Communicating Uncertainty between Risk Assessors and Risk Managers

Sandrine Blanchemanche
Research Context

• HolyRisk Project (2009-2013), France-USA
• Directors: S. Blanchemanche & A. Rona-Tas (UC, San Diego)
• Partners
  ▪ Jifsan/Cfsan: E. Calvey, J. Ruzante, S. Watters
  ▪ 3 Computer Sciences Teams
• US / EU Comparison
  ▪ What are the « practices » of sciences?
  ▪ What consequences Uncertainty and Precaution have on Risk Management Decision?
Outline

- Introduction
- Questions/Objectives
- Method
- Uncertainty explicitly expressed in risk assessment reports
- Communication of the language of science
- Conclusion
Introduction

- Scientific knowledge became one of the most important prerequisites for making regulatory decisions.
- As scientific knowledge is never complete, risk assessors are expected to present policy makers with not just what is known but also what is uncertain about a particular risk.
- For policy decisions the nature and level of the incompleteness of the evidence is of great importance and policy action will always be influenced not just by what seems firmly established but also by what is considered uncertain.
• FAO General Principle of food safety risk management: “Risk management decisions should take into account the uncertainty in the output of the risk assessment. The risk estimate should, wherever possible, include a numerical expression of uncertainty, and this must be conveyed to risk managers in a readily understandable form so that the full implications of the range of uncertainty can be included in decision-making.

For example, if the risk estimate is highly uncertain the risk management decision might be more conservative.”
Questions/objectives

• What uncertainties are expressed in risk assessments? How are they expressed?
  → Uncertainty explicitly expressed

• What kind of language is used in risk assessment
  → Language of science: Non formalized language used which may modify the understanding of the statement by the readers (Risk Managers)
Method

- Empirical analysis of Food Risk Assessments Reports in the US and Europe (BioHazards and Contaminants) and the follow up Risk Management
- Construction of a Typology of Uncertainty (28 variables) and a Typology of Judgment (5 variables)
- Double-coding of the documents through the typologies, storage in the HolyRisk Database
• The current presentation is based on:
  • The part « Summary » of the Risk Assessment Reports because they are considered as the fundamental text of the interaction between the assessors « the writers » and the managers « the readers »
  • 80 coded documents

<table>
<thead>
<tr>
<th></th>
<th>US</th>
<th>EU</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>BioHazard</td>
<td>7</td>
<td>29</td>
<td>36</td>
</tr>
<tr>
<td>Contaminant</td>
<td>7</td>
<td>37</td>
<td>44</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>66</td>
<td>80</td>
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Uncertainty explicitly expressed
Categorization of Uncertainty

- Literature
- FIRST CLASSIFICATION
- Coding of Risk Assessment
- FIRST ONTOLOGY
- Double-Coding, Refinement
- HIERARCHICAL ONTOLOGY
Uncertainty Ontology

Epistemic Uncertainty
- Missing factors/variables
  - Surrogate population
    - Inference from animal to human
    - Inference from general to sensitive population
  - Surrogate context
    - Inference from one scenario to another
    - Range inter- or extrapolation
    - Inference from in vitro to in vivo
  - Sampling
    - Inference in time
  - Surrogate hazard agent
    - Small sample size/few samples
    - Nonrandom/heterogenous/non-representative sample
  - Measure
  - Reporting
  - Comparability of data
- Ontic Uncertainty/Variability
- Model
  - Causal inference
    - Arbitrary assumptions of values used in the model
  - Measurement
    - Poor data quality/flawed measurement
    - Limits of analytic methods
  - Correlation
    - Combination effects
    - Correlated causal factors

Inference from one scenario to another
Inference from one scenario to another
Inference from one scenario to another
Inference from one scenario to another
Inference from one scenario to another
Inference from one scenario to another
US/EU differences in expressing uncertainty

Variables significantly different across countries are in red. In all cases the U.S. has the higher value.
Differences in expressing uncertainty between hazard categories

Variables significantly higher for contaminants are in red. Those significantly higher for biohazard are in blue.
Changes in expressing uncertainty over time (2000-2010)

Epistemic Uncertainty
- Data
  - Missing factors/variables
  - Surrogate data
    - Surrogate population
    - Surrogate context
      - Inference in time
        - Inference from animal to human
        - Inference from general to sensitive population
      - Inference from one scenario to another
      - Range inter- or extrapolation
      - Inference from in vitro to in vivo
  - Sampling
    - Surrogate hazard agent
      - Small sample size/few samples
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      - Inference from in vitro to in vivo

Variables significantly decreased between 2000 and 2010 are in blue.
Communication of the language of science
• Science has its own language, at the heart of the communication between risk assessors and managers

• We will look at more precisely

Confidence

Precaution

Uncertainty

Hedge
Hedge

• Hedges and the way in which they shape knowledge claims in science are well analyzed in Studies of Scientific Communication


• Definition: Expression of lack of complete commitment to the truth value of an accompanying proposition, regardless if the author is actually committed

  e.g. A possible expression of this finding may be that…


• … Linguistic element whose job is to make things fuzzier

  Lakoff, 1972
• Hedge is a conventional language – expected from the scientific community – used by scientists to anticipate audience reactions by moderating the degree of certainty with which they present their knowledge claims

Knorr-Cetina, 1981; Meyer, 1997

• But hedges may cause trouble for the understanding of the scientific statements
Hedge

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<tr>
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<tbody>
<tr>
<td>BioHazard</td>
<td>57 % (4/7)</td>
<td>68% (20/29)</td>
<td>66% (24/36)</td>
</tr>
<tr>
<td>Contaminants</td>
<td>86% (6/7)</td>
<td>59% (22/37)</td>
<td>64% (28/44)</td>
</tr>
<tr>
<td>Total</td>
<td>71% (10/14)</td>
<td>64% (42/66)</td>
<td>65% (52/80)</td>
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% of summaries that include at least one sentence with hedge

Hedges are very common in scientific statements both in the US and EU
Hedge in almost 2/3 of the summaries
Examples

• Given the very low prevalence and levels of E. Coli O157:H7 contamination (…), cross-contamination may not be a significant factor in the risk of illness from E. coli O157:H7 in non-intact beef (…)  
  E. Coli, USDA, 2002

• Compared to dietary exposure, non-dietary exposure to arsenic is likely to be of minor importance for the general population in the European Union (EU).

• The arsenic content in cooking water seems to be of special importance because it determines whether the arsenic concentrations (…)  
  Arsenic, EFSA, 2009
Examples, same summary

[... ] Compared to dietary exposure, non-dietary exposure to lead is likely to be of minor importance for the general population in the European Union (EU). House dust and soil can be an important source of exposure to lead for children. [...] The respective MOEs range from 1.2 to 4.2 and from 0.51 to 1.81, respectively. Hence, if exposure were closer to the upper bound estimates, the possibility of an effect on some consumers cannot be excluded. Breast-fed 3-month old infants are predicted to have a lead exposure that is below the BMDL_{01} intake value of 0.50 ug/kg b.w. per day for neurodevelopmental effects. Lead exposure based on lower bound assumptions in both average and high 3-month old infant consumers of infant formula is below the BMDL_{01}, but may exceed this level, based on upper bound estimates. [...]
Confidence

• Opposite of hedge: Confidence
• The experts express strong commitment to their proposition or chosen method. The experts want to stress that their statement is correct
• Not usual/conventional language for scientists
### Confidence

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<th>EU</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>BioHazard</td>
<td>28% (2/7)</td>
<td>24% (7/29)</td>
<td>25% (9/36)</td>
</tr>
<tr>
<td>Contaminant</td>
<td>28% (2/7)</td>
<td><strong>40% (15/37)</strong></td>
<td><strong>39% (17/44)</strong></td>
</tr>
<tr>
<td>Total</td>
<td><strong>28% (4/14)</strong></td>
<td>33% (22/66)</td>
<td><strong>32% (26/80)</strong></td>
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</table>

% of summaries that include at least one sentence expressing Confidence

Confidence is expressed in about 1/3 of summaries
More frequently used in Europe for Contaminants
• In a more likely scenario with a daily consumption of 10% contaminated Irish pork for a mean consumer of pork fat for the respective period of the incident (90 days), at the highest recorded concentration of dioxins (200 pg WHO-TEQ/g fat), the body burden would increase by approximately 10%. **EFSA considers this increase in body burden of no concern for this single event.**

Dioxins (in pork), EFSA, 2008

• Evaluation of the few available national dietary exposure data indicated that a *reasonable approximation* of European diets could be obtained from the GEMS/Food Consumption Cluster Diets database, **and the Contam Panel therefore used these data** in estimating dietary exposure to aflatoxins from foods other than almonds, hazelnuts and pistachios.

Aflatoxin, EFSA, 2007

Average number of expressions of confidence per document per year
Regression of the number of times confidence is expressed in a document on year, country and type of hazard (n=80)

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
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<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>168.029</td>
<td>75.991</td>
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<tr>
<td>Year1</td>
<td>-.083</td>
<td>.038</td>
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<td>EU vs. US</td>
<td>-.234</td>
<td>.241</td>
</tr>
<tr>
<td>Biohazard vs. Contaminant</td>
<td>.083</td>
<td>.177</td>
</tr>
</tbody>
</table>

Model Summary

- Model R: .247
- R Square: .061
- Adjusted R Square: .024
- Std. Error of the Estimate: .770

a. Predictors: (Constant), cathaz#, country#, VAR00001

a. Dependent Variable: Confidence
Precaution

• Experts may express their choice of being cautious or relying on other work that is cautious; e.g., in working with the worst case scenario

• It creates a form of certainty by overestimating the risk, by being conservative, it can increase the certainty that there is no harm.
• Precaution is expressed in 13% of summaries
• Interestingly
  ▪ It appears to be more frequent in the US
    • US : 21% of summary (3/14)
    • EU : 12 % of summary (8/66)
  ▪ On the 11 documents: 5 are related to the risk assessment of prion diseases (BSE/TSE), between 2005-2008; one of the most controversial health risks in the 2000s
Examples

• Referring back to the gelatine opinion, **this is a worst case consumption scenario** where all the daily human dose of gelatine is assumed to be bovine bone derived (when it is more likely to be 1-5%).

  BSE, Efsa, 2006

• The CONTAM Panel considered the impact of the uncertainties on the risk assessment of exposure to uranium from food and water consumption and concluded that its assessment of the risk **is likely to be conservative** in the high exposure scenarios – i.e. **more likely to overestimate** than to underestimate the risk.

  Uranium, Efsa, 2009
Conclusion

• Communicating Uncertainty at the heart of the confrontation between 2 epistemic cultures
  ▪ Risk Assessors trying to moderate their certainty
  ▪ Risk Managers hoping for the most certain statements

• Need for more formalization
• How this language be formalized?
  ▪ Types of uncertainty may be filled out systematically at the end of the document (with their magnitude)
  ▪ Hedge: to be avoided
  ▪ Characterisation of the level of agreement among the expert
  ▪ Characterisation of the level of confidence (very high confidence -> very low confidence)
• The formalization would allow to help Risk Managers in managing unknowns, ignorance, uncertainty

• Communicating uncertainty betweens experts and regulators is crucial to avoid that public directly face uncertainty…
Managing Uncertainty

THE SCIENTIFIC COMMUNITY IS DIVIDED.
SOME SAY THIS STUFF IS DANGEROUS, SOME SAY IT ISN'T.