Public health-based risk ranking of (microbial) hazards in the food chain

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Risk ranking

● Why?
  - Limited resources
  - 24/7 news cycle ↔ science based decision making

● Consequences
  - Helps define focus for risk management
  - Does not directly determine actions
    » Options, costs, stakeholder views

● Limitations
  - Different definitions of risk

● Multi-dimensional problem

● Technical information ánd value judgements
  - Interaction between researchers and policy makers c.q. general population
Definitions of risk

- Public health metrics

- Values
  - Voluntary
  - Equity
  - Dread
  - Control
  - Uncertainty
  - Immediacy
  - Novelty
Value-based risk ranking

Slovic, Science 1987;236:280-285
EFSA BIOHAZ Risk Ranking Framework

1. Definition of what to be ranked
2. Selection of risk metrics
3. Risk ranking approach
4. Choice of the model type
5. Model variables - INPUT
6. Collection and evaluation of data for model variables
7. Restructure of model based on data availability
8. Data integration - OUTPUT
9. Presentation of the results

Communication between RA and RM
What to be ranked?

- Single hazard in multiple foods
  - Incidence
- Multiple hazards in single food
  - Severity
- Multiple hazards in multiple foods
  - Incidence and severity
Risk metrics

- Public health
  - Illness
    - General population, consulting patients, hospitalisations
  - Deaths
    - Catastrophic (identifiable) vs. chronic (statistical)
  - Years of life lost
  - Summary metrics of public health (DALY, QALY)

- Economic
  - Cost of illness
  - Willingness to pay (accept)
    - Revealed or stated preferences

- Incorporation of value judgements inevitable!
Risk ranking approaches

Bottom-up approach (forward)

Raw material ➔ Processing ➔ Distribution and storage ➔ Consumption ➔ Disease outbreaks

RISK

Top-down approach (backward)
Modelling approaches

- Opinion based
- Qualitative
  - Decision tree
  - Matrix
- Semi-quantitative
  - Multi Criteria Decision Analysis
- Quantitative
  - Comparative risk assessment
  - Disease burden
  - Attribution

- One time or continuous?
- Resources, data, timelines
- Simplicity vs. Precision
- Reproducibility
- Resolution
- Transparency
- Separate science and values
- Information management
- End user(s)
Decision tree for ranking hazards in poultry

FOOD BORNE HAZARD IDENTIFIED

HAZARD: RISK RELATED TO GROWTH OR INTRODUCTION POST-CARCASS CHILL

NO YES

HIGH HUMAN INCIDENCE?

NO YES

ATTRIBUTION TO POULTRY HIGH?

NO YES

PREVALENCE IN CARCASSES HIGH?

NO YES

HIGH

MEDIUM

LOW

DUCK MOUTH MIDDLE

PREVALENCE IN CARCASSES HIGH?

NO YES

CONSIDER IF IMPROVED CHANGES WILL MATERIALLY AFFECT THE RISK RATING OF THE RISK

NOT CONSIDERED FURTHER

INCLUDE

CONTROL OPTIONS LATER IN THE CHAIN

SEVERITY HIGH?

NO

ATTRIBUTION TO POULTRY HIGH?

NO YES

PREVALENCE IN CARCASSES HIGH?

NO YES

HIGH

MEDIUM

LOW

DUE TO CURRENT CONTROLS?

NO YES

BIOHAZ Panel, EFSA Journal 2012;10(6):2741
Qualitative risk ranking

- Rules of probability should be respected in qualitative matrices
- Some quantification of probabilities underlying risk qualifiers is necessary
- Marginal qualifiers should be different from those for the joint probabilities

How to define these terms?

Is Minor x Very Unlikely really equal to Low??

Risk matrix proposed by ANSES

<table>
<thead>
<tr>
<th>Probabilité d'émission / Release probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>N / N</td>
</tr>
<tr>
<td>QN / NN</td>
</tr>
<tr>
<td>M / M</td>
</tr>
<tr>
<td>EF / EL</td>
</tr>
<tr>
<td>TF / VL</td>
</tr>
<tr>
<td>F / L</td>
</tr>
<tr>
<td>PE / NVH</td>
</tr>
<tr>
<td>AE / QH</td>
</tr>
<tr>
<td>E / H</td>
</tr>
<tr>
<td>TF / VH</td>
</tr>
</tbody>
</table>

ANSES: A qualitative risk assessment method in animal health, November 2008
### Semi-quantitative risk ranking - Discontools

#### Prioritisation model

<table>
<thead>
<tr>
<th>Disease Spectrum</th>
<th>Composite</th>
<th>Cysticerosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>Ca/off</td>
<td>Total</td>
</tr>
<tr>
<td>CREASE ON INFECT 13 species</td>
<td>47.01</td>
<td>77.50</td>
</tr>
<tr>
<td>Speed of spread</td>
<td>5</td>
<td>2.50</td>
</tr>
<tr>
<td>Number of livestock species involved</td>
<td>5</td>
<td>2.50</td>
</tr>
<tr>
<td>Persistence of the infectious agent in the environment</td>
<td>5</td>
<td>2.50</td>
</tr>
<tr>
<td>Risk of spread to susceptible populations</td>
<td>5</td>
<td>2.50</td>
</tr>
<tr>
<td>Potentials for direct spread</td>
<td>4</td>
<td>2.00</td>
</tr>
<tr>
<td>Vector reservoir and potential spread</td>
<td>4</td>
<td>2.00</td>
</tr>
<tr>
<td>Variability of the agent</td>
<td>4</td>
<td>2.00</td>
</tr>
<tr>
<td>Understanding of fundamental immunology</td>
<td>4</td>
<td>2.00</td>
</tr>
<tr>
<td>Host-pathogen interaction</td>
<td>4</td>
<td>2.00</td>
</tr>
<tr>
<td>IMPACT ON ANIMAL HEALTH AND WELFARE - 3 (MRT)</td>
<td>43.10</td>
<td>0.00</td>
</tr>
<tr>
<td>Disease impact on production</td>
<td>1</td>
<td>0.50</td>
</tr>
<tr>
<td>Occurrence of animal welfare impact</td>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td>Proportion of animal affected suffering positive impact/ disease as a result of the disease</td>
<td>3</td>
<td>1.50</td>
</tr>
<tr>
<td>IMPACT ON ANIMAL HEALTH - HUMAN HEALTH - 6 (MRT)</td>
<td>46.10</td>
<td>66.50</td>
</tr>
<tr>
<td>Impact on occurrence of zoonoses</td>
<td>4</td>
<td>2.00</td>
</tr>
<tr>
<td>Likelihood of occurrence</td>
<td>4</td>
<td>2.00</td>
</tr>
<tr>
<td>Impact on occurrence of zoonoses</td>
<td>4</td>
<td>2.00</td>
</tr>
<tr>
<td>Transmissibility (spread from animal to human)</td>
<td>3</td>
<td>1.50</td>
</tr>
<tr>
<td>Spread in humans</td>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td>Economic potential</td>
<td>1</td>
<td>0.50</td>
</tr>
<tr>
<td>IMPACT ON WIDER SOCIETY - 3 (MRT)</td>
<td>43.10</td>
<td>16.66</td>
</tr>
<tr>
<td>Economic direct impact (including cumulative costs e.g. Economic vs Epizoonosis)</td>
<td>1</td>
<td>0.33</td>
</tr>
</tbody>
</table>

www.discontools.eu
Criteria for ranking of emerging zoonoses

1. Introduction
2. Transmission between animals
3. Economic damage in animal reservoir
4. Animal-human transmission
5. Transmission between humans
6. Public health impact
7. Morbidity
8. Mortality

Havelaar et al., PLoS One 2010:e13965
Ranking of emerging zoonoses in NL

![Graph showing normalized scores for various zoonoses in NL]

Havelaar et al., PLoS One 2010:e13965
Risk ranking: comparative risk assessment

sQMRA tool
iRISK: an interactive, web-based system for risk ranking

Burden of disease

- Outcome tree

\[ \text{DALY} = \text{YLL} + \text{YLD} \]

\[ YLL = \sum_{l} d_{l} \times e_{l} \]

\[ YLD = \sum_{l} n_{l} \times t_{l} \times w_{l} \]
Disease burden of enteric pathogens in NL (all sources)

- T. gondii has the highest burden
- Burden of Campylobacter similar
- Low burden for protozoa, STEC O157 and B. cereus toxin

Havelaar et al., Int J Food Microbiol 2012; 156:231-238
Disease burden per case

- Diseases affecting unborn or young children have the highest burden
- Systemic infections also have a high burden
- Lowest burden for protozoa

Havelaar et al., Int J Food Microbiol 2012; 156:231-238
Ranking of pathogens by population and individual burden

Havelaar et al., Int J Food Microbiol 2012; 156:231-238
Attribution of disease burden to major pathways

Havelaar et al., Int J Food Microbiol 2012; 156:231-238
Attribution of disease burden to food groups

- Beef/mutton: 16%
- Pork: 23%
- Poultry: 17%
- Eggs: 4%
- Dairy: 7%
- Fish/shellfish: 6%
- Fruit/vegetables: 6%
- Cereal products: 3%
- Beverages: 2%
- Other food: 7%
- Human/animal: 9%
- Other food: 7%

Havelaar et al., Int J Food Microbiol 2012; 156:231-238
How to interpret results?

*Our food is safer than ever*

*The health loss due to unhealthy diet is many times greater than that attributable to unsafe food*

- Unfavourable dietary composition: 245,000 DALYs
- Overweight: 215,000 DALYs
- Microbiological infection by known pathogens: 1,000-4,000 DALYs
- Chemical constituents: 1,500-2,000 DALYs

⇒ No need for further action?

*Van Kreijl et al., 2006. RIVM report number 270555009*
Conclusions

- Comparing risks is not impossible or immoral, but it is very difficult; more so than either supporters or detractors of the practice seem to realize - Adam Finkel
- Risk ranking should take a structured approach
- Risk ranking approaches should be fit for purpose
  - Selection of risk metrics
  - Selection of risk ranking model
  - Resources and time vs. transparency and repeatability
- Whenever possible quantitative risk ranking approaches are preferable
- Good risk ranking models are simplified risk assessment models
- Interaction between risk managers and risk assessors is a critical success factor
- Risk ranking is only the beginning of a decision making process
Thanks to …

- EFSA BIOHAZ Panels, secretariat and WG on risk ranking, chair Kostas Kotsoumanis
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- Roger Cooke