Development of a model for *Listeria monocytogenes* in RTE foods

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Outline

- Introduction and model scope
- Selection of D-R models
- Exposure assessment
- Simulation and output
- An easy-to-use framework: Excel Add-in “Lis-RA”
- Conclusions
Outline

- Introduction and model scope
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Introduction

Probabilistic risk assessment of *Listeria monocytogenes* for in RTE foods developed by EFSA in collaboration with the University of Córdoba (Spain) and IRTA (Spain)

Closing gaps for performing a risk assessment on *Listeria monocytogenes* in RTE foods: **Activity 2**, a quantitative risk characterization on *L. monocytogenes* in RTE foods; starting from the retail stage

- packaged (hot, cold) smoked or gravad fish (not frozen),
- packaged heat-treated meat products (cooked meat, sausages, pâté)
- soft or semi-soft cheeses (excluding fresh cheeses)

The risk assessment scope covers from retail to home, considering Listeria growth up to consumption

1Contract number: OC/EFSA/BIOCONTAM/2014/02CT1
Listeriosis

*L. monocytogenes* is a psychrotrophic microorganism able to produce a foodborne diseases.

Listeriosis is mostly related to relatively high doses and

Elderly population (>64) is most affected group, particularly >84 year (ECDC/EFSA, 2016)

In 2014: “EU case fatality was 17.7% among the 1,524 confirmed cases with known outcome”
Quantitative Microbial risk assessment

EXPOSURE ASSESSMENT

HAZARD CHARACTERIZATION

RISK CHARACTERIZATION
Model scope

Food chain step/s: **from retail to consumption**

- **Selected RTE food categories:**
  - packaged (hot, cold) smoked or gravad fish,
  - packaged heat-treated meat products (cooked meat, sausages, pâté)
  - soft or semi-soft cheeses (excluding fresh cheeses)

- **Post retail factors:** time and temperature

- **Handling scenarios:** slicing, packaging type, formulation with growth inhibitors,...

- **Population:** normal and susceptible (elderly and pregnant) population.
In-silico risk assessment model for listeriosis and RTE products
Data Collection by EFSA

- Pesticide residues occurrence
- Contaminant occurrence
- Food Consumption
- Food additive usage and occurrence
- Veterinary medicinal product residues
- Zoonoses, antimicrobial resistance & foodborne outbreaks
- EU-wide Baseline studies

Raw data framework

European Food Safety Authority

EU-wide Baseline studies
Data analysis/processing tools

- Systematic review
- Data quality assessment
- Expert knowledge elicitation
- Statistical analysis Numerical methods
Numerical techniques

MONTECARLO

Probability distributions

Random combinations

Resultant distribution

Calculations

Spreadsheet
Second order model

Variability

Uncertainty

(adapted from Hoffman and Hammonds, 1994)
How to complete the risk picture?

DATA

PROCESSING DATA TOOLS

INPUT → MODEL → OUTPUT
Outline

- Introduction and model scope
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Dose-response (D-R) model

• Mathematical function that may be used to describe the relationship between dose and the magnitude of a response on a continuous scale in an individual.

Adapted from Haas et al. 1999
Selection of D-R models for risk assessment

Tool to evaluate the quality of the Exponential dose-response models currently available:

Application of Numeral Unit Spread Assessment Pedigree (NUSAP) system
The NUSAP system (Boone et al., 2009) is intended to assess data quality resulting from uncertainties that are hard to quantify such as methodological and epistemological uncertainties, and that are not systematically taken into account in scientific studies.

NUSAP scoring system

Objective scores
Assessors

Weights to Pedigree Criteria
Experts
Selection of D-R models for risk assessment

Pedigree criteria

Proxy:
- Year of publication of the dose-response model.
- Geographical origin of primary data. Not applicable for animal models.

Empirical basis:
- Primary source of data.
- Number of independent sources for the primary source of data.
- Number of subpopulation groups from which data were analysed.

Methodological rigor
- Inclusion of variability and uncertainty.
- Statistical analysis. Not applicable for Buchanan et al. (1997) approach.
- Number and descriptions of endpoints.
- Publication source.

Validation:
- Validation of the dose-response model with other datasets.
Selection of D-R models for risk assessment

Pedigree criteria

Score system

Scoring

Final score

Assessor

Expert

Self-assessment

Objective scoring

Weight

Weight

Assessor

Expert

Self-assessment

Objective scoring

Weight
Selection of D-R models for risk assessment

**Outcome:**

- Arithmetic *versus* geometric sequence (arithmetic sequence, i.e. 1, 2, 3 and 4).
- General agreement in the difficulty of FDA/FSIS model to be implemented; the model is neither readily reproduced nor readily defined.
Outline

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- Exposure assessment
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- An easy-to-use framework: Excel Add-in “Lis-RA”
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Exposure Assessment

MAIN VARIABLES:

- Prevalence/concentration distributions of *L. monocytogenes*
- Stochastic model for the growth of *L. monocytogenes*
- Temperature-time profiles from retail to home
- Time to consumption
- Food serving size and number of serving per year
Structure of exposure assessment

**Categories**
- Packaged heat-treated meat products
- Soft or semi-soft cheese
- Packaged (not Frozen) smoked and gravad fishes

**Sub-Categories**
- Cooked meat, sausage, Pâté
- Cold and hot smoked fish and gravad fish

**Scenarios**
- *ROP/normal; Sliced/non-sliced
- Sliced/non-sliced
- ROP/normal; Sliced/non-sliced

---

*ROP: REDUCED OXYGEN PACKAGING*
Structure of exposure assessment

**Iteration i:** COLD SMOKED FISH UNDER REDUCED OXYGEN PACKAGING

- **Prevalence**
  - Smoked
  - Gravad

- **Concentration**
  - Smoked
  - Gravad

**INITIAL LEVELS**

- Cold smoked
- Hot smoked
- ROP
- Air

**GROWTH**

- Smoked
- Gravad

**CONSUMPTION**

- Adult
- Elderly
- Pregnant

- Cold smoked
- Hot smoked
- ROP
- Air

*Assuming no different patterns for cold and hot smoked*
Prevalence categorization models

Food-based sub-categories for initial prevalence

- Cooked meat*
- Sausage*
- Paté
- Smoked fish (cold)
- Smoked fish (hot)
- Gravad fish
- Soft/semi-soft cheeses

Meat products
Fish products
Cheese products

**Scenarios for initial prevalence:**

- Packaging type for heat treated meat and smoked and gravad fish: Air (normal) and ROP (Reduced Oxygen Packaging)
- Slicing and non-slicing for heat-treated meat
- Hot and cold smoked fish

*Cooked meat and sausage were treated as individual subcategories for the BLS data. Monitoring data and scientific studies could not distinguish between both subcategories
<table>
<thead>
<tr>
<th>Food category</th>
<th>Subcategory</th>
<th>Scenario</th>
<th>Fitted Beta distributions</th>
<th>Mean [C.I. 95%]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RTE fish products</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cold-smoked fish</td>
<td>Sliced</td>
<td></td>
<td>Beta(76+1;511-76+1)</td>
<td><strong>0.151</strong> [0.116-0.186]</td>
</tr>
<tr>
<td></td>
<td>Non sliced</td>
<td></td>
<td>Beta(18+1;102-18+1)</td>
<td><strong>0.183</strong> [0.103-0.270]</td>
</tr>
<tr>
<td>Hot-smoked fish</td>
<td>Sliced</td>
<td></td>
<td>Beta(20+1;239-20+1)</td>
<td>0.087 [0.049-0.130]</td>
</tr>
<tr>
<td></td>
<td>Non sliced</td>
<td></td>
<td>Beta(12+1;273-12+1)</td>
<td>0.047 [0.021-0.078]</td>
</tr>
<tr>
<td>Gravad fish</td>
<td>Sliced</td>
<td></td>
<td>Beta(30+1;219-30+1)</td>
<td><strong>0.140</strong> [0.091-0.194]</td>
</tr>
<tr>
<td></td>
<td>Non sliced</td>
<td></td>
<td>Beta(0+1;33-0+1)</td>
<td>0.029 [0.005-0.103]</td>
</tr>
<tr>
<td><strong>RTE meat products</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooked meat</td>
<td>Sliced</td>
<td></td>
<td>Beta(43+1;2297-43+1)</td>
<td>0.019 [0.013-0.026]</td>
</tr>
<tr>
<td></td>
<td>Non sliced</td>
<td></td>
<td>Beta(3+1;193-3+1)</td>
<td>0.021 [0.003-0.045]</td>
</tr>
<tr>
<td>Sausage</td>
<td>Sliced</td>
<td></td>
<td>RiskBeta(11+1;548-11+1)</td>
<td>0.022 [0.009-0.037]</td>
</tr>
<tr>
<td></td>
<td>Non sliced</td>
<td></td>
<td>RiskBeta(2+1;214-2-1)</td>
<td>0.014 [0.001-0.034]</td>
</tr>
<tr>
<td>Paté</td>
<td>Sliced</td>
<td></td>
<td>RiskBeta(7+1;114-7+1)</td>
<td>0.069 [0.023-0.125]</td>
</tr>
<tr>
<td></td>
<td>Non sliced</td>
<td></td>
<td>RiskBeta(2+1;70-2+1)</td>
<td>0.042 [0.003-0.010]</td>
</tr>
<tr>
<td><strong>RTE cheese products</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft and semi-soft cheese</td>
<td>Sliced</td>
<td></td>
<td>RiskBeta(5+1;816-5+1)</td>
<td>0.007 [0.002-0.015]</td>
</tr>
<tr>
<td></td>
<td>Non sliced</td>
<td></td>
<td>RiskBeta(8+1;2298-8+1)</td>
<td>0.004 [0.001-0.007]</td>
</tr>
</tbody>
</table>

(a) Beta distributions were defined as \((\alpha = s + 1; \beta = N-s + 1)\), being \(s + 1\) the number of positives and \(N\) the total number of samples per RTE food subcategory.

(b) No positive samples were reported. A prior Beta \((1,1)\) was considered for describing uncertainty in prevalence estimates.
## Defining concentration at retail

<table>
<thead>
<tr>
<th>Food category</th>
<th>Sub-category</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTE fish products</td>
<td>Cold-smoked fish</td>
<td>BLS/monitoring 11-14/Activity 1</td>
</tr>
<tr>
<td></td>
<td>Hot-smoked fish</td>
<td>BLS/monitoring 11-14/Activity 1</td>
</tr>
<tr>
<td></td>
<td>Gravad fish</td>
<td>BLS/monitoring 11-14/Activity 1</td>
</tr>
<tr>
<td>RTE meat products</td>
<td>Cooked meat</td>
<td>Monitoring 11-14/Activity 1</td>
</tr>
<tr>
<td></td>
<td>Sausage</td>
<td>Activity 1</td>
</tr>
<tr>
<td></td>
<td>Pâté</td>
<td>Monitoring 11-14/Activity 1</td>
</tr>
<tr>
<td>RTE cheese products</td>
<td>Soft and semi-soft cheese</td>
<td>Monitoring 11-14/Activity 1</td>
</tr>
</tbody>
</table>

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.

**Contract number**: NP/EFSA/BIOCONTAM/2015/04-CT1
Defining concentration at retail

Initial concentration simulated in the model represents for mean concentration variation between lots.

Collected data are assumed to come from different batches.

Data from positive and negative samples (censored data) were considered for building probability distributions: e.g. 0 cfu/25g $\rightarrow$ < 0.04 cfu/g

Log normal was used to describe variability of lot mean concentration: distribution was fitted to collected data.

Poisson distribution was used to simulate partitioning (sampling) in the model. In doing so, doses per serving size can be estimated.

This distribution assumes an random contamination pattern.
Defining concentration at retail

As prevalence was modelled separately, lognormal distribution was truncated to the minimum concentration values resulting into positive servings. This corresponds to the theoretical minimum concentration (TMC) for a positive sample (1 cell in 25g).

This was applied to each food subcategory.

- Excluded region, corresponding to non-prevalent data by BSL
- Non-prevalence samples were modelled by Beta distribution
Defining concentration at retail

Fitting of the log normal distributions to describe the initial concentration of *L. monocytogenes* of cold smoked fish at retail (A) and correlation between mean (µ) and standard deviation (SD) values resulting from the bootstrap of simulated data (B)
Defining concentration at retail

<table>
<thead>
<tr>
<th>Food subcategory</th>
<th>Mean</th>
<th>SD</th>
<th>50th Perc.</th>
<th>5th Perc.</th>
<th>95th Perc.</th>
<th>LogL</th>
<th>AIC</th>
<th>BIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold smoked fish</td>
<td>0.867</td>
<td>1.842</td>
<td>1.248</td>
<td>0.394</td>
<td>4.620</td>
<td>-1.50x10³</td>
<td>3.12x10³</td>
<td>3.14x10³</td>
</tr>
<tr>
<td>Hot smoked fish</td>
<td>-0.271</td>
<td>0.943</td>
<td>1.318</td>
<td>-0.511</td>
<td>1.593</td>
<td>-1.79x10³</td>
<td>3.59x10³</td>
<td>3.60x10³</td>
</tr>
<tr>
<td>Gravad fish</td>
<td>1.011</td>
<td>1.931</td>
<td>1.236</td>
<td>0.524</td>
<td>4.950</td>
<td>-2.39x10²</td>
<td>4.83x10²</td>
<td>4.92x10²</td>
</tr>
<tr>
<td>Cooked meat</td>
<td>1.100</td>
<td>2.119</td>
<td>1.241</td>
<td>0.523</td>
<td>5.453</td>
<td>-7.10x10²</td>
<td>1.42x10³</td>
<td>1.44x10³</td>
</tr>
<tr>
<td>Sausage</td>
<td>2.194</td>
<td>2.704</td>
<td>1.151</td>
<td>1.598</td>
<td>7.482</td>
<td>-3.22x10¹</td>
<td>6.84x10¹</td>
<td>7.53x10¹</td>
</tr>
<tr>
<td>Pâté</td>
<td>1.461</td>
<td>2.334</td>
<td>1.213</td>
<td>0.852</td>
<td>6.240</td>
<td>-1.86x10³</td>
<td>3.73x10³</td>
<td>3.74x10³</td>
</tr>
<tr>
<td>Soft and semi-soft cheese</td>
<td>0.909</td>
<td>1.917</td>
<td>1.252</td>
<td>0.389</td>
<td>4.886</td>
<td>-3.14x10²</td>
<td>6.32x10²</td>
<td>6.46x10²</td>
</tr>
</tbody>
</table>
Serving size and number of servings

- Linear extrapolation:

\[ \text{[the value of numbers of serving /person]} \times \text{the total subpopulation in the survey country}. \]

<table>
<thead>
<tr>
<th></th>
<th>Austria</th>
<th>Denmark</th>
<th>Finland</th>
<th>Germany</th>
<th>Greece</th>
<th>Ireland</th>
<th>Latvia</th>
<th>Netherlands-Romania</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL consumption</td>
<td>1.73E+10</td>
<td>9.4E+09</td>
<td>2.64E+10</td>
<td>3.65E+10</td>
<td>0.00E+00</td>
<td>7.87E+09</td>
<td>0.00E+00</td>
<td>5.35E+10</td>
</tr>
<tr>
<td>Susceptible population</td>
<td>NA</td>
<td>1.22E+09</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Healthy population</td>
<td>NA</td>
<td>7.48E+09</td>
<td>2.40E+10</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Elderly population</td>
<td>3.78E+09</td>
<td>9.0E+09</td>
<td>2.00E+09</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
<td>6.15E+09</td>
<td>0.00E+00</td>
</tr>
<tr>
<td>Healthy population</td>
<td>1.33E+10</td>
<td>7.48E+09</td>
<td>2.48E+10</td>
<td>5.00E+10</td>
<td>0.00E+00</td>
<td>7.75E+09</td>
<td>0.00E+00</td>
<td>8.91E+10</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>1.08E+08</td>
<td>1.51E+08</td>
<td>5.33E+08</td>
<td>#DIV/0!</td>
<td>#DIV/0!</td>
<td>2.06E+08</td>
<td>#DIV/0!</td>
<td>2.53E+08</td>
</tr>
<tr>
<td>Total/pers.</td>
<td>2034.09E+06</td>
<td>1683.94E+03</td>
<td>4.48E+03</td>
<td>4.47E+02</td>
<td>0.00E+00</td>
<td>1.71E+03</td>
<td>0.00E+00</td>
<td>3.18E+03</td>
</tr>
<tr>
<td>#Servings (50g)</td>
<td>3.46E+08</td>
<td>1.50E+08</td>
<td>5.28E+08</td>
<td>7.23E+08</td>
<td>0.00E+00</td>
<td>1.57E+08</td>
<td>0.00E+00</td>
<td>1.07E+09</td>
</tr>
</tbody>
</table>

APPROXIMATION

<table>
<thead>
<tr>
<th></th>
<th>Total consumption</th>
<th>Total population</th>
<th>Elderly population</th>
<th>Healthy population</th>
<th>Pregnant population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>1.76E+10</td>
<td>1.10E+10</td>
<td>2.16E+10</td>
<td>2.02E+10</td>
<td>6.92E+10</td>
</tr>
<tr>
<td>Denmark</td>
<td>9.40E+09</td>
<td>1.10E+09</td>
<td>1.06E+09</td>
<td>1.06E+09</td>
<td>1.06E+09</td>
</tr>
<tr>
<td>Finland</td>
<td>2.64E+10</td>
<td>1.05E+10</td>
<td>1.06E+09</td>
<td>1.06E+09</td>
<td>1.06E+09</td>
</tr>
<tr>
<td>Germany</td>
<td>3.65E+10</td>
<td>1.10E+10</td>
<td>1.06E+09</td>
<td>1.06E+09</td>
<td>1.06E+09</td>
</tr>
<tr>
<td>Greece</td>
<td>0.00E+00</td>
<td>1.10E+09</td>
<td>1.06E+09</td>
<td>1.06E+09</td>
<td>1.06E+09</td>
</tr>
<tr>
<td>Ireland</td>
<td>7.87E+09</td>
<td>1.10E+09</td>
<td>1.06E+09</td>
<td>1.06E+09</td>
<td>1.06E+09</td>
</tr>
<tr>
<td>Latvia</td>
<td>0.00E+00</td>
<td>1.10E+09</td>
<td>1.06E+09</td>
<td>1.06E+09</td>
<td>1.06E+09</td>
</tr>
<tr>
<td>Netherlands-Romania</td>
<td>5.35E+10</td>
<td>1.10E+09</td>
<td>1.06E+09</td>
<td>1.06E+09</td>
<td>1.06E+09</td>
</tr>
</tbody>
</table>

EFSA food consumption database per surveyed country and subpopulation

• When there are missing population groups, the available groups are used for extrapolation to the rest
• When there are missing countries, the available countries are used for extrapolation to the rest: no pattern
Some concepts need to be clarified:
- **Shelf-life**: time elapsed from production date to use-by-date.
- **Remaining shelf-life**: time elapsed from purchase date (PD) to use-by-date (UBD). It is calculated as UBD-PD.
- **Time-to-consumption (TTC)**: time elapsed from purchase date (PD) to consumption.

- No available data covering all food categories and subcategories
- Use of **BASELINE data**, in which use-by-date and purchase date are reported. Remaining shelf-lives were calculated as indicated above.
- **Exponential distribution to describe TTC by means of the 99% percentile** (a statistic from the remaining shelf-lives calculated) and a minimum value (uniform (0.01; 0.04) months as initial guess).
Time-temperature profiles

- Temperature-time profiles obtained from the FRISBEE project (http://frisbeetool.eu/FrisbeeTool/about.html) encompassing different RTE products such as deli-meat, cheese and vegetables were used as the basis to estimate *L. monocytogenes* growth from retail to consumption. Datasets were rearranged include temperature records every 5 hours and only from retail to consumption.
- **No data were available for fish, so those profiles for meats are assumed to be the same for fish.**
- Time in time-temperature profiles is truncated based on time-to-consumption output. Thus, a profile can never exceed the simulated time-to-consumption.
Growth model

Cooked meat & sausage/Pate/ smoked and gravad fish/ soft and semisoft cheese

EGRs are assumed to include the effect of microbial microbiota in food: data are taken from products naturally contaminated

The effect of LAB on Maximum Population Density (MPD) of \( L.\ monocytogenes \) can be simulated i) interaction term and ii) using a probability distribution for MPD obtained from experiments in naturally contaminated foods.

The deterministic secondary models used for LAB was deemed to be suitable for estimating the effect on MPD of Listeria
Refined EGR 5C distributions

\[ EGR_{Y^C} = EGR_{5^C} \left( \frac{Y^o C - T_{\min}}{T_{5^C} - T_{\min}} \right)^2 \]

\[ EGR_{Lact} = a (Lact_{max} - Lact) \]

INITIAL GUESS

\[ \frac{1}{N(t)} \frac{dN(t)}{dt} = EGR \cdot \alpha(t) \cdot f(t) \]

INPUT variables (DIST)

EXPERT OPINION; LITERATURE AND MINTEL

OUTPUT

\[ \frac{1}{N(t)} \frac{dN(t)}{dt} = EGR \cdot \alpha(t) \cdot f(t) \]

N(0) is a distribution (1-4 log)

MODIFIED TERM FOR MICROBIAL INTERACTION

\[ f(t) = \left( 1 - \frac{N_{list}(t)}{N_{max\ list}} \right) \left( 1 - \frac{N_{LAB}(t)}{N_{max\ LAB}} \right) \]
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Risk characterization: risk simulation

Individual risk:

Probability distribution for probability of illness from a single hamburger meal predicted by the *E. coli* O157:H7 Process Risk (Adapted from Cassin et al. 1998)

\[ \text{Pill}_i = \text{Prevalence}_i \times \text{Dose}_i \times \text{r-value} \]

Population risk:

Integration of probability distribution for the probability of illness for the whole population (total number of exposures)

\[ \text{cases} = \sum_{n=1}^{23} \pi_n \cdot P \cdot N \cdot f_n \sum_{n=1}^{23} D_n \cdot \text{Pill}_n \cdot N \cdot f_n = P \cdot N \cdot r \sum_{n=1}^{23} D_n \cdot \text{Pill}_{n-1} \]
Risk characterization: cases/year

Population risk

- Sausage: 23%
- Cooked meat: 37%
- Pâté: 7%
- Soft and semi-soft cheese: 1%
- Cold smoked fish: 16%
- Gravad fish: 16%
- Hot smoked fish: 0%
Risk characterization: cases/year

Population risk

- Healthy: 11%
- Elderly: 48%
- Pregnant: 41%
Risk characterization: cases/year

Population risk

**HEALTHY**
- Cold smoked fish: 21%
- Gravad fish: 19%
- Cooked meat: 28%
- Sausage: 25%
- Pâté: 5%
- Soft and semi-soft cheese: 2%
- Hot smoked fish: 0%

**ELDERLY**
- Cold smoked fish: 18%
- Gravad fish: 9%
- Cooked meat: 29%
- Sausage: 23%
- Pâté: 8%
- Soft and semi-soft cheese: 1%
- Hot smoked fish: 0%

**PREGNANT**
- Cold smoked fish: 11%
- Gravad fish: 9%
- Cooked meat: 50%
- Sausage: 23%
- Pâté: 6%
- Soft and semi-soft cheese: 0%
- Hot smoked fish: 1%
Risk characterization: cases/year

Population risk

Listeriosis in pregnant

BASELINE MODEL
Risk characterization: cases/year

Population risk

Listeriosis in healthy

BASELINE MODEL
Scenario analysis: heat-treated meat
Scenario analysis: smoked and gravad fish

Percentage of variation

-200%  -100%  0%  100%  200%  300%  400%  500%  600%  700%

Max concentration  Time to consumption  Temperature  lag time
Scenario analysis: soft and semi-soft cheese
Outline

- Introduction and model scope
- Selection of D-R models
- Exposure assessment
- Simulation and output
- An easy-to-use framework: Excel Add-in “Lis-RA”
- Conclusions
An Excel Add-in, “Lis-RA”, for listeriosis risk model simulation

*Lis-RA*, a customized Ribbon-based system, was developed in VBA using libraries from @Risk software.

*Lis-RA* allows users to select/upload models, time-temperature profiles sand scenarios.
An Excel Add-in, “Lis-RA”, for listeriosis risk model simulation

Users can introduce scenario probabilities, input values and select the model order (first order or second order)
An Excel Add-in, “Lis-RA”, for listeriosis risk model simulation

Model simulation settings and selection of the type of growth model
An Excel Add-in, “Lis-RA”, for listeriosis risk model simulation

Graphical and numerical output are automatically reported after simulation.
Outline

- Introduction and model scope
- Selection of D-R models
- Exposure assessment
- Simulation and output
- An easy-to-use framework: Excel Add-in “Lis-RA”
- Conclusions
Conclusions

Similar values to those reported by the surveillance system, confirming higher incidence in elderly population.

Heat treated meat was the RTE product with highest overall risk of listeriosis specifically for the subcategory cooked meat.

Semi-soft cheese and hot smoked fish were the subcategories resulting in the lowest estimated risk.

Aspects related to the consumption patterns, shelf-life and processing were key in the differences found between these subcategories.

Concerning specific scenarios, the highest risk was obtained for normal packaged and sliced Pâté in pregnant population. The lowest risk values were observed for non-sliced hot smoked fish and soft and semi-soft cheese.

Maximum concentration at retail and temperature were the most relevant variables for listeriosis risk.
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