UNIVERSITEIT GENT

FACULTY OF BIOSCIENCE ENGINEERING

# Quantitative risk assessment of *Campylobacter* spp. in minced poultry based meat preparations in Belgium


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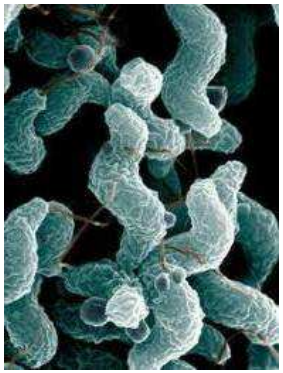
IBW
DEPARTMENT OF INDUSTRIAL BIOLOGICAL SCIENCES

# Campylobacteriosis



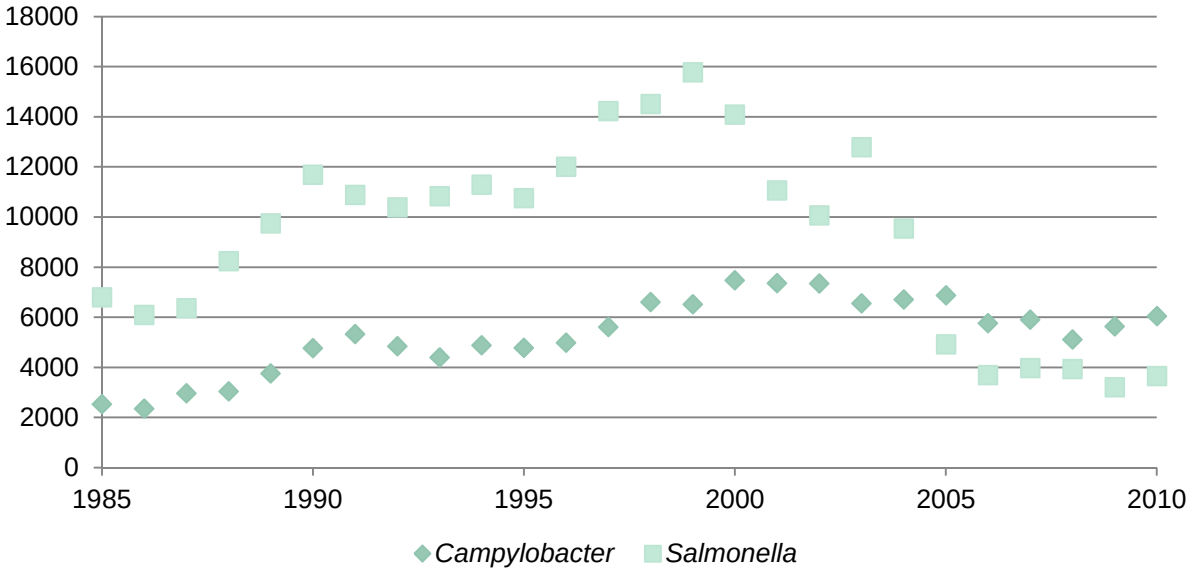



Figure. Evolution of the annual incidence of campylobacteriosis and salmonellosis in Belgium
(Scientific Institute of Public Health, 2011; 2011)

First cause of foodborne bacterial infections since 2005:

- 6000 cases versus 4846 reported cases of salmonellosis
- The number of reported cases has increased significantly (6074 in 2010 compared to 1703 in 1984).
- Campylobacteriosis shows a seasonal effect: increase in summer period

# Thermotolerant *Campylobacter* spp.

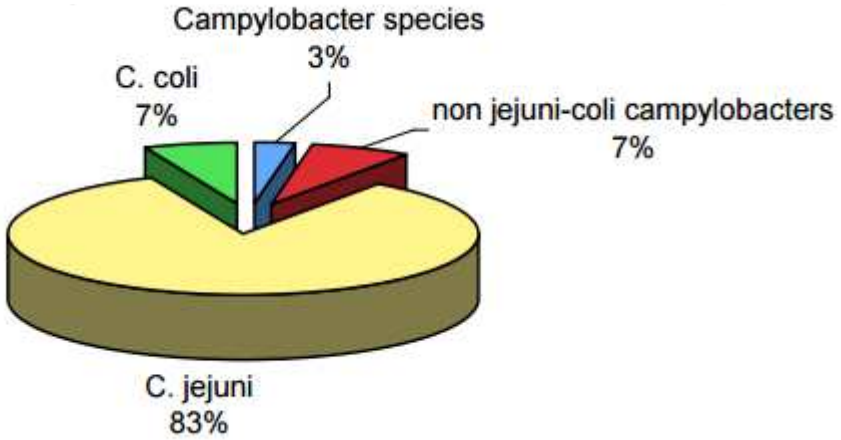



Figure. Campylobacter: distribution of *Campylobacter* species isolated in the laboratory Hallepoort in 2011

https://nrchm.**wiv-isp**.be/nl/ref_centra_labo/campylobacter/Rapporten/Rapport%20Campylobacter%202011.pdf

⇒ Microaerophilic (5% $O_2$-10%$CO_2$-85%$N_2$)
⇒ Nutritionally demanding
⇒ Sensitive to stress: air, light, drying, heating, salt levels, reduced pH, reduced $a_w$, freezing, …

# ➢ *C. jejuni* is commonly associated with poultry.

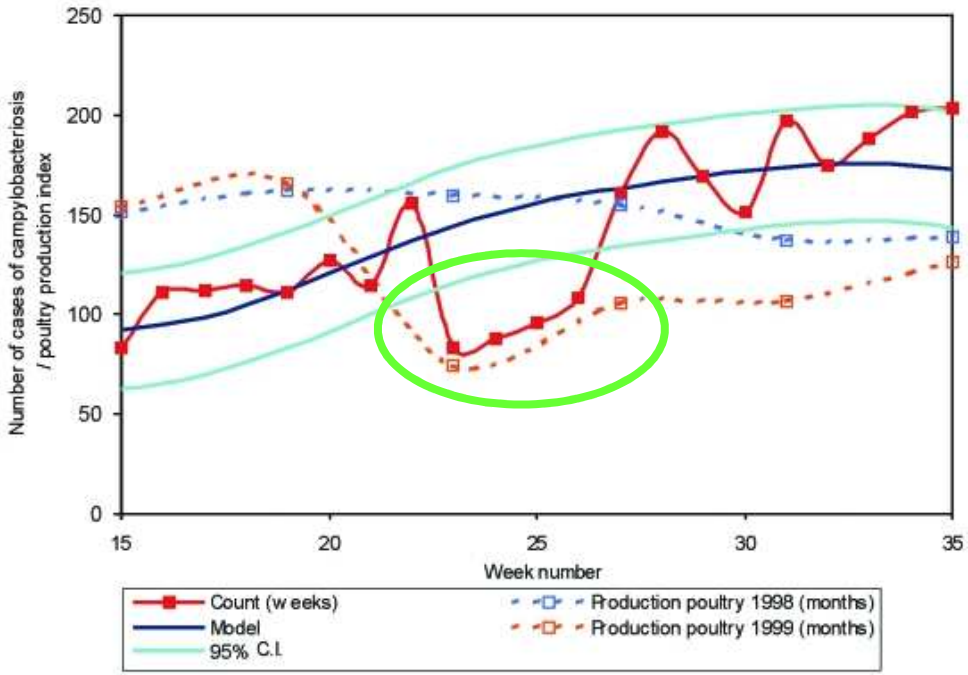



Figure. Campylobacteriosis in Belgium at period of dioxin crisis, model 1994-1998 and poultry production index. (Vellinga and Van Loock, 2002)

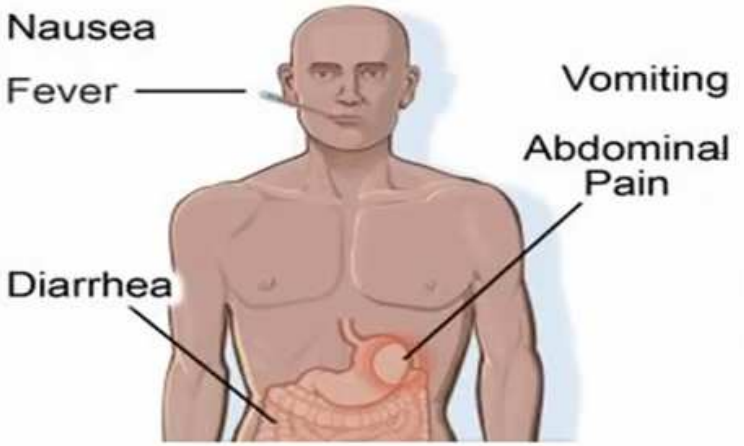
Dioxin crisis:

June 1999: 375 cases whereas 643 cases expected

**40% less**

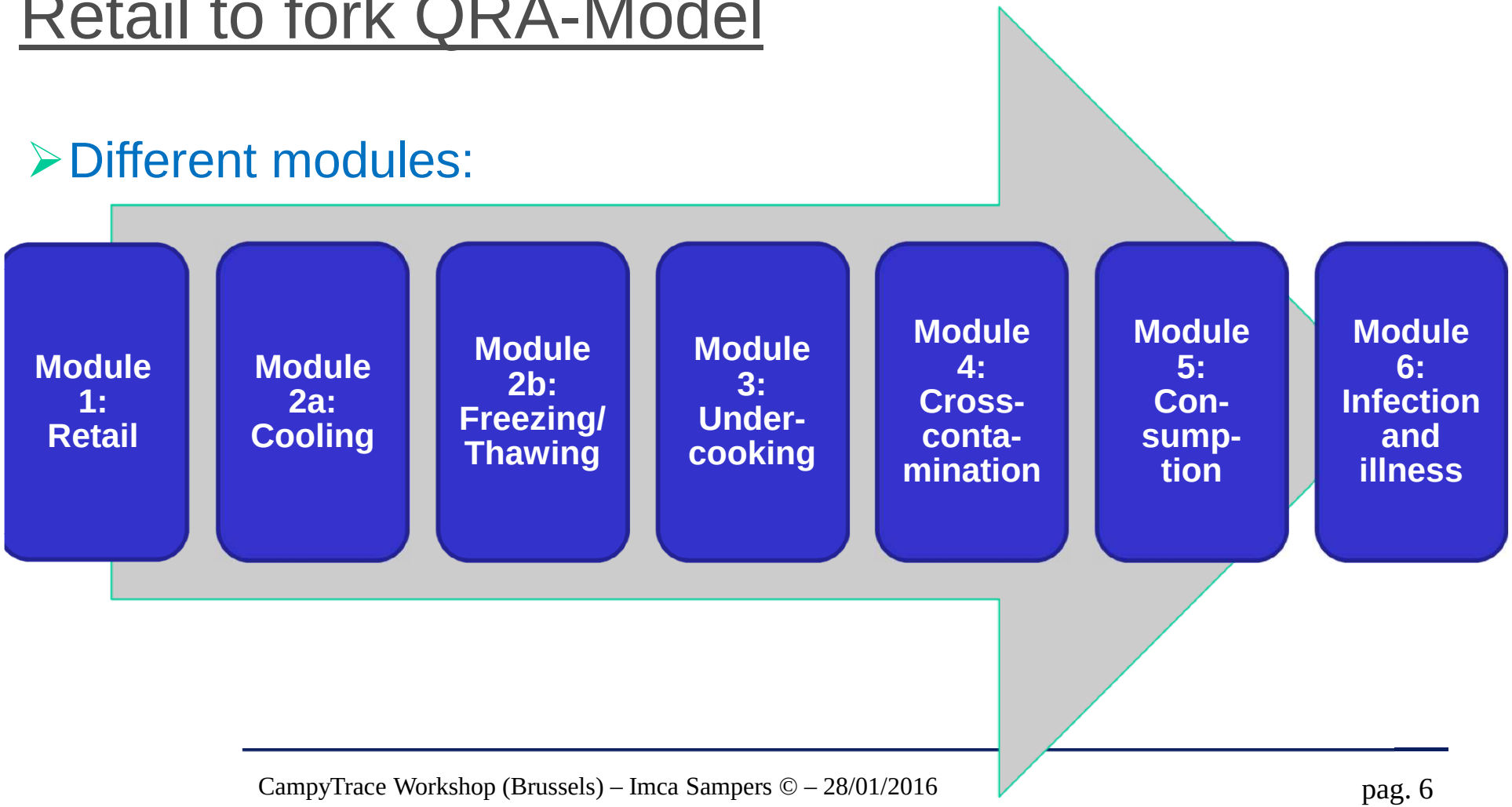
# QRA from retail to fork

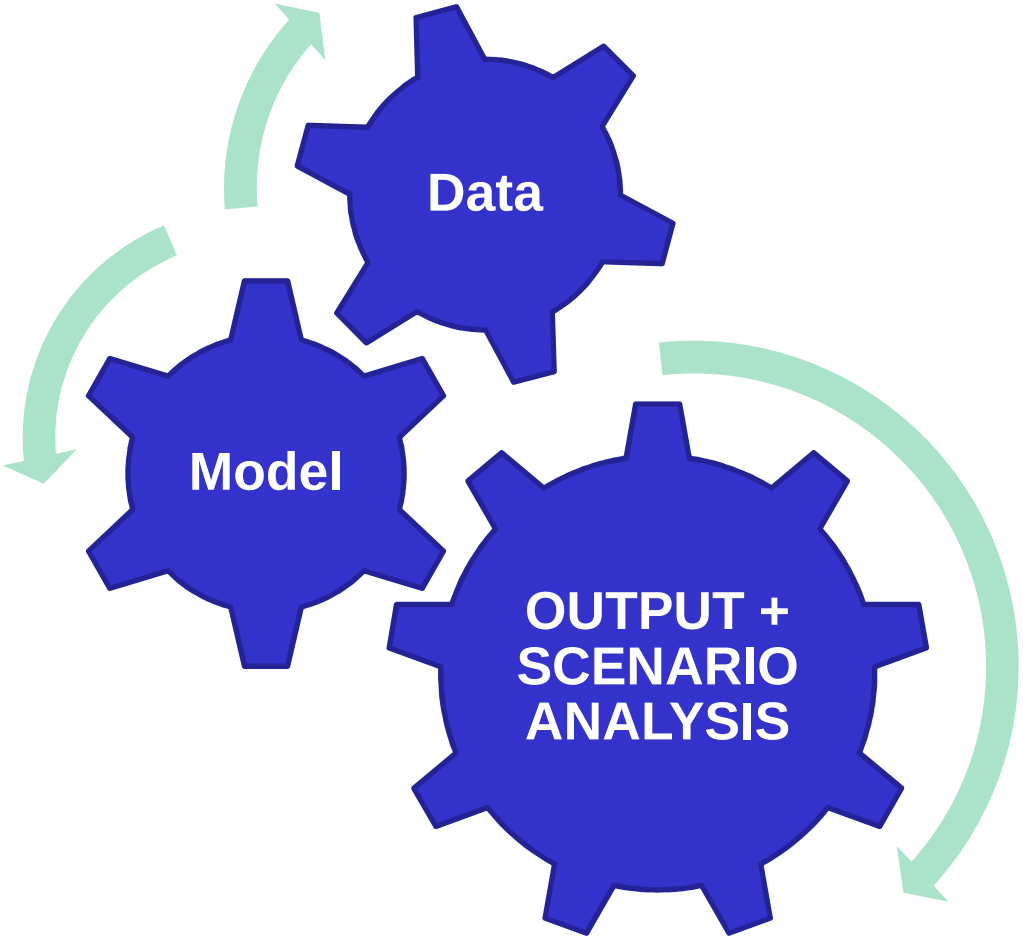


# Retail to fork QRA-Model

- Different modules:




Data
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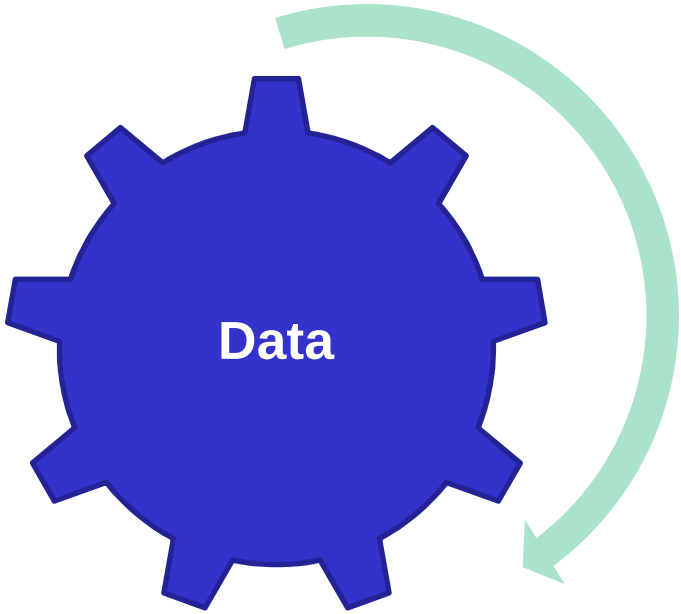

Data

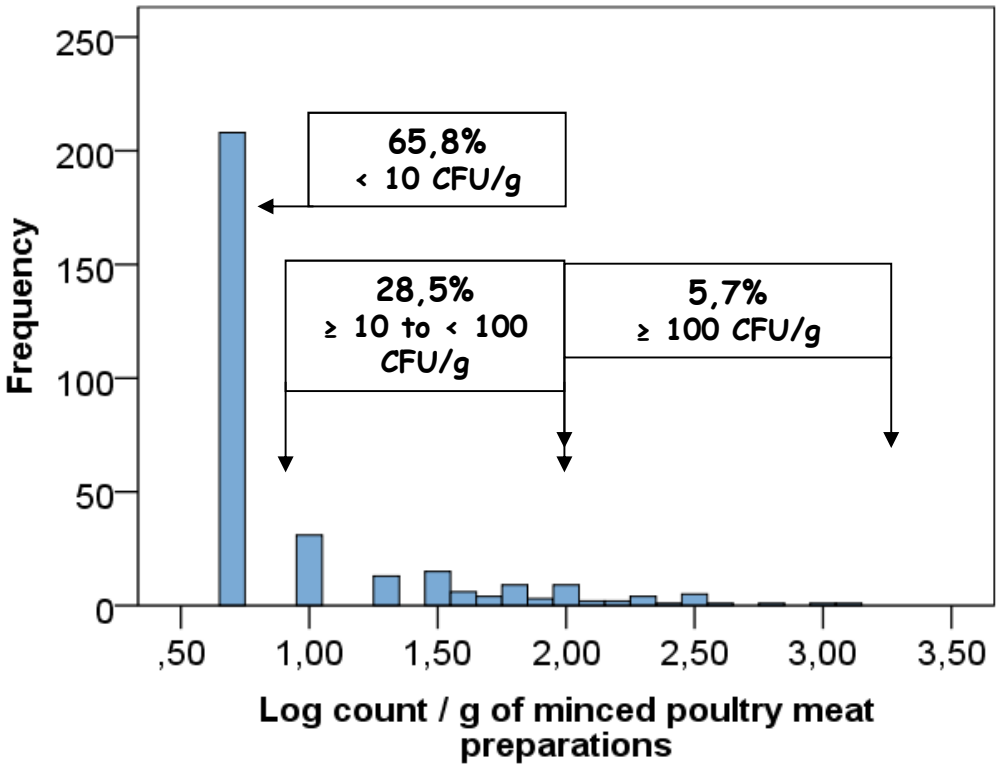
**Module 1: Retail**

**41%**

**(128/316)**

of the Belgian poultry meat preparations samples were tested positive for *C. jejuni* and *C. coli*

**►The average count was 1.4 $log_{10}$ cfu/g with a standard deviation of ± 0.6 $log_{10}$ CFU/g (only positive samples)**

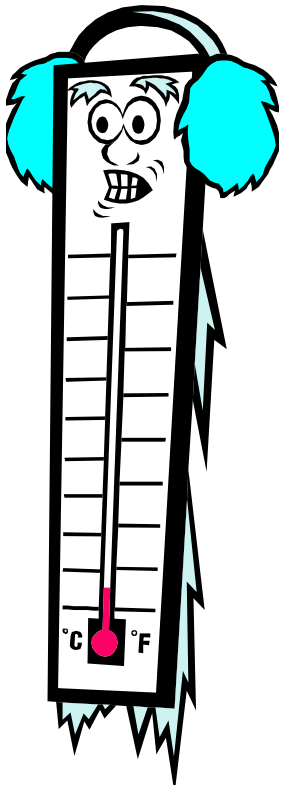


- Survival experiments of *Campylobacter* spp. upon
  - *cooling/freezing*

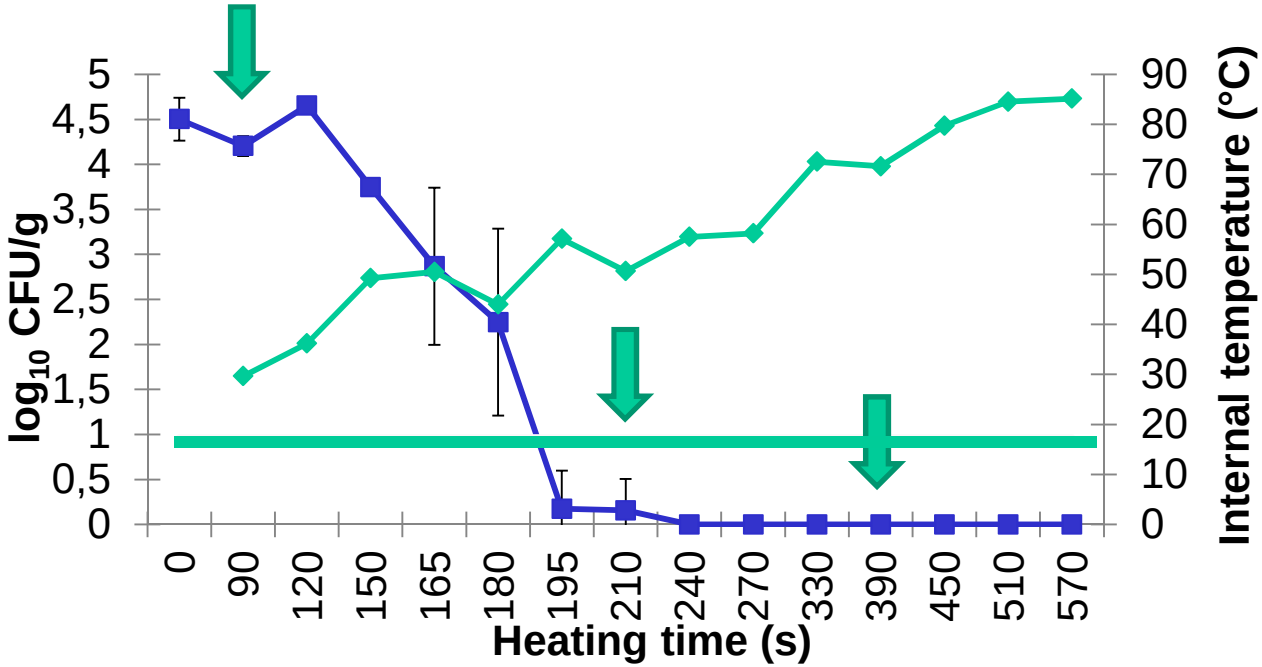
| Experiment 1 | Campylobacter ($log_{10}$ cfu/g) | |
|---|---|---|
| Incubation (days) | 4°C | -22°C |
| 0 | 2.8 | 2.8 |
| 1 | 2.5 | 1.2 |
| 3 | 2.3 | 1.4 |
| 7 | 2.1 | 1.3 |
| 14 | 2.3 | 1.0 |
| Experiment 2 | Campylobacter ($log_{10}$ cfu/g) | |
| Incubation (days) | 4°C | -22°C |
| 0 | 2.1 | 2.1 |
| 1 | 1.9 | 1.1 |
| 3 | 1.8 | <1 |
| 7 | 1.9 | <1 |
| 14 | 1.4 | <1 |

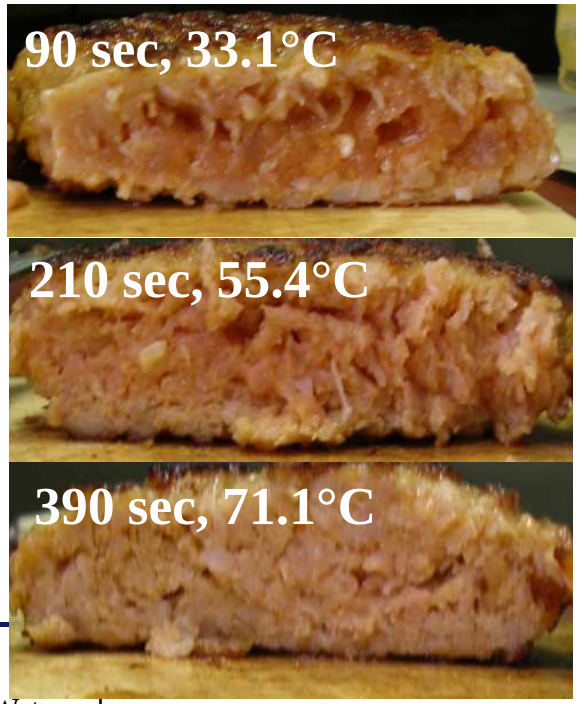
**~ - 1 log**

**~ - 1 log**



- Survival experiments of *Campylobacter* spp. upon
  - *Cooling/freezing*
  - *consumer-based frying of chicken burgers*



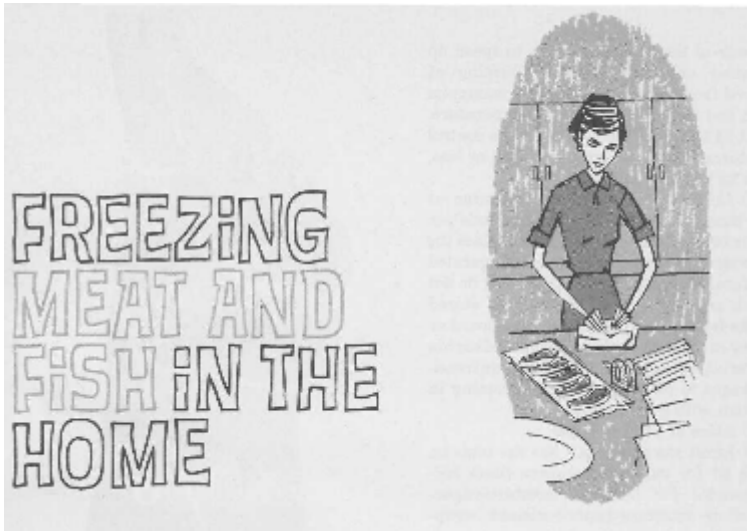
# Consumption patterns and consumer behavior

- Consumption and preparation of poultry meat by Belgian consumers were surveyed.
- A self-completion questionnaire survey

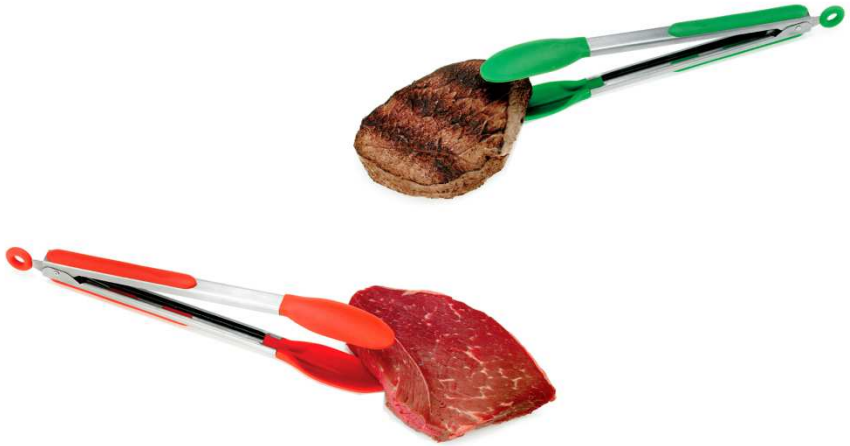
- The survey included questions on risk factors associated with campylobacteriosis i.e.
  - storage conditions
  - potential for cross-contamination
  - undercooking

| Demographic variable | % of respondents (n = 1,618) |
|---|---|
| **Gender** | (n = 1,617) |
| **Male** | 34.6 |
| **Female** | 65.4 |
| **Age** | (n = 1,615) |
| **19 – 29** | 36.3 |
| **30 - 65** | 58.4 |
| **65+** | 5.3 |
| **Frequency of cooking** | (n = 1,537) |
| **Rarely** | 7.9 |
| **Weekly** | 16.3 |
| **Several times a week** | 36.0 |
| **Daily** | 39.8 |

- **61%** identified home freezing of fresh poultry meat as common storage technique!

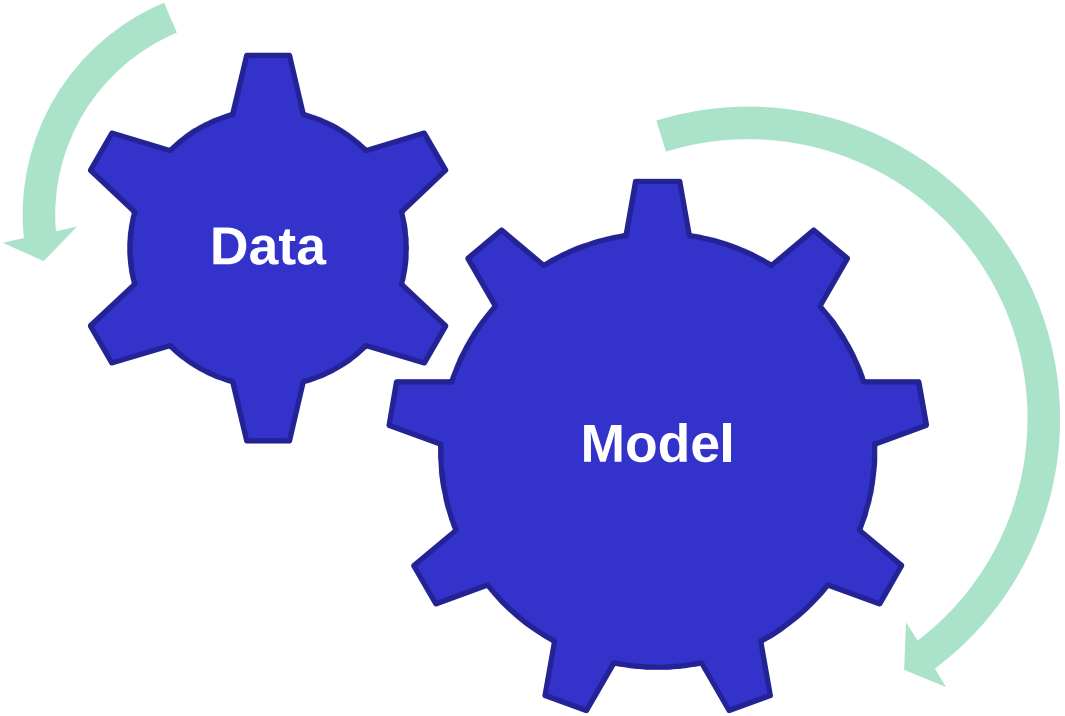



- **27%** of the respondents appeared to have some form of unsafe handling of food linked to cross-contamination:
  - **11,22%** would put cooked meat on the same plate where raw meat was before.

- **3.7%** prefer raw to medium cooked.
- **16%** would eat not well-cooked poultry meat if served at a barbecue.

**=> Obtained data can serve as input for risk assessment on campylobacteriosis.**

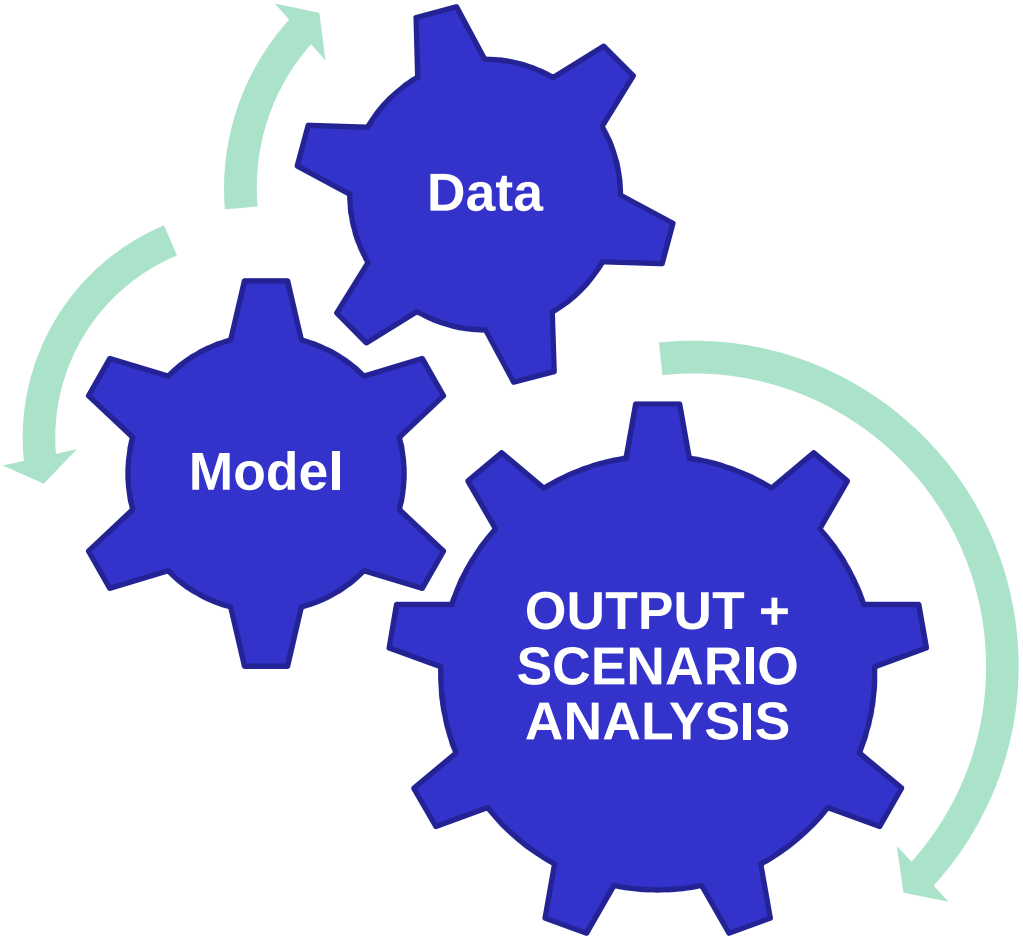

Data
Model

- Built in @Risk© 7 software, an Excel add-in program:

| | New model minced meat prepartions with(out) cross-contamination | | | |
|---|---|---|---|---|
| | | Formulas | Output | |
| 1 | Size of minced PMP serving for a adult | RiskDiscrete(Risktriangle of Portion;market share) | Portion | g/portion |
| | Mu | RiskSimtable('Data Minced by Arno'!B15:B2014) | | |
| | Sigma | RiskSimtable('Data Minced by Arno'!C15:C2014) | | |
| | Concentration of Campy on minced PMP per g | risknormal(mu; sigma;RiskTruncate(;6.5)) | | log CFU/g |
| | Number of Campy on minced PMP per g | MACHT(10;E5) | Number Campylobacter | CFU/g |
| | Concentration of Campy on minced PMP per portion | RiskPoisson(E8*E3) | Number per portion | CFU/portion |
| 2 | Campy reduction due to cooling | Riskdiscrete | | $log_{10}$ CFU/g |
| | Number of Campy on minced PMP per portion after cooling | RiskBinomial(E8;(10^-E12)) | Number after cooling | CFU/portion |
| 5 | Probability of crosscontamination from plate | Fixed value from questionnaire | | - |
| | Cross-contamination = 1; No cross-contamination = 0 | RiskBinomial(1; E37) | | |
| 6 | Number of Campy on minced PMP per portion at exposure | E32*E35*E23+E32*E38*E29+(1-E32)*E35*E22+(1-E32)*E38*E28 | Number at exposure | CFU/portion |
| 8 | Probability of infection of 1 cell | RiskBeta(α;β) | Pinf\|1 | |
| | Probability of infection of dose | 1-(1-E43)^E40 | Pinf\|D | |
| | Probability of illness given infection | =1/3 | | |
| | Probability of illness | E44*E45 | Pill | |

- The modular process risk model (MPRM) was used (Nauta, 2002, 2008)
- The **risk estimate** of the model relates to the **incidence of illness** (campylobacteriosis) in the Belgian population due to consumption of poultry minced meat preparations.


| | | | | |
|---|---|---|---|---|
| Cooling or not | Freezing | Undercooking | Cross-contamination | Consumption |
| Cooling or not | | Undercooking | Cross-contamination | Consumption |
| Cooling or not | | | Cross-contamination | Consumption |
| Cooling or not | Freezing | | Cross-contamination | Consumption |
| Cooling or not | Freezing | Undercooking | | Consumption |
| Cooling or not | | Undercooking | | Consumption |
| Cooling or not | Freezing | | | Consumption |
| Cooling or not | | | | Consumption |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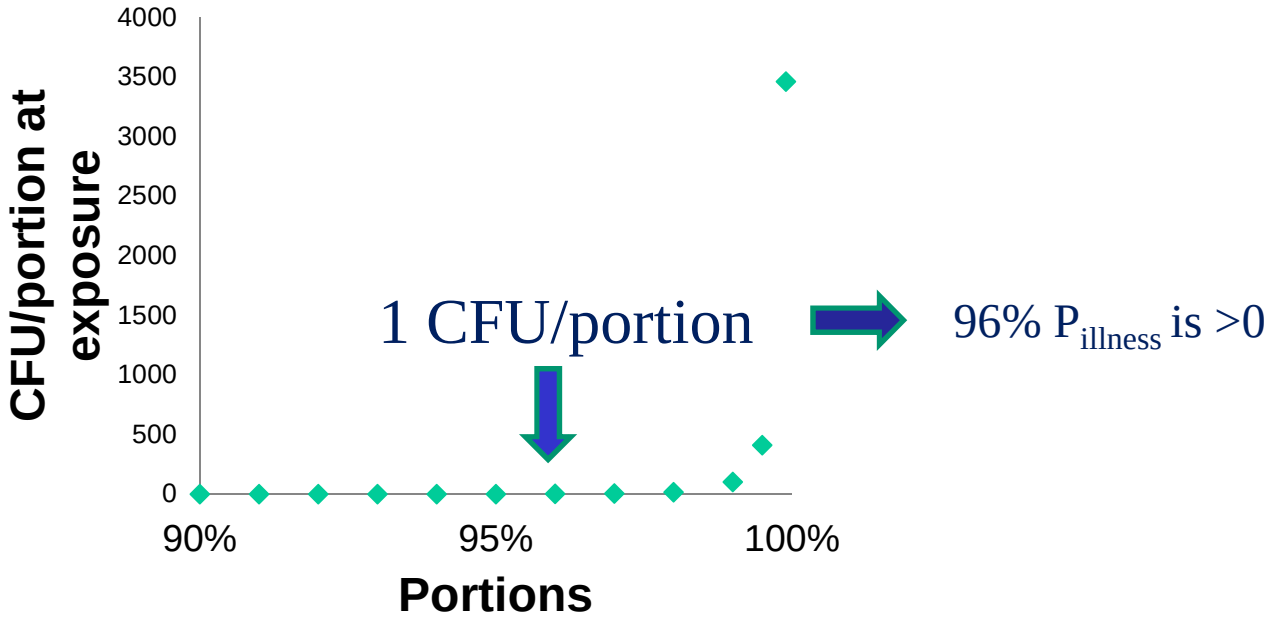
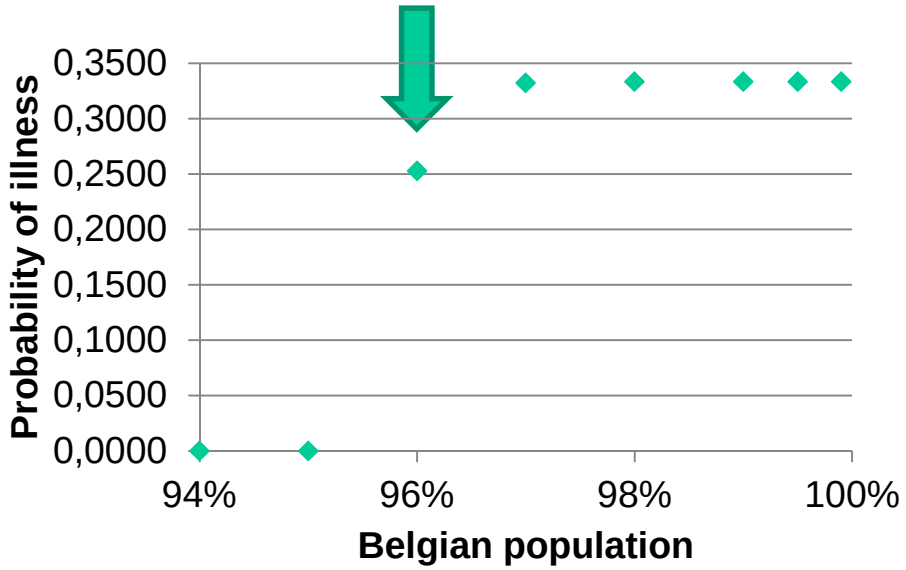



- QMRA model estimates
  - a mean number of 22 CFU/portion;
  - a minimum of 0 CFU/portion
  - and a maximum of 163040 CFU/portion.

- QMRA model estimates a mean incidence of **1011 cases/100,000** persons in Belgian population (≈1%, due to minced pmp) when eating one portion




<-> a notification rate of 55,78 cases/100,000 inhabitants over all involved food products in 2010.

## ➢ Uncertainty is evaluated in **a scenario analysis**

| | | |
|---|---|---|
| **Producer's responsibility** | **Action limit** | **Max. 100 CFU/g**<br>**Max. 1000 CFU/g**<br>**Max. 10000 CFU/g** |
| **Consumer's responsibility** | **Cross-contamination (only plate)** | **No cross-contamination** |
| | **Freezing** | **0% - 100%** |
| | **Undercooking** | **No undercooking**<br>**Probability of 16%**<br>**Probabiltiy of 100%** |

Combinations…

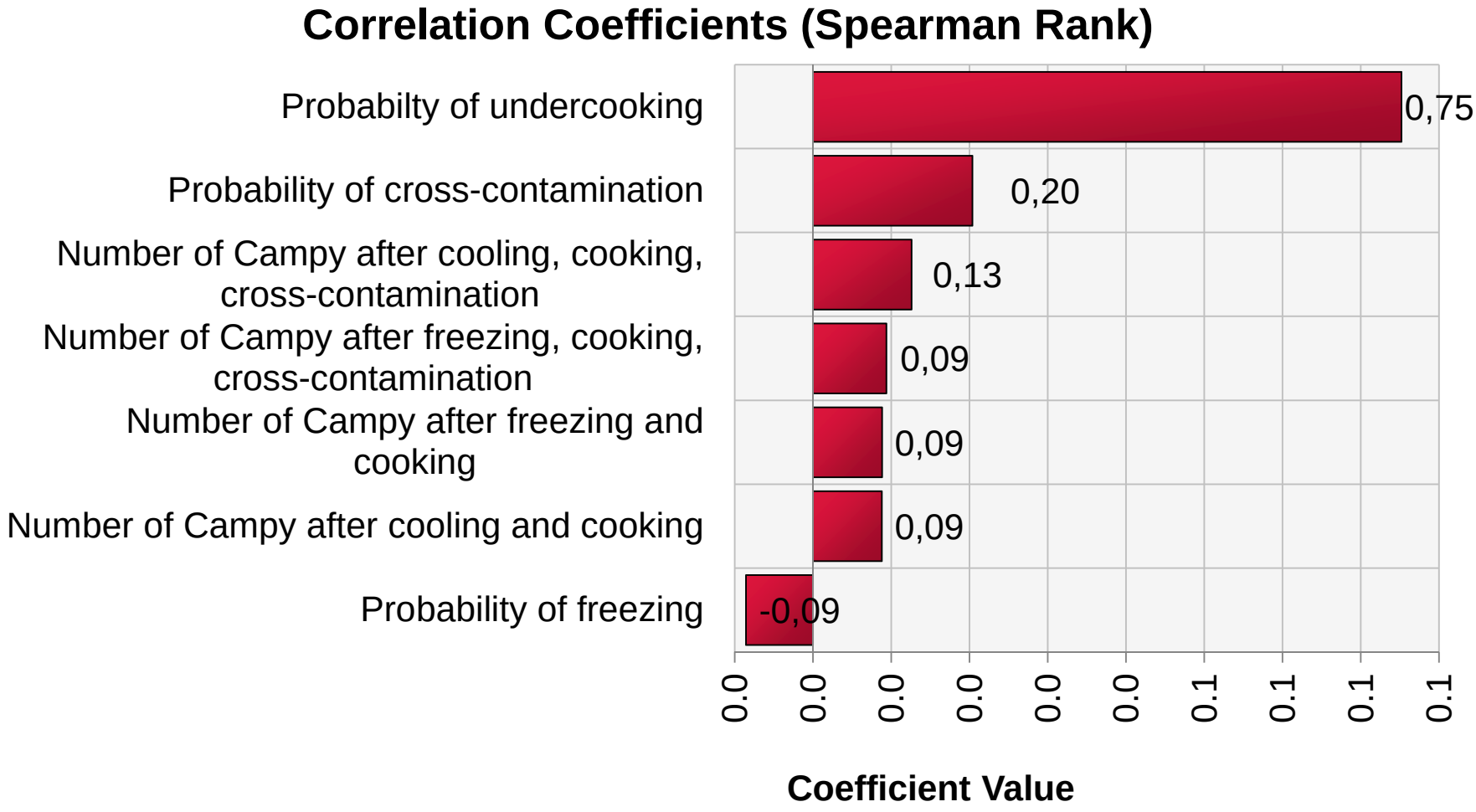
# Number of *Campylobacter* at exposure

| | Min | Mean | Max | 15% | 20% | 50% | 85% | 86% | 93% | 94% | 95% | 96% | 97% | 98% | 99% | 99,5% | 99,90% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Freeze 61%; undercook 3,7%; cross 11,2%** | 0 | 22 | 163040 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 14 | 100 | 409 | 3460 |
| **Scenario 0: Action limit 100CFU/g** | 0 | 7 | 8828 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 10 | 66 | 270 | 1687 |
| **Scenario 0: Action limit 1000CFU/g** | 0 | 16 | 51657 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 13 | 96 | 384 | 3343 |
| **Scenario 0: Action limit 10000CFU/g** | 0 | 19 | 111498 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 14 | 96 | 378 | 3241 |
| **Scenario 0: Freeze 100%** | 0 | 1 | 5407 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 14 | 43 | 261 |
| **Scenario 0: Freeze 0%** | 0 | 46 | 203135 | 0 | 0 | 0 | 0 | 0 | 0,2 | 1 | 2 | 7 | 31 | 131 | 548 | 1477 | 7494 |
| **Scenario 0: Undercook 0%** | 0 | 0 | 654 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 18 |
| **Scenario 0: Undercook 16%** | 0 | 85 | 467011 | 0 | 0 | 0 | 0,4 | 1 | 24 | 39 | 65 | 111 | 205 | 417 | 1169 | 2618 | 11952 |
| **Scenario 0: Undercook 100%** | 0 | 536 | 401516 | 0,4 | 1 | 14 | 321 | ND | 1093 | 352 | 1714 | 2233 | 3072 | 4737 | 9260 | 16928 | 54237 |
| **Scenario 0: Cross 0%** | 0 | 13 | 36763 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 10 | 87 | 378 | 2592 |
| **Freeze 0%; undercook 3,7%; Action limit 100CFU/g** | 0 | 17 | 12745 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 5 | 23 | 104 | 398 | 868 | 2757 |

# Probability of illness when exposed to 1CFU/portion

| | Pill (1CFU/portion) | Ill/year/100000 | Ill/year | |
|---|---|---|---|---|
| **Freeze 61%; undercook 3,7%; cross 11,2%** | 0,2527 (96%) | 1011 | 109570 | |
| **Scenario 0: Action limit 100CFU/g** | 0,2527 (96%) | 1011 | 109570 | = |
| **Scenario 0: Action limit 1000CFU/g** | 0,2527 (96%) | 1011 | 109570 | = |
| **Scenario 0: Action limit 10000CFU/g** | 0,2527 (96%) | 1011 | 109570 | = |
| **Scenario 0: Freeze 100%** | 0,2527 (97%) | 758 | 82177 | ↓ |
| **Scenario 0: Freeze 0%** | 0,1061 (94%) | 637 | 69007 | ↓ |
| **Scenario 0: Undercook 0%** | 0,1087 (99%) | 109 | 11783 | ↓ |
| **Scenario 0: Undercook 16%** | 0,1061 (86%) | 1485 | 161016 | ↑ |
| **Scenario 0: Undercook 100%** | 0,1162 (20%) | 9296 | 1007678 | ↑ |
| **Scenario 0: Cross 0%** | 0,1162 (86%) | 349 | 37788 | ↓ |
| **Freeze 0%; undercook 3,7%; Action limit 100CFU/g** | 0,1061 (94%) | 637 | 69007 | ↓ |

# Sensitivity analysis



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# Conclusion

## For risk modellers:

- Count input: watch out the tail of the distribution and where it is coming from.
- Little is known of the pathogenesis of *Campylobac*ter spp. and the effects of acquired immunity to inform future risk assessments.

## For risk managers:

- The model allows also the evaluation of different mitigation strategies via scenario analysis/sensitivity analysis.
  - Freezing is a reliable control option, but alone cannot guarantee total absence of *Campylobacter*.
  - Governmental/industrial mitigation strategy would have a low impact for these type of minced products and if the counts will be kept as low.
  - Enhancing the consumer awareness of the importance of good hygiene and handling practices in domestic kitchens
- Risk managers can now link this consumer model to a processing model to see the impact of the overall chain.

# Thank you for your attention…

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