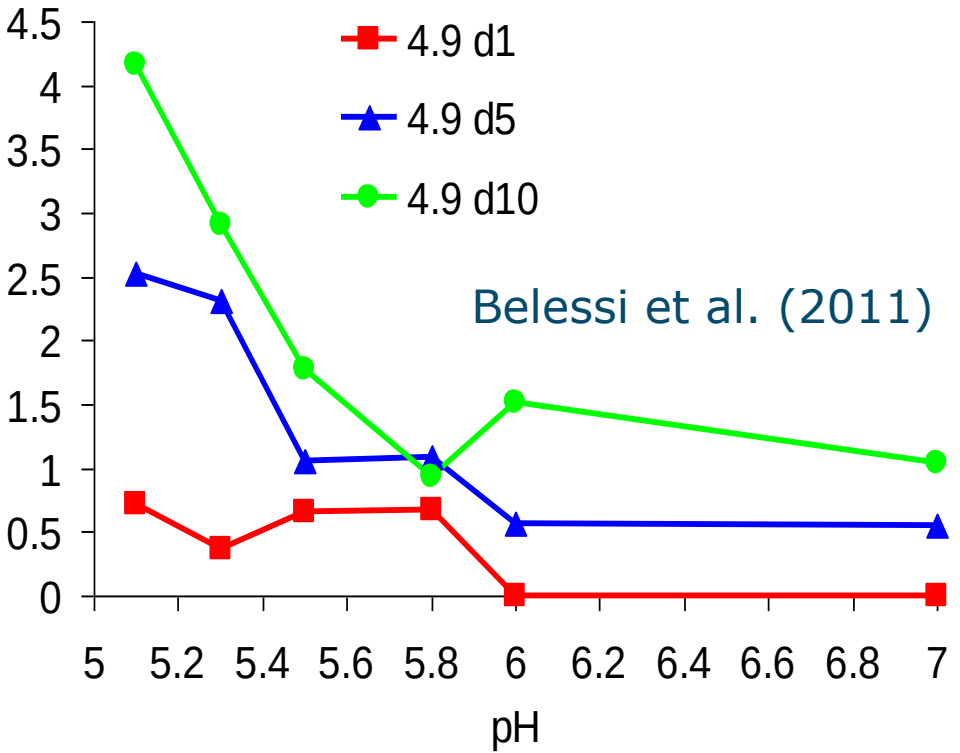


Kutalik et al. (2005)



IMPACT OF SHIFTS FROM NG TO G ON LAG TIME OF *LM*





Habituation at NG a_w = adaptation

Habituation at NG pH = exhaustion

EVIDENCE FOR RISK CHARACTERIZATION - SUMMARY QMRA

QMRA:

- Hazard identification, exposure assessment, hazard characterization & risk characterization

Risk characterization:

- Probability x severity
- Probability = f(exposure)
- Exposure = f(consumption frequency, serving size, prevalence, concentration resulting from direct transfer or growth/inactivation of *L. monocytogenes*)

Results from the review of QMRA outputs

Deli meats

- Cross-contamination frequency (other products or environment)
- Prevalence/levels at processing plant
- Slicing at retail
- Storage time (22 d at retail & 5 d at home)
- Storage temperature: 7^{o}C critical limit for risk reduction
- Growth inhibitors (preservatives)

Results from the review of QMRA outputs

Fish products

- GROWTH is important. Attention to factors that control the concentration of *L. monocytogenes* at the time of consumption
  - Short time, low T
  - Competition with LAB
- Sensitivity of population through the dose response model

Results from the review of QMRA outputs

Dairy products

- Raw milk: Storage temperature, time till consumption and purchase location (better buy from the farm)
- Increase pasteurization temperature (HTST concept) reduces background flora and favours *L. monocytogenes* growth
- Raw-milk cheese -> 53-112 fold higher risk than pasteurized-milk cheeses. Starters reduce the risk
- Soft-ripened cheese by pasteurized milk: avoid cross-contamination

Results from the outsourcing activity 2 risk assessment

Activity 2: a quantitative risk characterization on *Lm* in RTE foods; starting from the retail stage

- OC/EFSA/BIOCONTAM/2014/02–CT1
- 1/10/2014-31/01/2017


EXTERNAL SCIENTIFIC REPORT

Closing gaps for performing a risk assessment on *Listeria monocytogenes* in ready-to-eat (RTE) foods: activity 2, a quantitative risk characterization on *L. monocytogenes* in RTE foods; starting from the retail stage

- Complete QMRA: from retail to consumer
- Inputs (prevalence) from EU monitoring, BLS & literature
- Growth models
- Consumption data based on EFSA database
- Reduced Oxygen Packaging and slicing as practices
- Time-temperature data based on available reports
- Dose response by Pouillot et al. (2015) with varying susceptibility parameter

EVIDENCE FOR RISK CHARACTERIZATION - SUMMARY QMRA

- QMRA Outputs: Predicted number of listeriosis cases **annually** in the EU (population risk & public health burden)

Elderly: > 65 years

RTE food subcategory	Population subgroups			
	Healthy[a]	Elderly[b]	Pregnant	TOTAL
Cold smoked fish	54 (42, 68)	201 (154, 254)	104 (75, 138)	358 (271, 460)
Hot smoked fish	NC (NC, 1)	1 (NC, 1)	6 (4, 8)	7 (4, 10)
Gravad fish	48 (33, 70)	230 (160, 320)	92 (63, 129)	370 (257, 519)
Cooked meat	71 (50, 98)	316 (218, 449)	477 (337, 659)	863 (604, 1207)
Sausage	64 (31, 118)	252 (120, 469)	225 (107, 417)	541 (258, 1003)
Pâté	12 (4, 27)	92 (28, 220)	54 (16, 130)	158 (48, 377)
Soft and semi-soft cheese	5 (2, 10)	11 (5, 20)	3 (1, 6)	19 (8, 36)
Total	254 (162, 392)	1,103 (685, 1,733)	961 (603, 1,487)	2,318 (1,450, 3,612)
	= 11%	= 48%	= 41%	

$$P_{\text{infection}} = 1 - e^{-rD}$$

EVIDENCE FOR RISK CHARACTERIZATION - SUMMARY QMRA

- QMRA Outputs: Predicted number of cases **per risk per 10^6 servings** (individual & food related risk)

High risk scenaria:

- High risk for pregnant population regardless of product and this **>> elderly >>> healthy**
- Gravad fish sliced and packed under normal or ROP atmosphere (**pregnant**)
- Cold smoked vs hot smoked fish (**pregnant**)
- Cooked meat sliced/packaged aerobically (**all groups**)
- Sliced cheese (**pregnant**)

CONCLUSIONS

- Growth of *L. monocytogenes* = risk determining step. Storage times-T, antimicrobials & competition → control the risk
- At retail, cross-contamination of RTE foods from other products/retail environment = important risk factor
- Cooked meat (863) > sausage (541) > gravad fish (370) > cold smoked fish (358) > pâté (158) > soft and semi-soft cheese (19) and hot-smoked fish (7 cases)
- For hot-smoked fish and cooked meat, most cases attributed to the pregnant population, for the rest of food subcategories most cases were attributed to the elderly population (≥ 65 years old)
- Estimated risk/10^6 servings in general highest for the pregnant population > elderly > healthy population
- Most cases predicted in the elderly (48%) > pregnant population (41%) > healthy population (11%)