HM Government

Quantitative MRA models for evaluating the effects of interventions in reducing risks for consumer

Catherine McCarthy, UK Office for Sanitary and Phytosanitary Trade Assurance, DEFRA, UK

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RIBMINS talk 21st June 2022

My background

- Qualified as a vet from the Royal Veterinary College in 2010
- 8 years working as a small animal vet in the UK
- PhD in Veterinary Epidemiology & diplomat from the European College Veterinary Public Health (ECVPH)

Previous relevant career

- 1 year working as a risk analyst in Wageningen BioVeterinary Research, **Netherlands**
- 2 years working as a risk analyst at the Animal and Plant Health Agency, **UK**
- Produced a range of **animal & human health risk assessments** (import, outbreak, abattoir, trade)

Current role

Veterinary risk lead within the UK Office for Sanitary and Phytosanitary Trade Assurance

- This role was previously delivered by **EU agency DG Santé F**.
- Work focuses on identifying and **managing public and animal health risks** presented by SPS imports to GB (plant health risks are managed separately).

Terminology!

Why do we need risk analysis?

Essential tools used by WTO (Codex Alimentarius, WOAH (OIE) & IPPC)

What is a risk analysis?

Overall end-end process in assessing, managing and communicating risks:

1. Risk assessment	2. Risk management	3. Risk communication

Quantitative: outcome expressed in numbers / rates (incl. **Microbial Risk Assessments**)

Qualitative: outcome expressed in scores (negligible/very low/low/medium/high/very high)

Codex Alimentarius (public health):

1. Hazard identification / characterization
2. Exposure assessment
3. Risk characterization

World Organisation for Animal Health (animal health):

1. Entry assessment
2. Exposure assessment
3. Consequence assessment

OUTCOME:

Evidence based policy / decision making

Why would we need a risk assessment?

Data are scarse

Predicting the effect from multiple interventions

Traditional studies are time-consuming

Large host variability

Predicting effect on multiple pathogens

Traditional studies are costly

Large operator / farm / abattoir / country (etc) variability

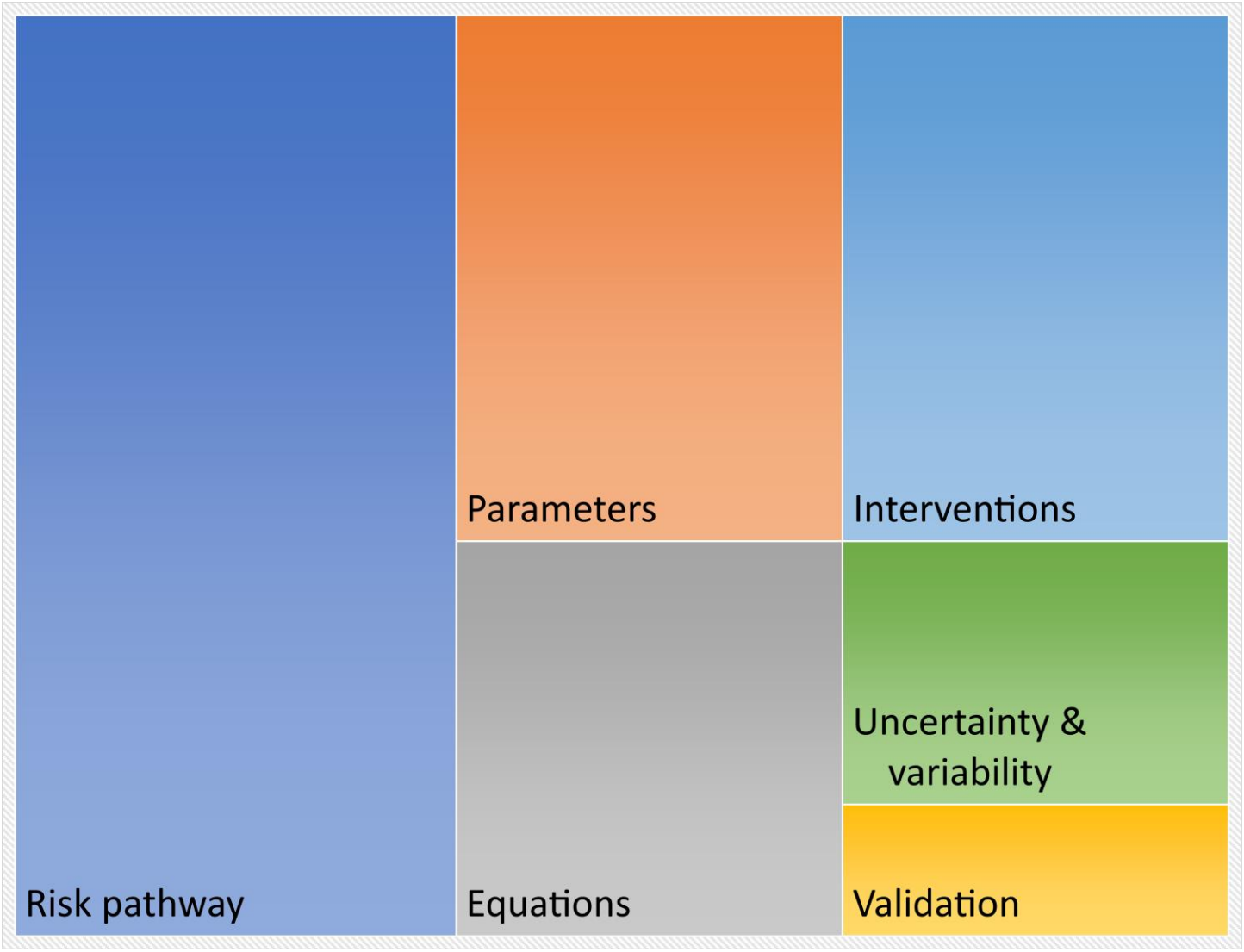
Large amount of data uncertainty

Novel situations / pathogens

Traditional studies have animal welfare implications

Help target / plan traditional studies

Steps involved in producing Quantitative Microbial Risk Assessments (QMRA)

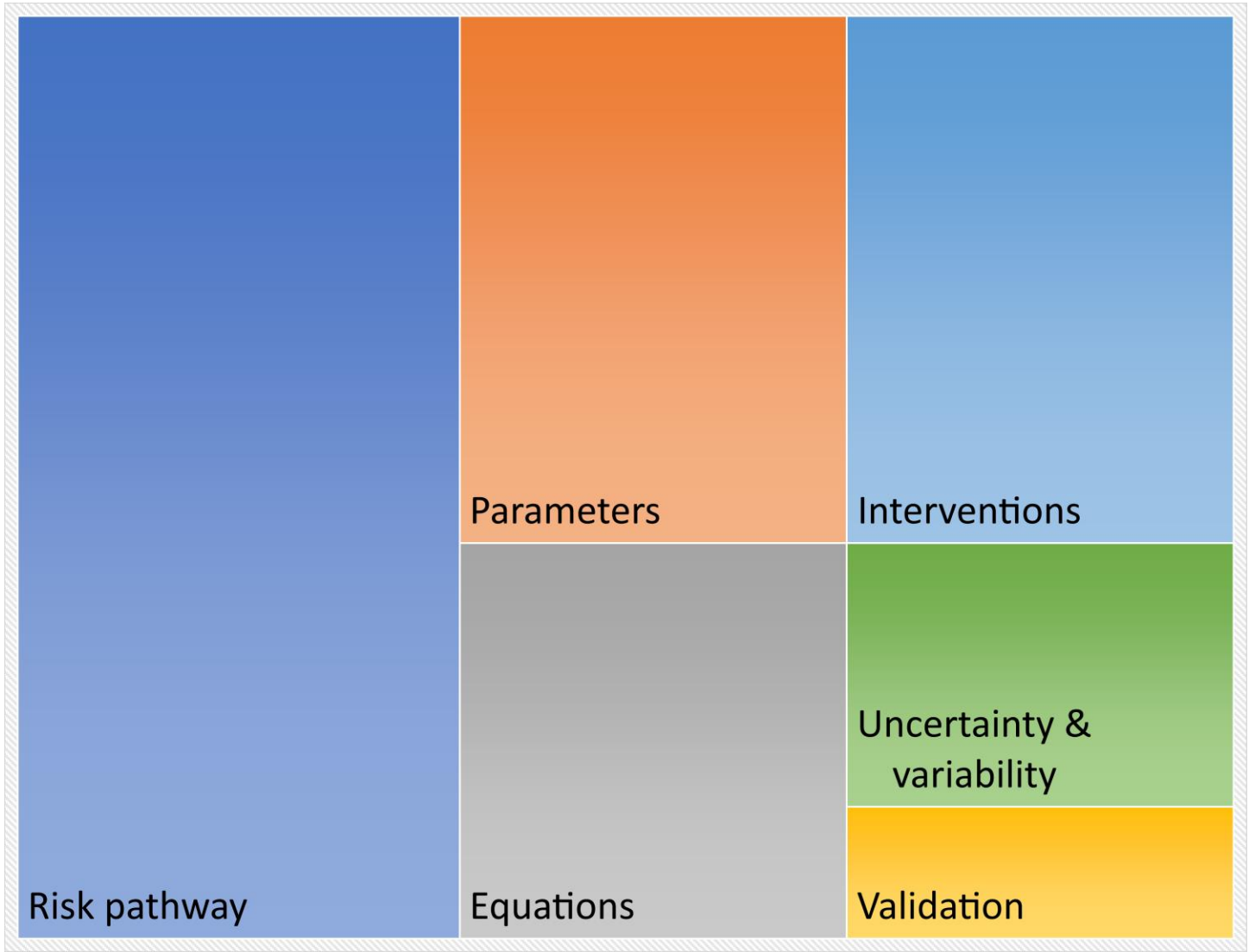


Top 3 tips for demystifying microbial risk assessments

Hypothetical scenario:

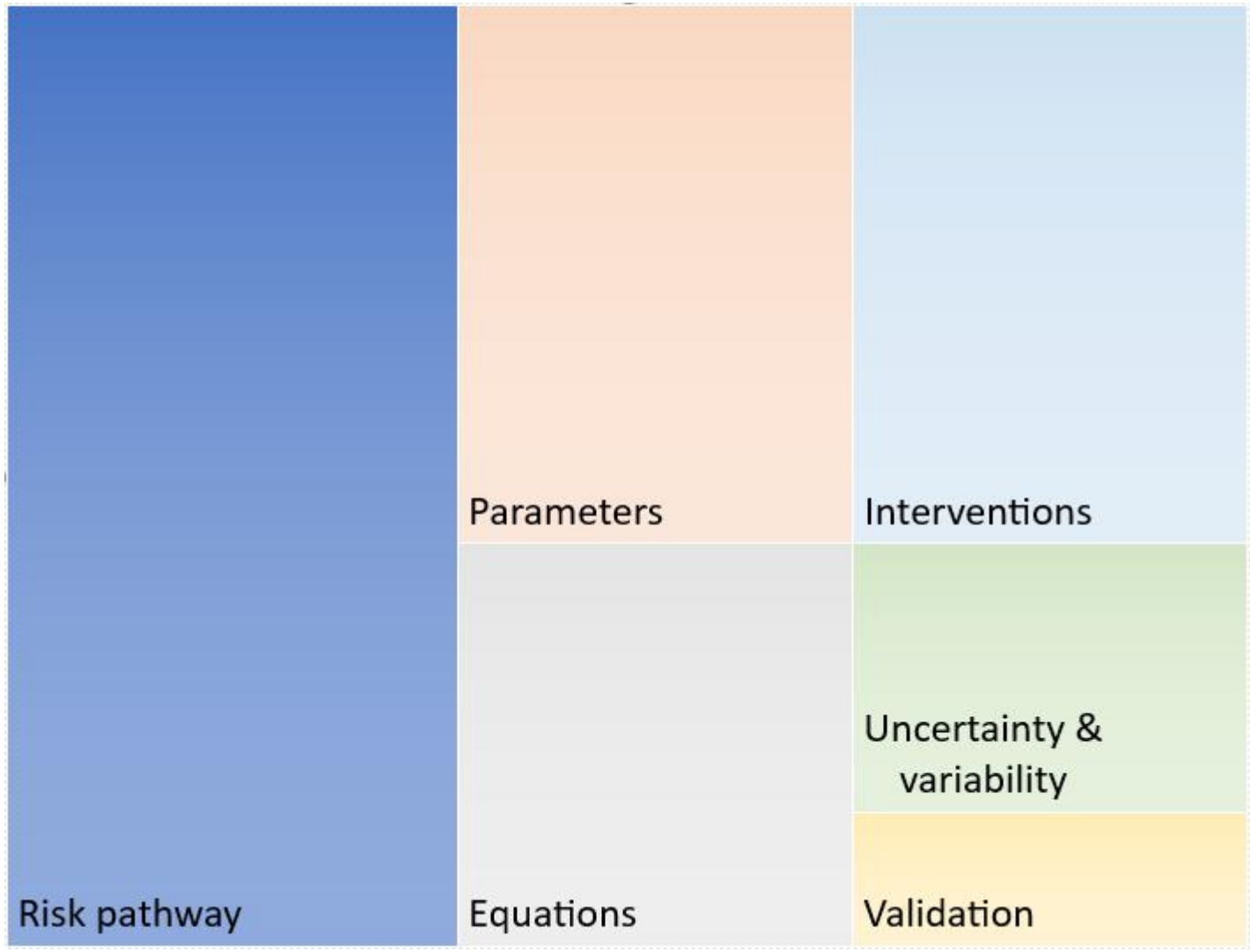
What is the annual reduction in human salmonellosis cases in Europe if pigs were washed prior to slaughter?

- Washing carcasses has been proposed as a method of controlling the rate of Salmonella cross-contamination at slaughter
- Salmonella has a **large amount** of country and individual pig **variation**
- Full farm – to – fork problem
- In this hypothetical scenario, the European Commission would like to understand whether it would be beneficial to mandate the use of carcass washing at abattoir. They have requested that you perform a **QMRA**


Risk pathway
Parameters
Equations
Interventions
Uncertainty & variability
Validation

Tip 1: Understand the RISK PATHWAY

What is the annual reduction in human salmonellosis cases in Europe if pigs were washed prior to slaughter?

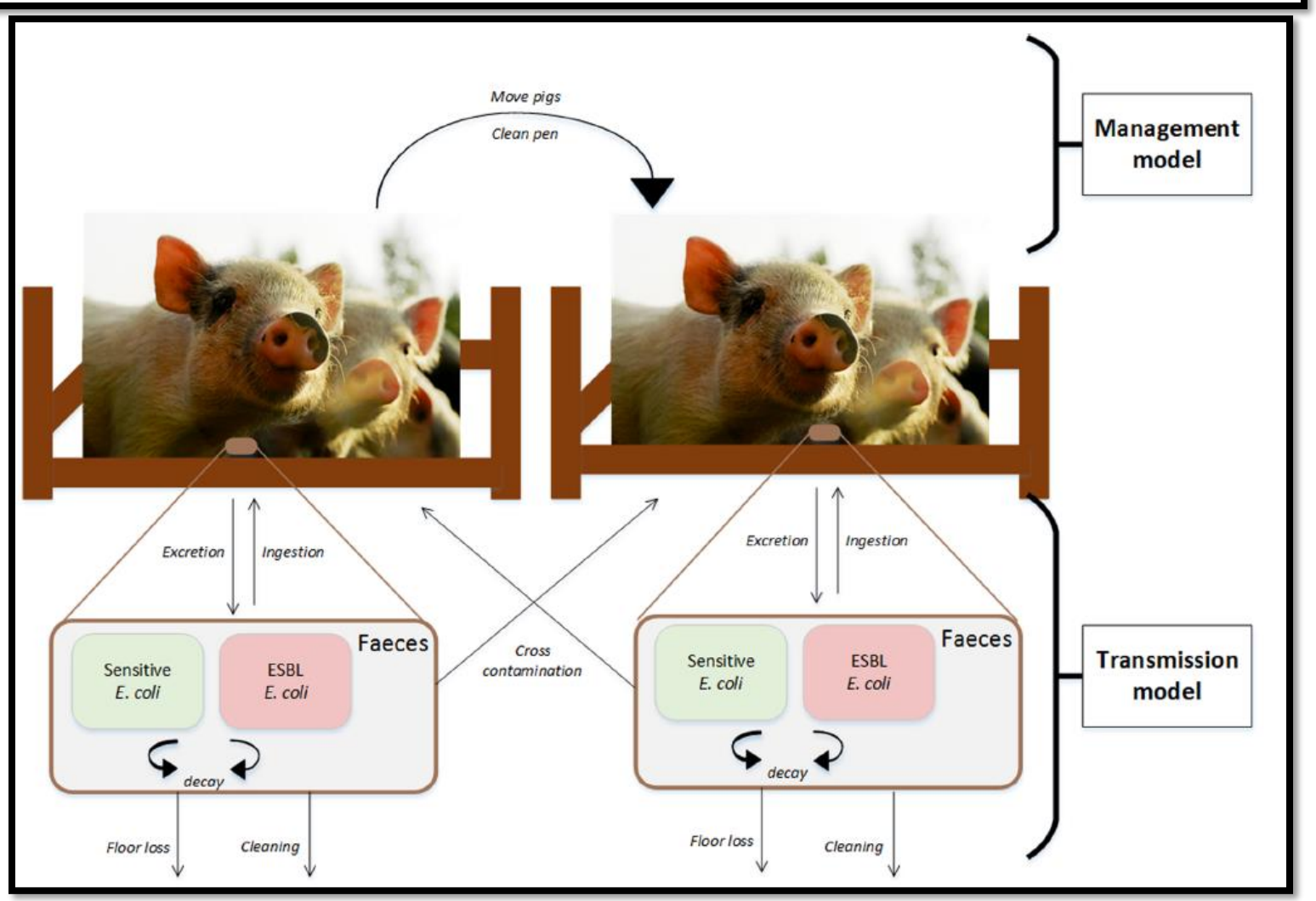


Key opportunity to understand (and describe) complexity of system

Extremely important part of the risk assessment process!

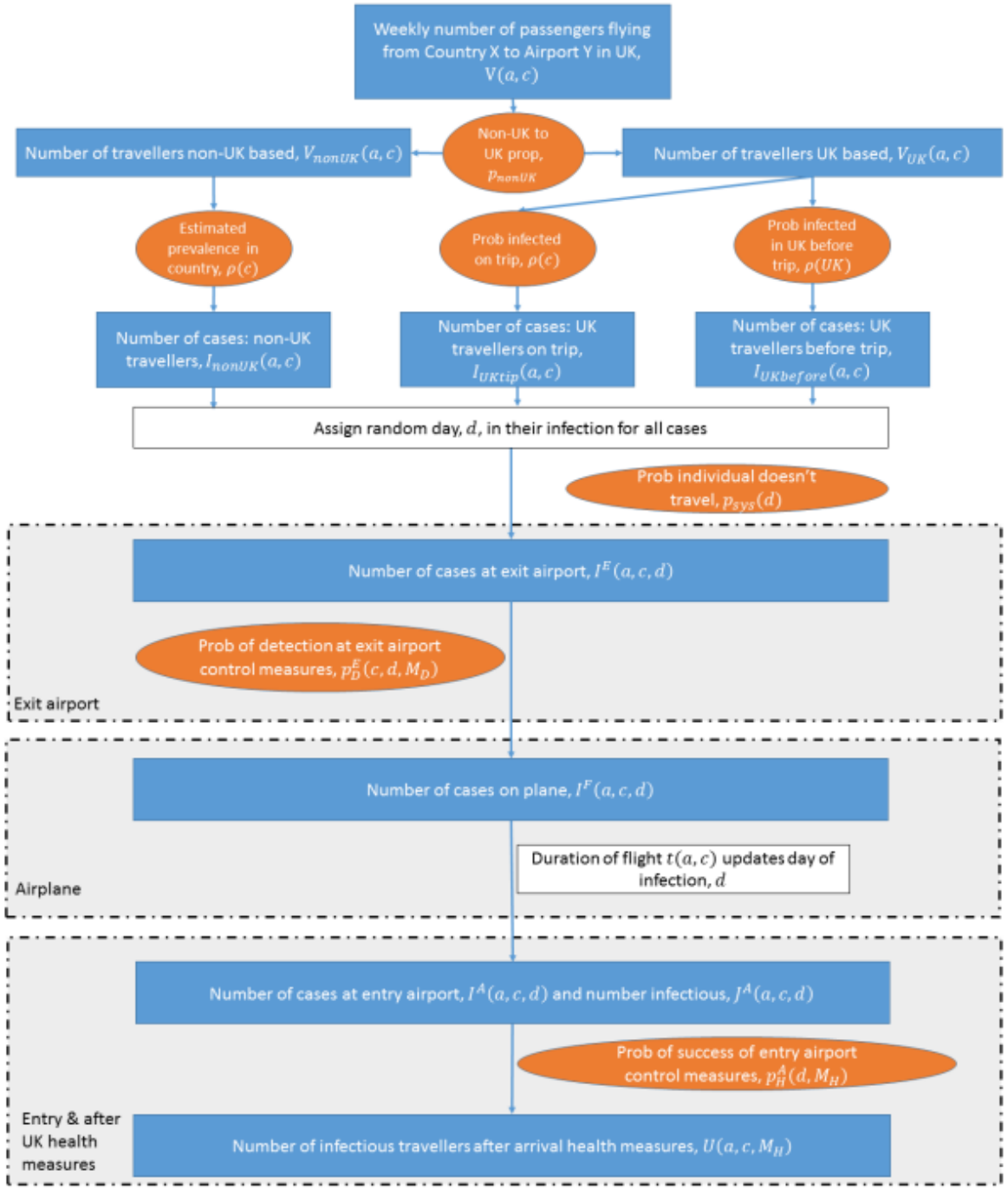
Estimating the likelihood of ESBL-producing *E. coli* carriage in slaughter-aged pigs following bacterial introduction onto a farm: A multiscale risk assessment

Catherine McCarthy [a,*], Alexis Viel [b], Chris Gavin [a], Pascal Sanders [b], Robin R.L. Simons [a]



Example **spatial** demonstration of risk pathway

McCarthy et al., 2022, Microbial Risk Analysis



The risk of introducing SARS-CoV-2 to the UK via international travel in August 2020

Rachel A. Taylor, Catherine McCarthy, Virag Patel, Ruth Moir, Louise A Kelly, Emma L Snary

Example **temporal** demonstration of risk pathway

Taylor et al., 2020 medRxiv

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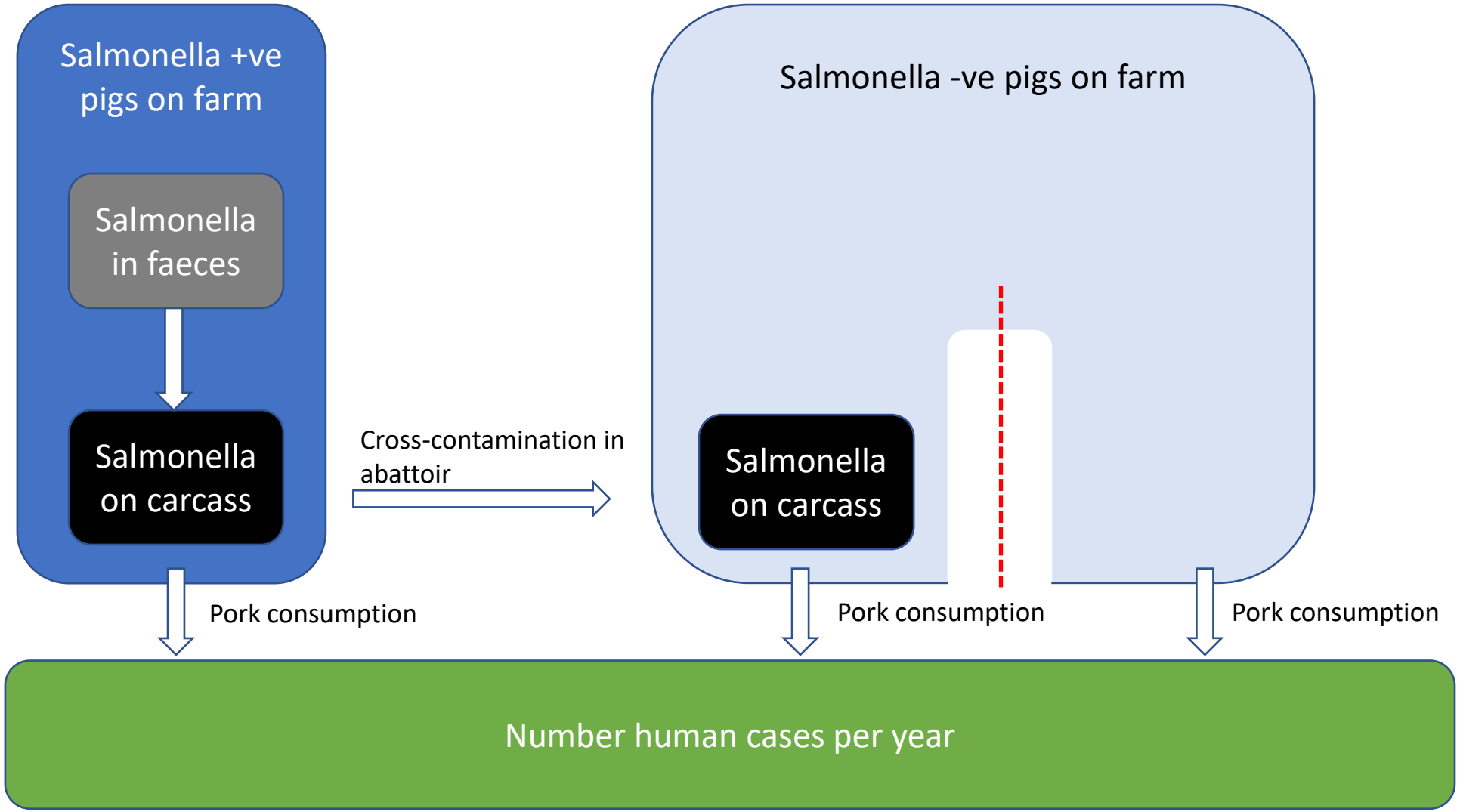

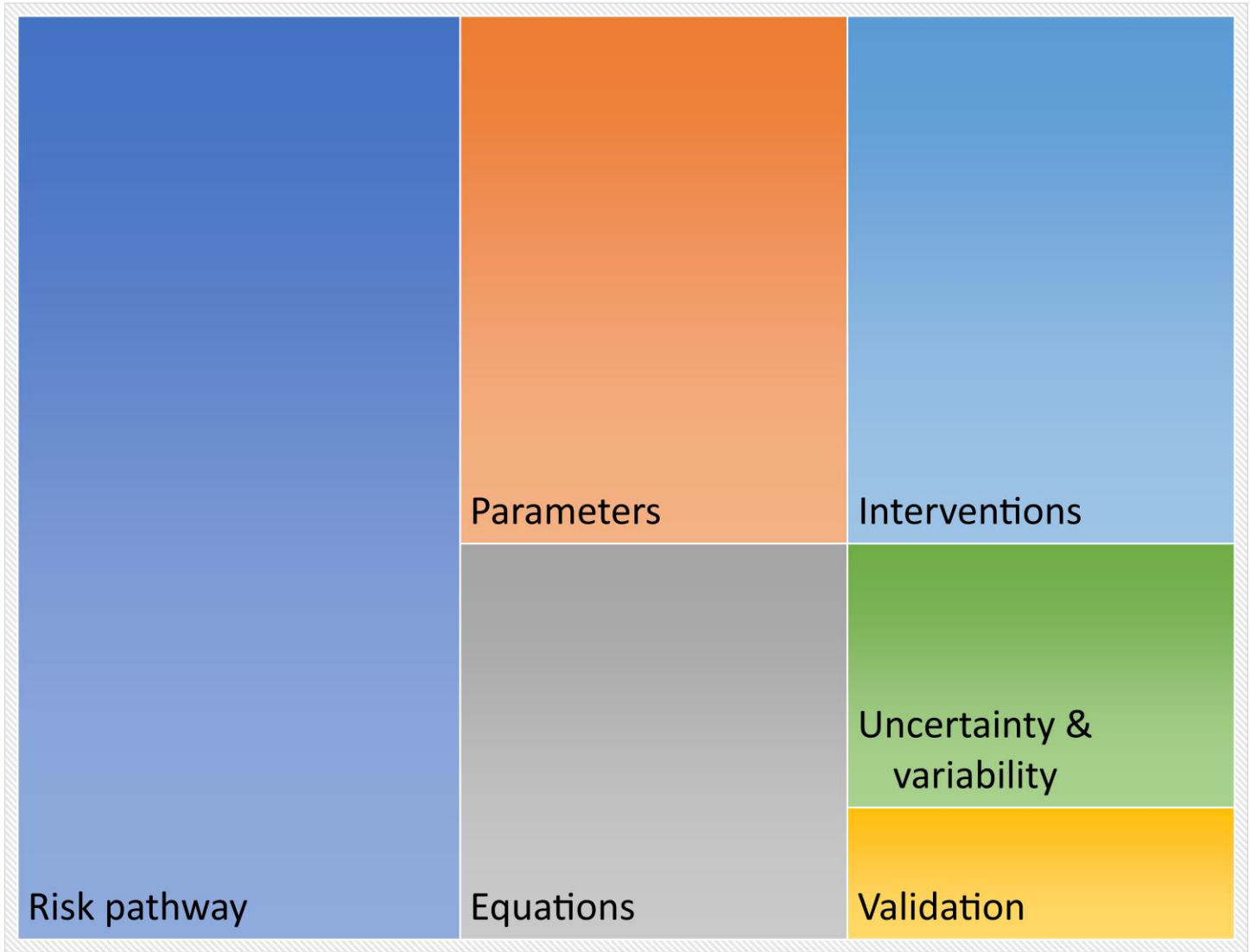
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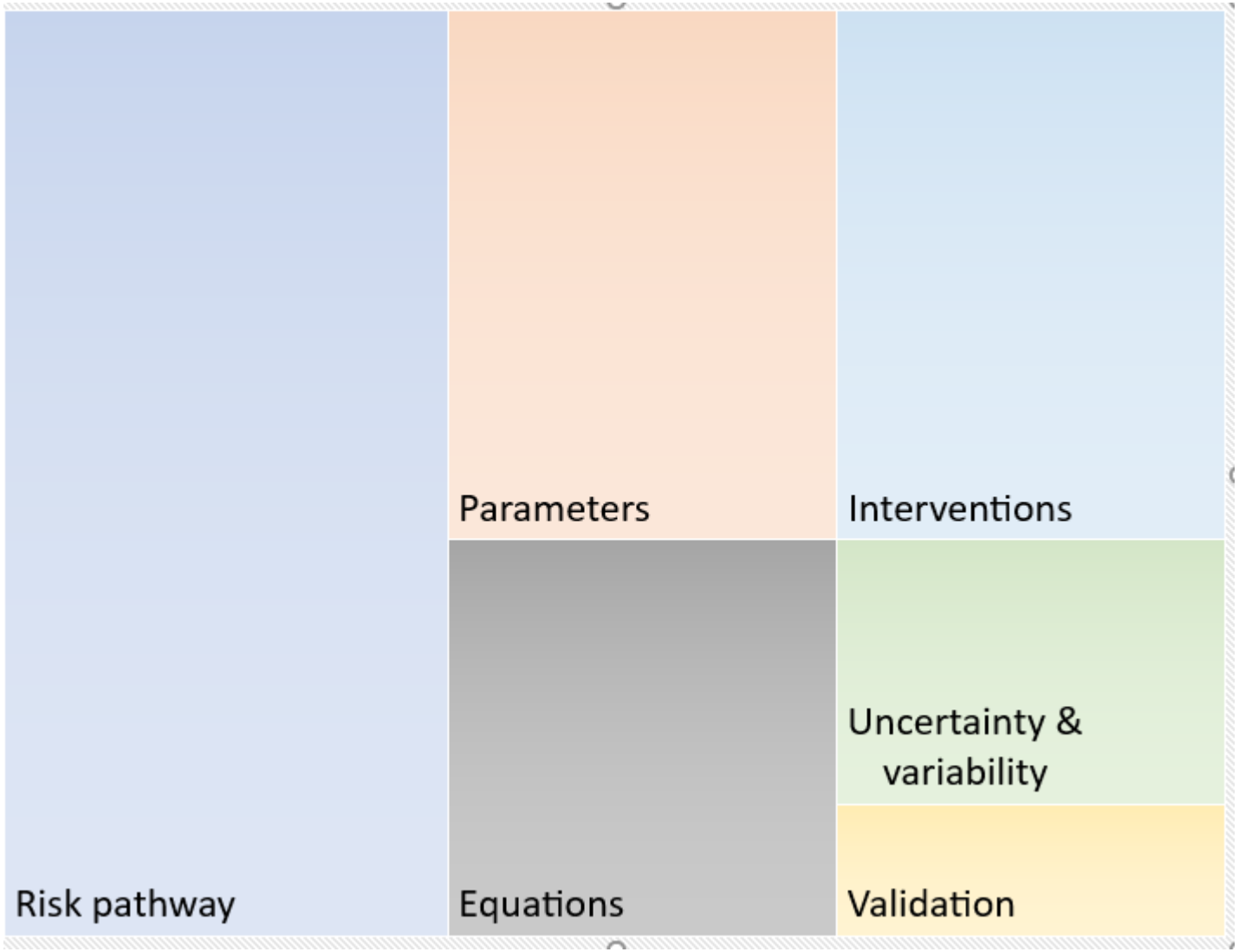
Tip 2: EQUATIONS are merely shorthand

What is the annual reduction in human salmonellosis cases in Europe if pigs were washed prior to slaughter?



Not as awful as they sound

I'm not a mathematician (honestly!)

Don't freak out!

……..It's really just short-hand

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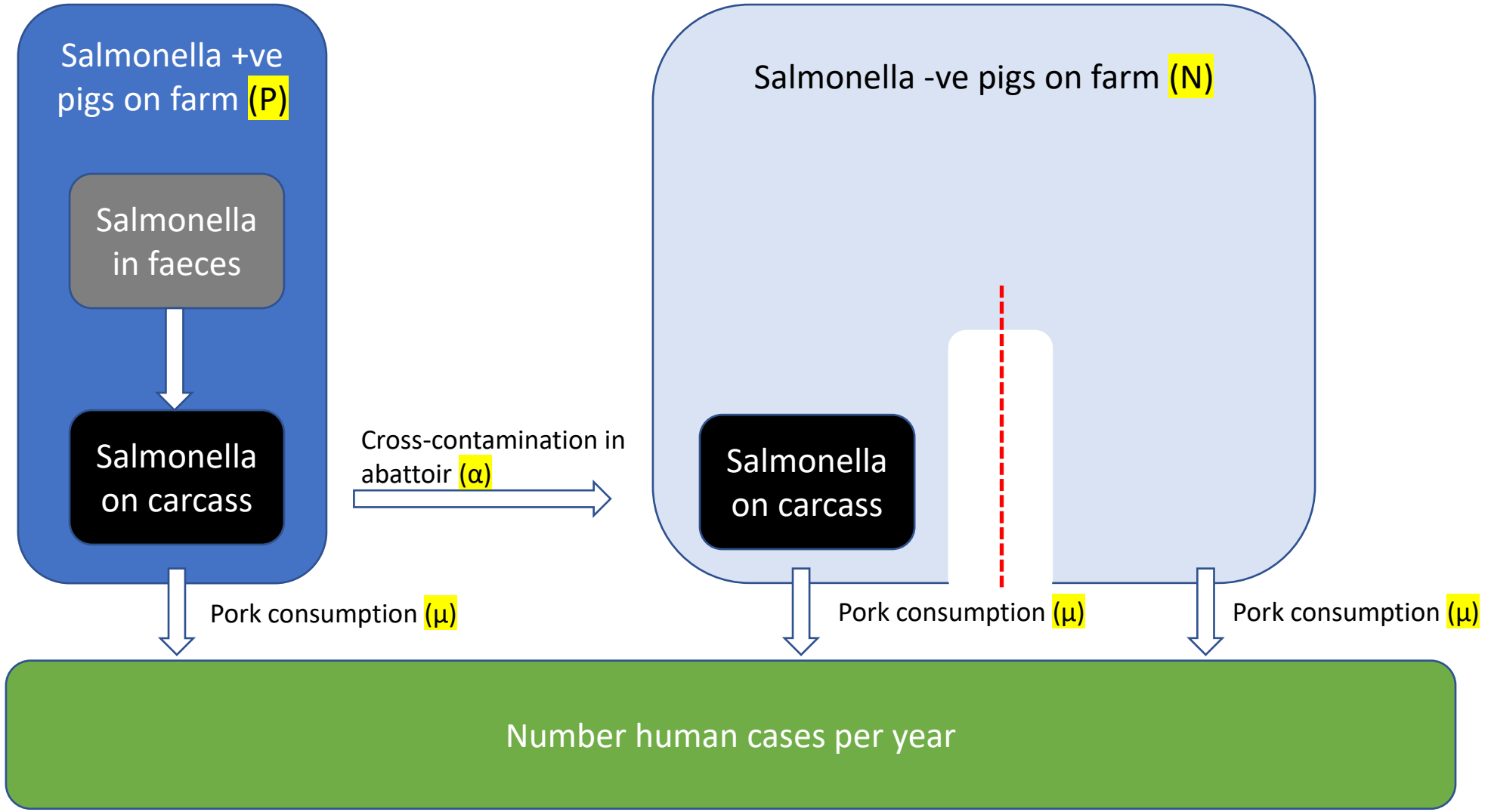

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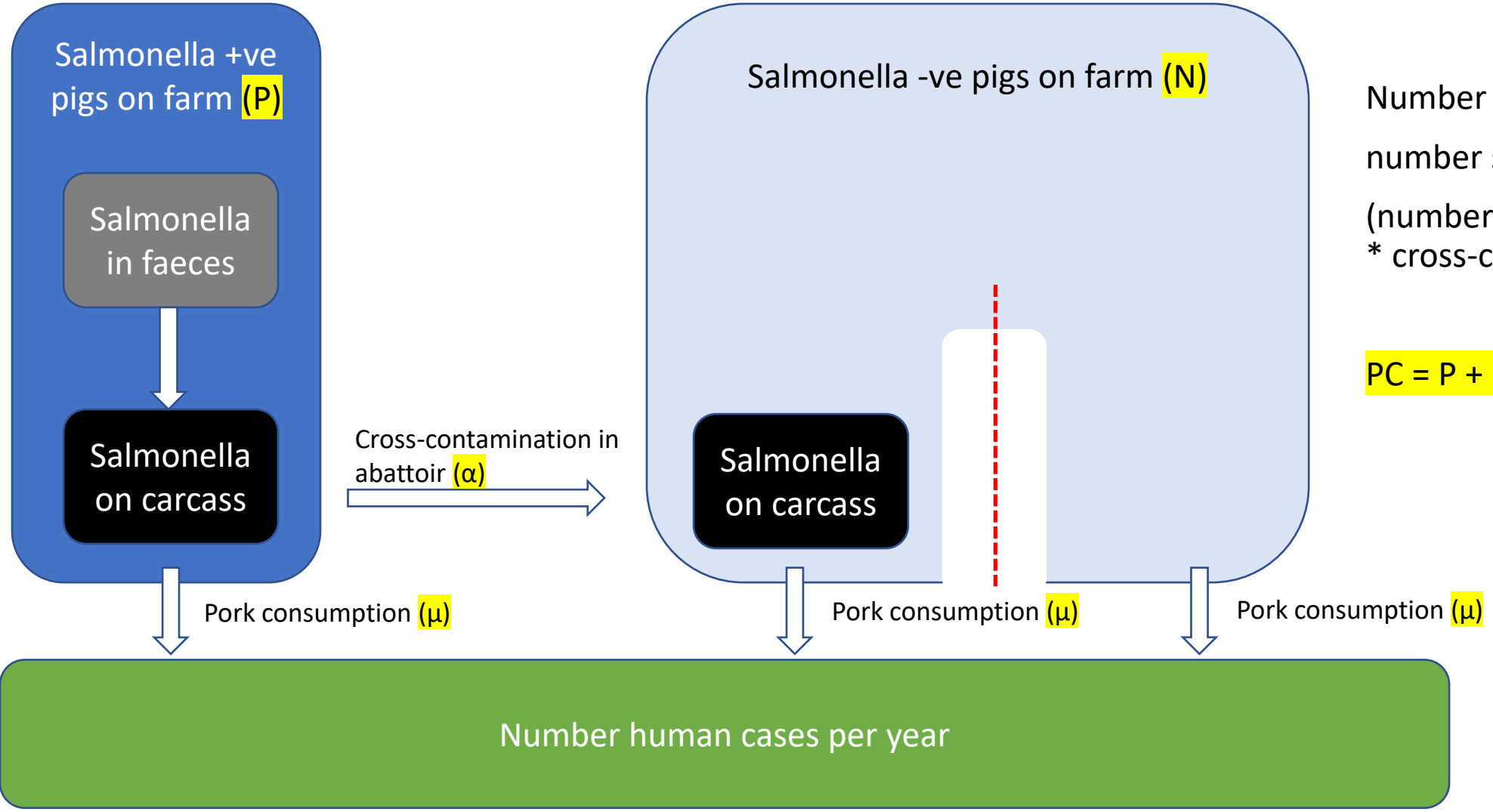

Number salmonella +ve carcasses =

number salmonella +ve pigs on farm +

(number salmonella –ve pigs on farm * cross-contamination factor)

$PC = P + \alpha N$

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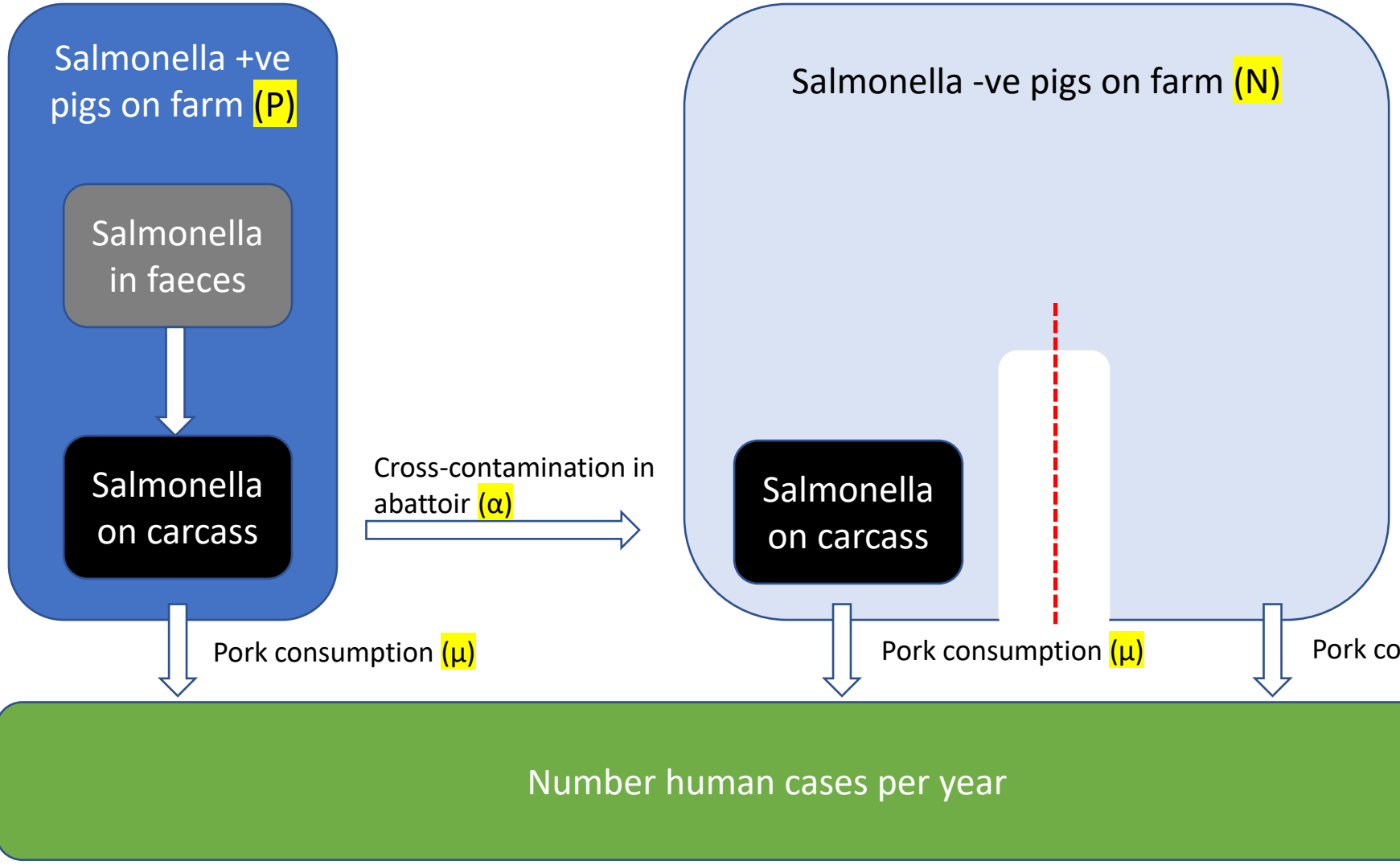

Number human cases per year =

number salmonella +ve carcasses *

pork consumption per year per adult in each country

SC = μPC

ASSUMING that the infectious dose for Salmonella is 1 (no dose response)

Tip 2: EQUATIONS are merely shorthand

What is the annual reduction in human salmonellosis cases in Europe if pigs were washed prior to slaughter?

Description	Variable	Units
Number Salmonella +ve pigs on farm	P	% pigs
Number Salmonella -ve pigs on farm	N	% pigs
Probability of cross-contamination in abattoir	α	rate
Pork consumption	μ	g/person/year

Number positive carcasses: $PC = P + \alpha N$
Number human cases: $SC = \mu PC$

ASSUMPTION: infectious dose for Salmonella is 1

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Number human cases: $SC = \mu PC$

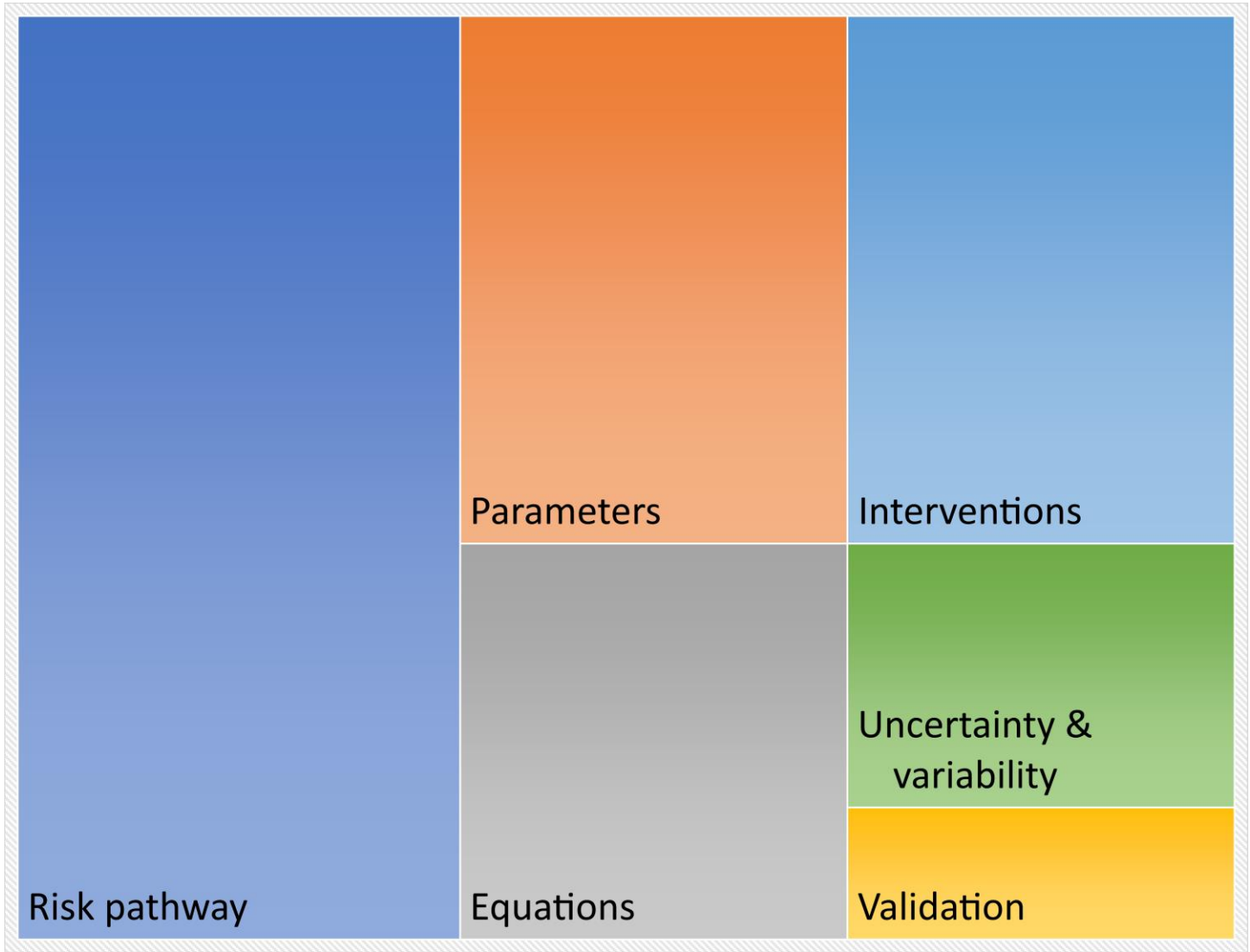
ASSUMPTION: infectious dose for Salmonella is 1

INTERVENTION:
Often literature search / expert opinion / bespoke study

e.g. “carcass washing reduces cross-contamination by between 5 and 20%. This effect is greatest in multi-species abattoirs, abattoirs with multiple staff and abattoirs slaughtering more than 100 pigs per day”

OUTPUT:

Carcass washing reduces the number of human salmonellosis cases in Europe by 40% (95% confidence interval 20-80%)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Tip 3: Look for any UNCERTAINTY & VARIABILITY

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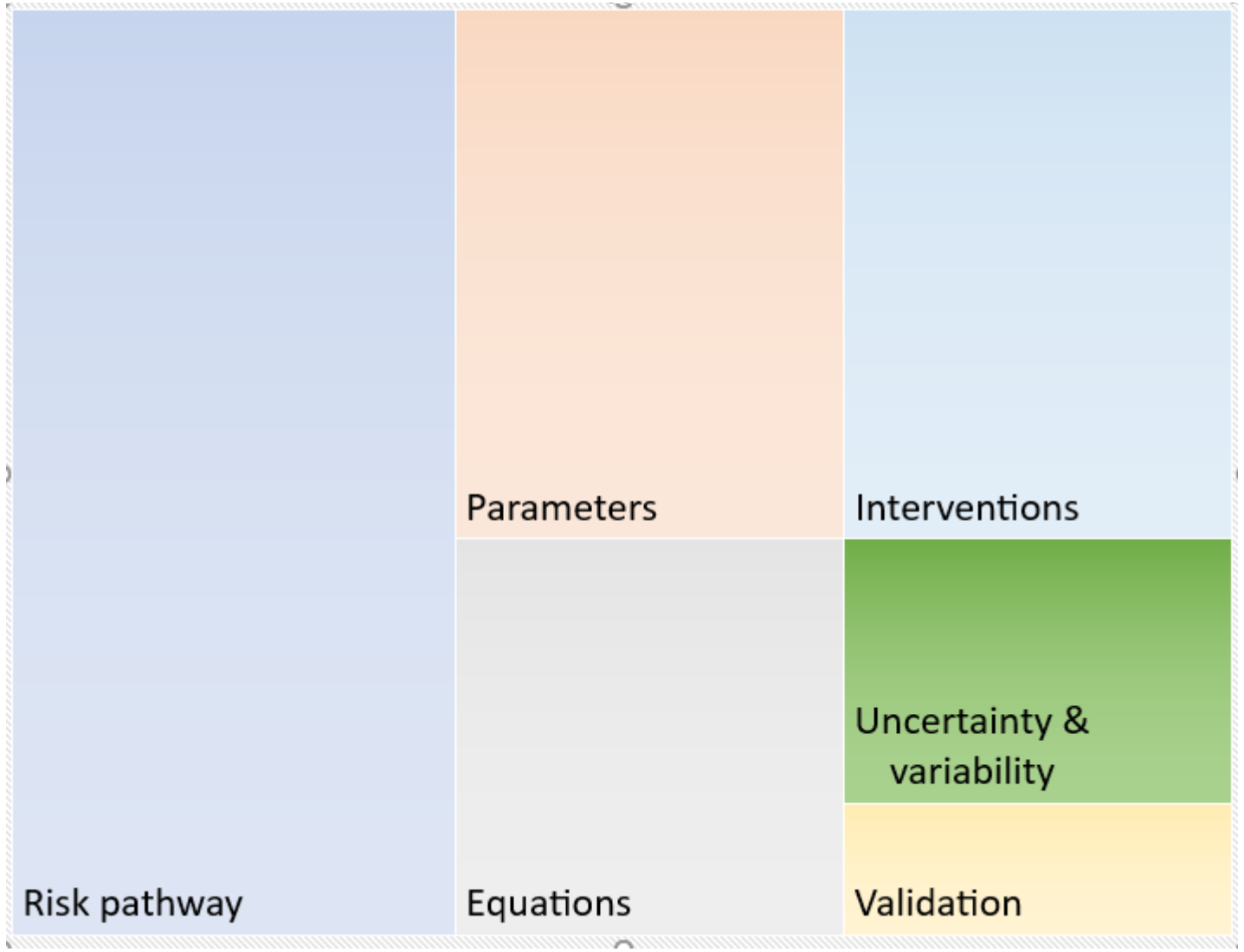

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VARIABILITY

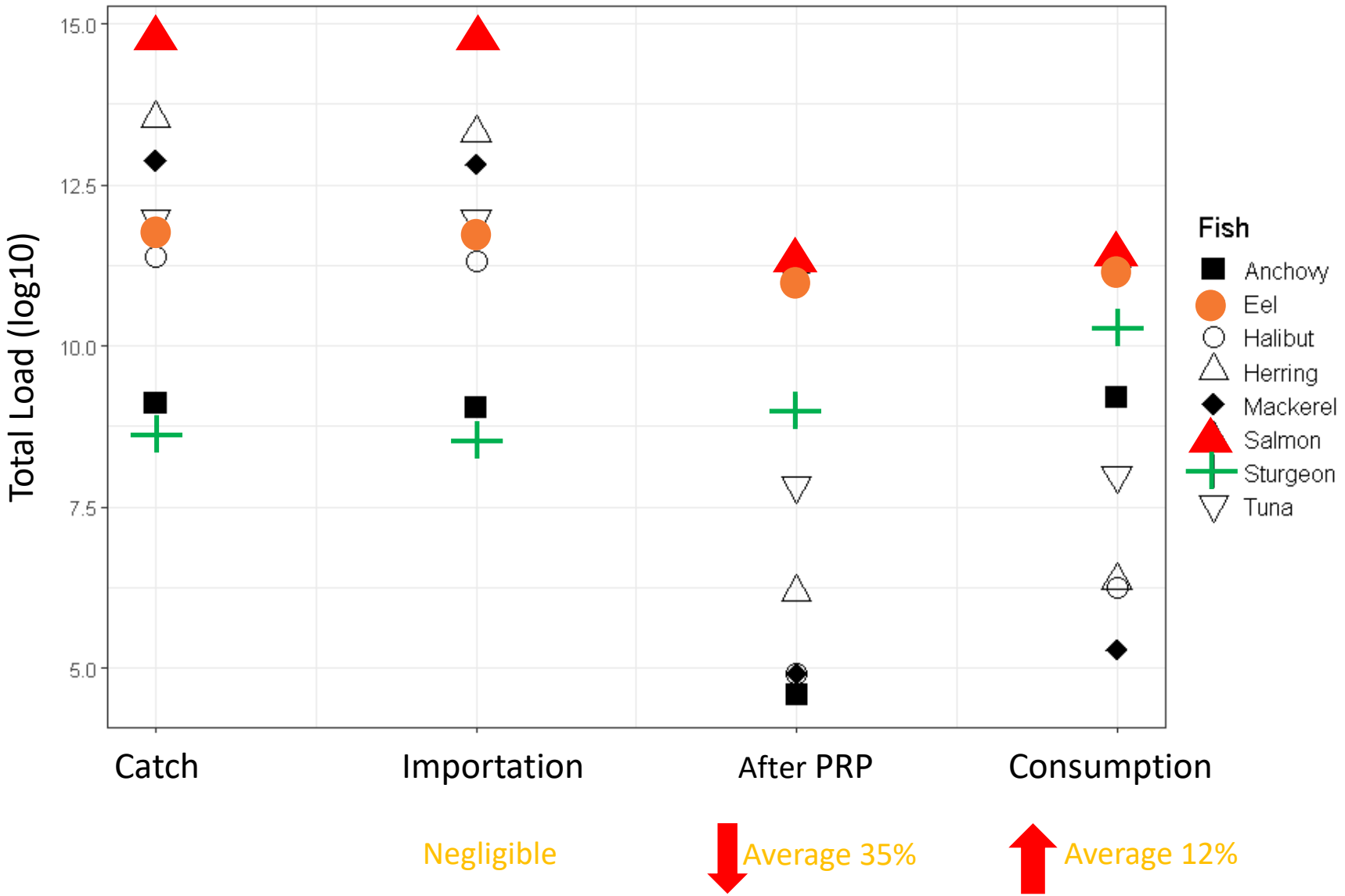
- Effect of natural (often biological) **variations**
- **E.g.**, the probability of cross-contamination (α), may vary between 1 in every 3 carcasses in **some** abattoirs, and 1 in every 20 carcasses in **other** abattoirs.
- **Solution**: run the model lots of times with different rates to work out an average value across all abattoirs

UNCERTAINTY

- Effect of **lack of confidence** in data
- E.g. some studies say cross-contamination could be 1 in every 3 but other studies say **those data aren't accurate**
- **Solution**: sensitivity analysis. Change the variable and see whether the model outputs follow the same **trend** (e.g. is carcass washing still "protective" or is there now no effect?)
- Useful for guiding future observation studies

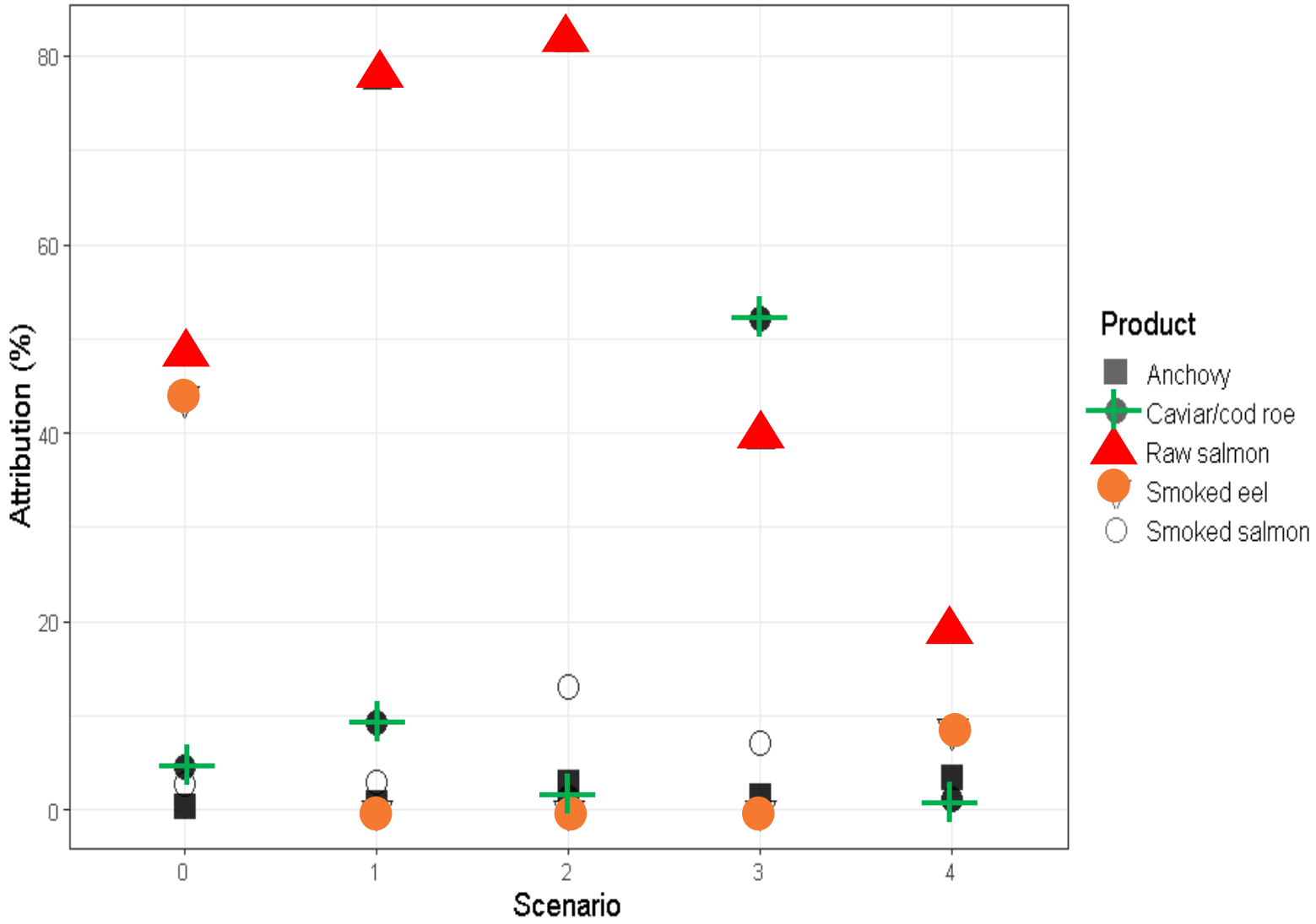
COMPARATIVE EXPOSURE ASSESSMENT OF ESBL-PRODUCING *ESCHERICHIA COLI* THROUGH SEAFOOD CONSUMPTION

C.A. M[C]CARTHY*, J.E. CHARDON AND C.J. DE VOS



Uncertainty analysis

1) Temperature at point catch 5C cooler
2) Processing 10-fold less efficient
3) Processing 10-fold more efficient
4) Max storage times 5*mean



In summary

- Risk assessments are useful (vital) tools in formulating evidence based decisions
- Quantitative, microbial risk assessments provide statistical outputs to complex biological, multi-faceted systems
- Concentrate on the risk pathway. This will tell you whether the risk assessment is truly answering the question you want answered!
- Equations are purely short-hand. Try writing them out in words if they seem daunting!

Further Reading

- Scientific Opinion on a Quantitative Microbiological Risk Assessment of Salmonella in slaughter and breeder pigs (wiley.com)
- The risk of introducing SARS-CoV-2 to the UK via international travel in August 2020 | medRxiv
- Estimating the likelihood of ESBL-producing E. coli carriage in slaughter-aged pigs following bacterial introduction onto a farm: A multiscale risk assessment – ScienceDirect
- Integration of computational tools, data analysis and social science into food safety risk assessment - - 2020 - EFSA Journal - Wiley Online Library
- Livestock Health and Food Chain Risk Assessment - - 2020 - EFSA Journal - Wiley Online Library
- Comparative Exposure Assessment of ESBL-Producing E. coli through seafood consumption – SVEPM Proceedings