# Use of DALYs in Risk Benefit Assessment modeling to evaluate edible insects as red meat replacers

(the NovRBA Project)

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# The NovRBA Project

**Nov**el Foods as Red Meat Replacers: an insight using **R**isk-**B**enefit **A**ssessment Methods

- Aim: To estimate the overall health impact of **replacing red meat** with a **novel food (case study: insects)** via Risk-Benefit Assessment (RBA)
- Selected food item to be replaced: beef patties
- Selected insect species: *A. domesticus* (house cricket), in the form of powder

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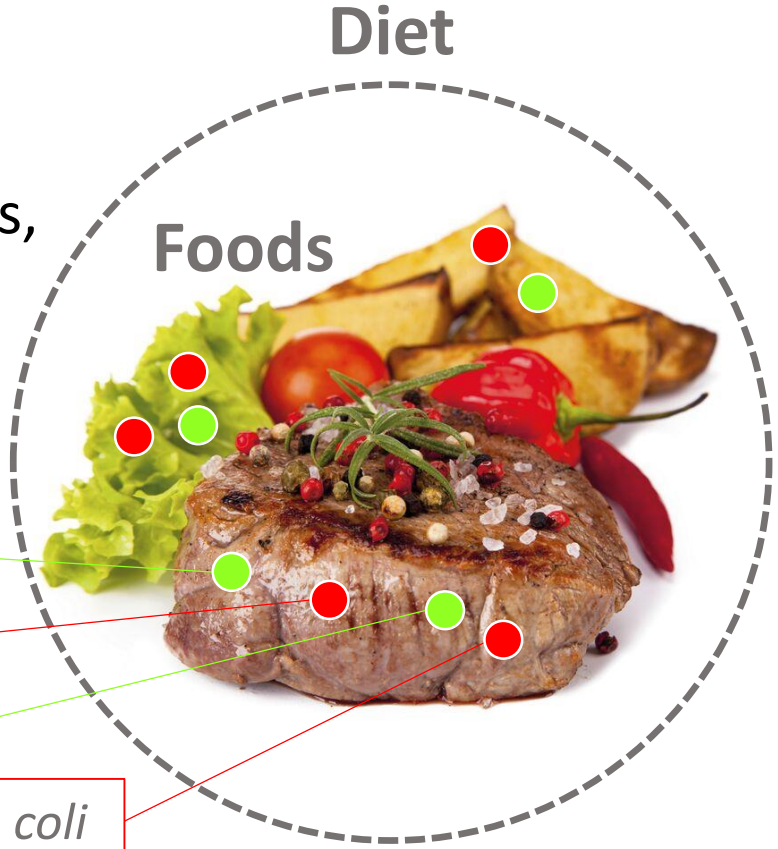
# Risk-Benefit Assessment

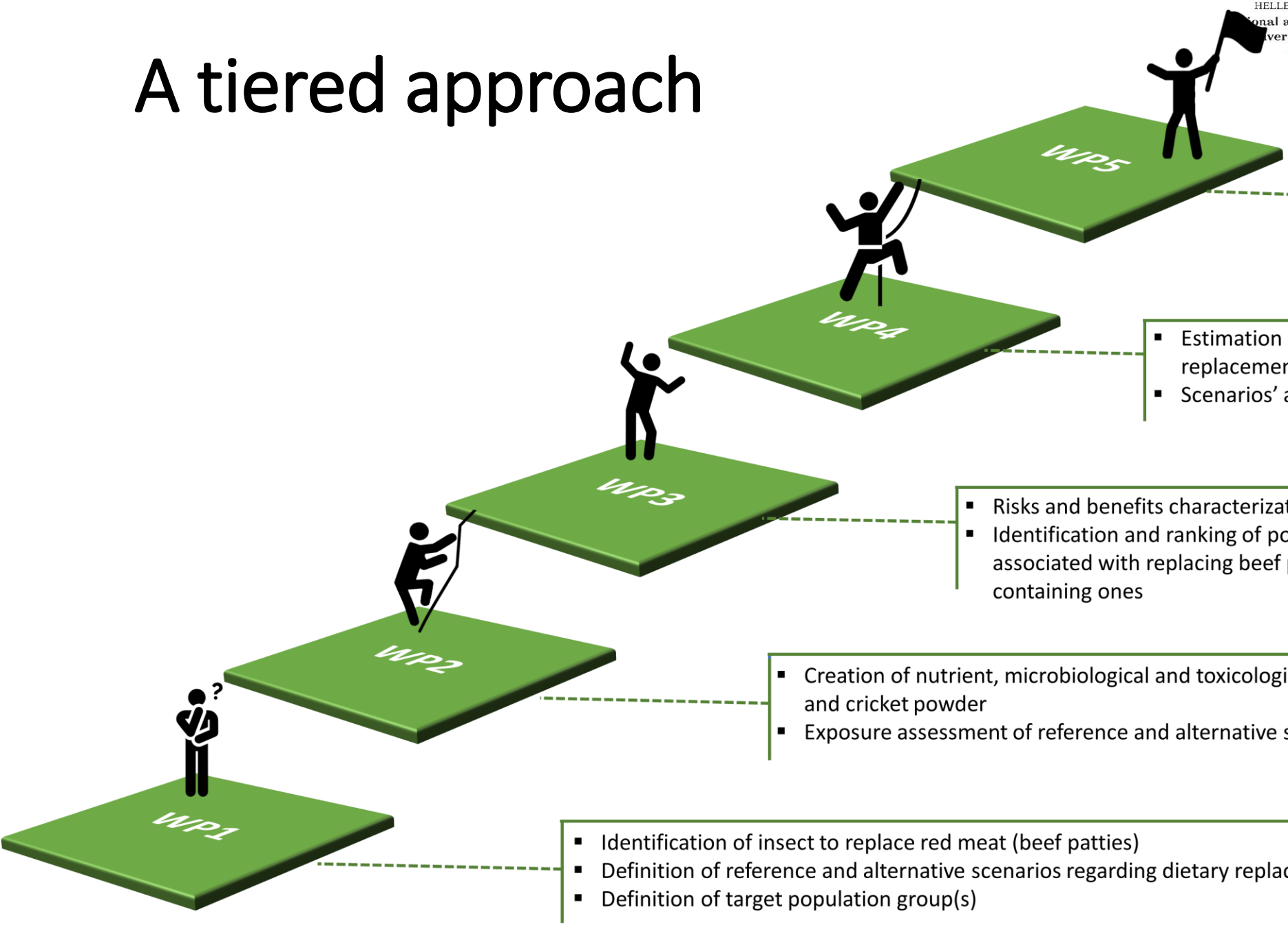
- decision-support tool, new for the area of food & nutrition
- characterisation of human health risks & benefits…

  …linked to specific foods/ food components/diets
- Multidisciplinary approach that combines:

  **a)** nutritional, **b)** microbiological & **c)** toxicological aspects, under a single methodological framework
- prediction of overall health impact



# A tiered approach




- Design of communication strategy
- Dissemination of results

- Estimation of the overall health impact of red meat replacement by insects
- Scenarios' analysis and comparison

- Risks and benefits characterization
- Identification and ranking of potential health outcomes associated with replacing beef patties with cricket-powder-containing ones

- Creation of nutrient, microbiological and toxicological profiles of minced beef and cricket powder
- Exposure assessment of reference and alternative scenarios

- Identification of insect to replace red meat (beef patties)
- Definition of reference and alternative scenarios regarding dietary replacement
- Definition of target population group(s)

# Identification & Quantification of associated health outcomes

- EFSA DRV scientific opinions
- Literature review (**systematic reviews, dose-response meta-analyses**)
- Focus on **hard endpoints** – intermediate factors excluded
- **Risk of bias** assessment
- Priority to epidemiological studies
- **Quantification** of burden of disease through **DALYs**
- Estimate of DALYs & incident rates from **Global Burden of Disease (GBD)** database
- **Country-specific DALYs**, when available
- Data on countries' adult populations from **WHO European Health for All** database

# Risk & Benefit characterisation

## Nutrients & compounds of toxicological concern

$$\beta = \ln RR_{literature} / Dose$$

$$RR(i) = \exp(\beta \times exposure(i))$$

β: linear slope; $RR_{literature}$: relative risk for the specific dose; RR(i): relative risk for scenario; exposure(i): exposure for scenario

$$PIF = (RRalt - RRref) / RRref$$

$$Ncase(j) = PIF(j) \times Incidence(j) \times Frequency_{beef}$$

PIF: potential impact fraction; Ncase: number of cases; frequency: of patty consumption

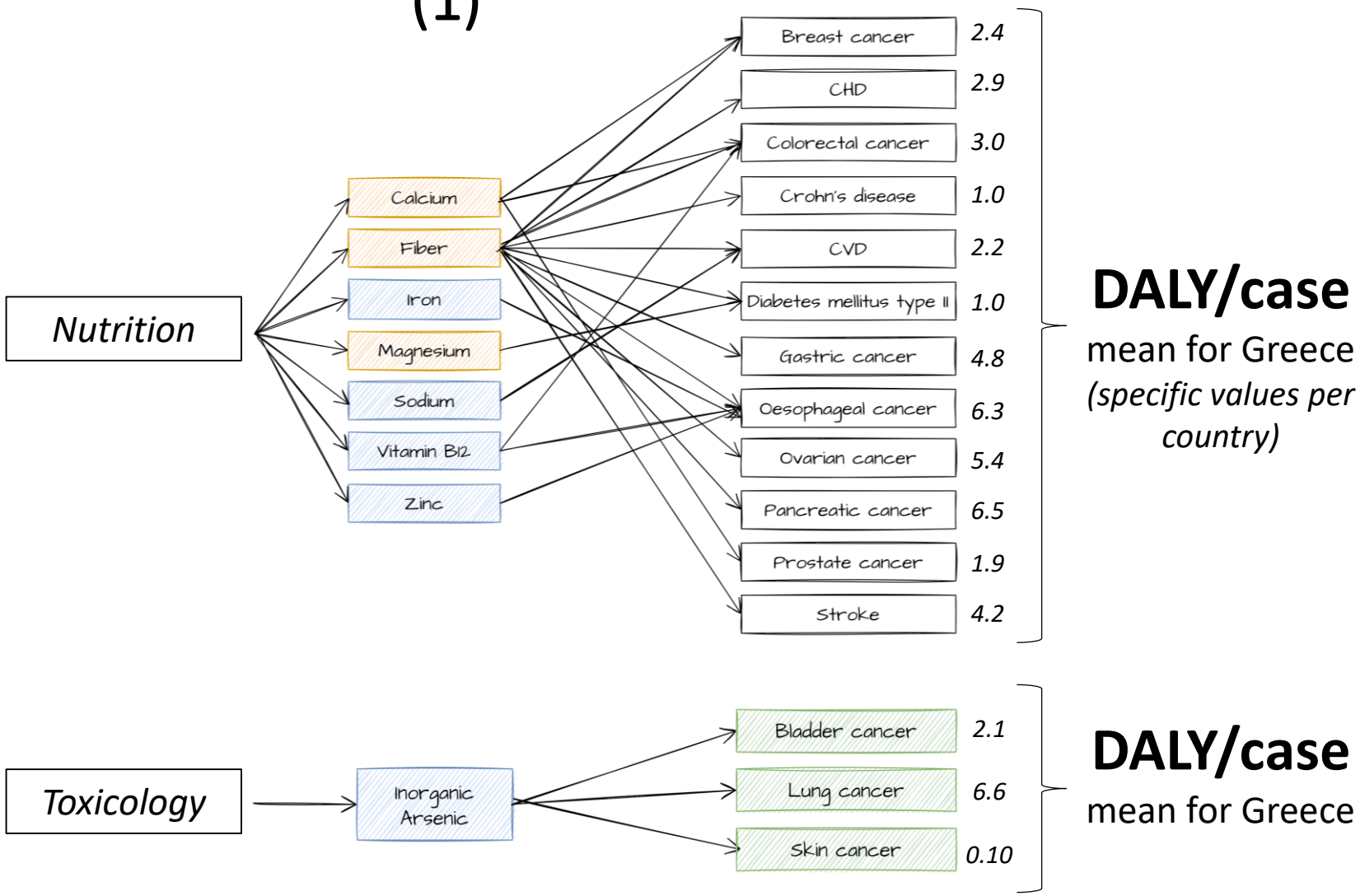
## Microbiological hazards

- Beef: **Top to bottom approach,** considering current disease incidence and source attribution estimates and ratio of beef consumed as patty
- proportion of **foodborne disease attributable** to beef: from WHO GBD Study estimates

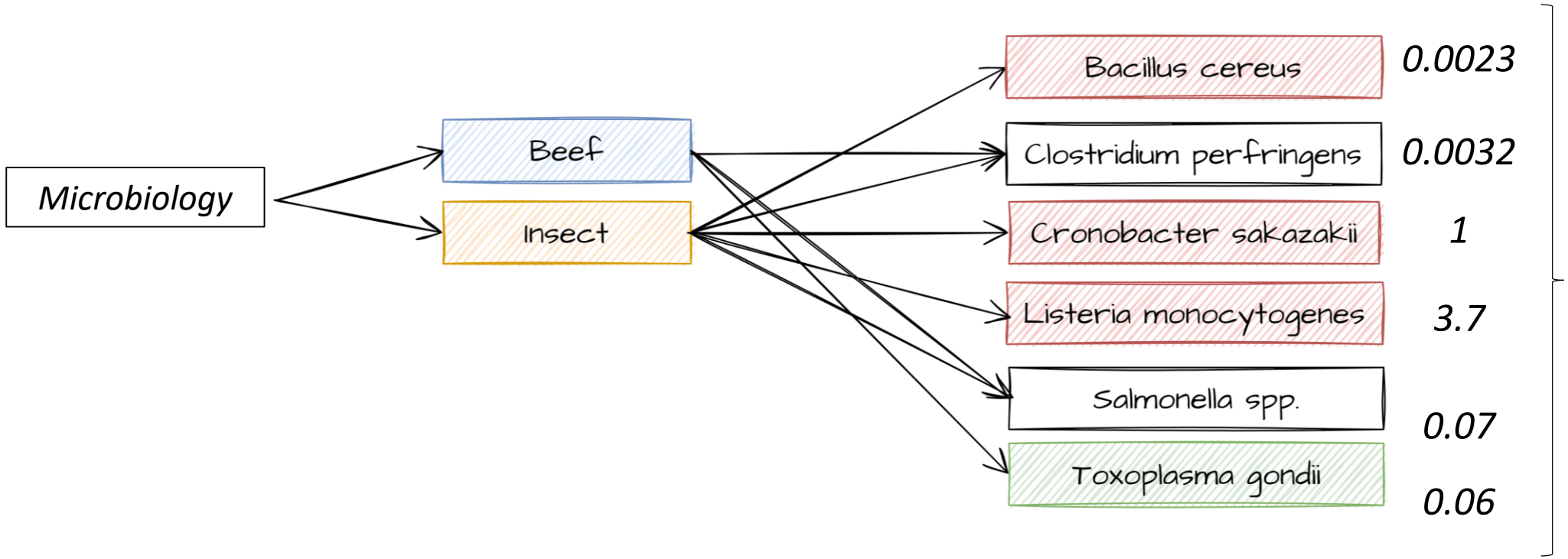
$$\text{Number of cases (i)} = \text{Incidence(i)} \times \text{Attribution\_proportion (beef)} \times Ratio_{patty/beef}$$

- Cricket powder: **Bottom-up approach** (for insects) using inactivation models for vegetative bacteria; estimating prevalence and levels when contaminated with spore-forming bacteria.

# Results (1)


Nutrition
Calcium
Fiber
Iron
Magnesium
Sodium
Vitamin B12
Zinc
Breast cancer
CHD
Colorectal cancer
Crohn's disease
CVD
Diabetes mellitus type II
Gastric cancer
Oesophageal cancer
Ovarian cancer
Pancreatic cancer
Prostate cancer
Stroke
2.4
2.9
3.0
1.0
2.2
1.0
4.8
6.3
5.4
6.5
1.9
4.2
DALY/case
mean for Greece
(specific values per country)
Toxicology
Inorganic Arsenic
Bladder cancer
Lung cancer
Skin cancer
2.1
6.6
0.10
DALY/case
mean for Greece
Decrease: Ref->Alt
Increase: Ref->Alt

# Results (2)




Decrease: Ref->Alt

Increase: Ref->Alt

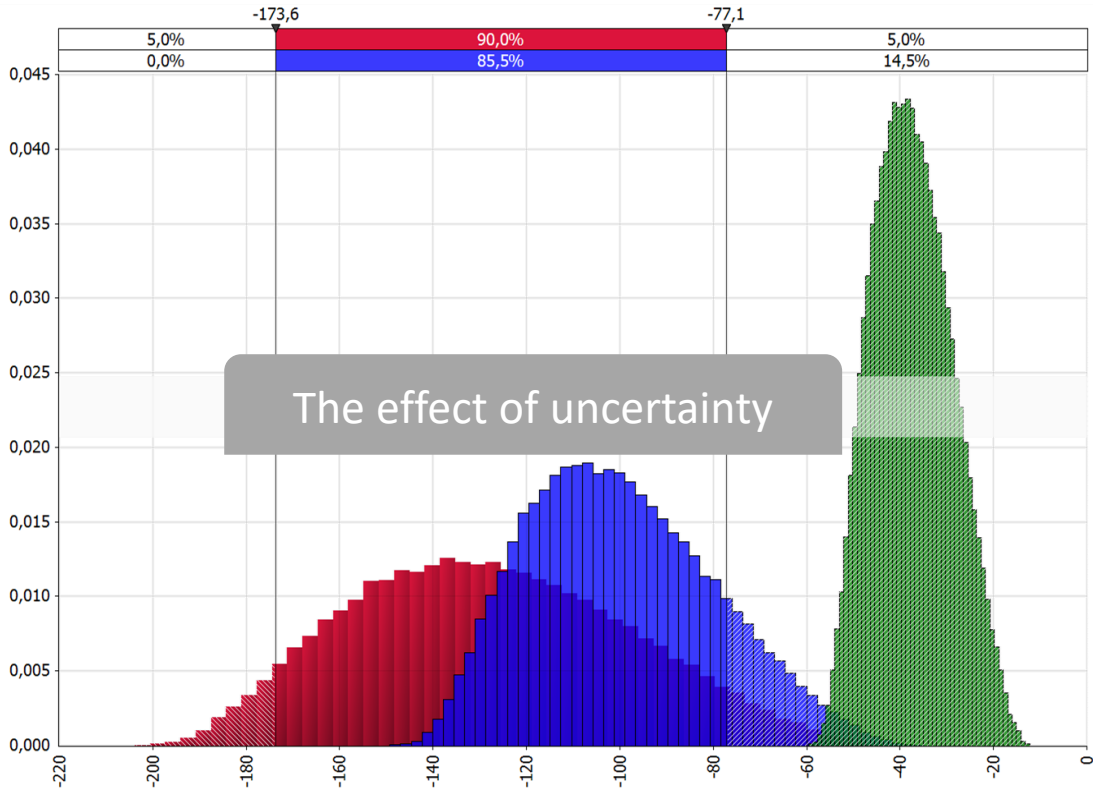
# Results (3)

Total DALYs saved (-) or lost (+) when moving from Reference to Alternative scenario

| | Greece | Denmark | France |
|---|---|---|---|
| **Nutrition** | **-5.206** | **-2.360** | **-17.400** |
| Calcium | **0.06%** | **0.39%** | **0.36%** |
| Fiber | **15%** | **18%** | **15%** |
| Iron | **0.08%** | **0.19%** | **0.16%** |
| Magnesium | **0.50%** | **0.24%** | **0.70%** |
| Sodium | **84%** | **80%** | **82%** |
| Vit B12 | **0.71%** | **1.69%** | **1.28%** |
| Zinc | **0.03%** | **0.17%** | **0.16%** |
| **Toxicology** | **-0.1** | **-0.1** | **-0.7** |
| In Arsenic | **100%** | **100%** | **100%** |

| | | Greece | Denmark | France |
|---|---|---|---|---|
| | **Microbiology** | **-3494.29** | **-6316.91** | **-6446.53** |
| Beef | *Clostridium perfringens* | **10%** | **6%** | **6%** |
| | *Salmonella spp* | 0.0000002% | 0.0000003% | 0.0000002% |
| | *Toxoplasma gondii* | 0.4% | 0.3% | 0.3% |
| Cricket powder | *Bacillus cereus* | **88%** | **92%** | **92%** |
| | *Clostridium perfringens* | 2% | 1% | 1% |
| | *Cronobacter sakazakii* | 0% | 0% | 0% |
| | *Listeria monocytogenes* | 0% | 0% | 0% |
| | *Salmonella spp* | 0% | 0% | 0% |

# Results (4)




| | Sum of ΔDALY | Nutrition | Toxicology | Microbiology |
|---|---|---|---|---|
| **Greece** | -8.753 (-14.848 ; -4.595) | -5.206 | -0.1 | -3.52 |
| **Denmark** | -6.572 (-13.444 ; -2.737) | -2.36 | -0.11 | -4.225 |
| **France** | -21.972 (-34.400 ; -12.613) | -17.4 | -0.69 | -4.305 |

**Total DALY saved per year per 100 000 people**

**Greece in red**, **France in green** and **Denmark in blue**

# Conclusion

- Overall health impact of the substitution **is positive**
- High contribution of **nutritional impact**
- Overall, microbiological impact is beneficial, but risks associated with cricket powder must be refined (data on occurrence and concentration)
- Conclusions must be read **considering model limitations:** significant components and health outcomes that were not quantified in this RBA

| | |
|---|---|
| **Components** (lack of dose-response data) | Copper, Phosphorus, *Clostridium botulinum* |
| **Health outcomes** (not considered because of lack of information on DALYs) | Colorectal adenoma (calcium, fiber)<br>Diverticular disease (fiber)<br>Gestational diabetes mellitus (iron)<br>Metabolic syndrome (calcium, magnesium) |

- Differences in the reference populations
  (WHO database: +15 years; GBD Database: +20 years)

**Compositional profile of house cricket**

**The NovRBA Project Report**

**Communicating RBA**

# Thank you for your attention!

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