Quantitative microbial risk assessments in the food chain context – examples, advantages and challenges

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The challenge when addressing food safety problems is to make a synthesis and assessment of the current state of knowledge, but also the lack of knowledge and uncertainties. The synthesis and assessment of knowledge has usually been in the form of a scientific review resulting in an opinion with conclusions and recommendations addressing the terms of reference. Systematic literature reviews, meta-analyses, qualitative and/or quantitative and/or microbial risk assessments offer alternative approaches for looking deeper into the food safety problems.

The purpose of risk assessments is to enable risk managers to make informed risk management decisions using all available knowledge and insights, complementing socioeconomic, legal and political considerations. In other words risk assessment is the scientific part of risk management. I will try to illustrate this by examples (*Salmonella* in layers, *Campylobacter* in chickens, and a qualitative and quantitative approach on *Salmonella* in pigs from the last 10 years:

The risk assessment of *Salmonella* in layers (FAO/WHO, 2002) - One important finding was that reducing flock prevalence and also the within flock prevalence results in a directly proportional reduction in public health risk. For example, reducing flock prevalence from 50% to 25% or the within flock prevalence from 10% to 5% results in a halving of the public health risk. This is a justification for having prevalence targets (or performance objectives) for layers. In EU a reduction of the number of human *Salmonella* cases is often linked to reduction of *Salmonella* flock prevalence in layers – one of the success stories of EU food safety risk management.

The risk assessment of *Campylobacter* in broilers (FAO/WHO, 2009) - The important finding here was that a reduction in retail prevalence of positive chicken products as well as flock prevalence has a roughly proportional effect on the public health risk. In addition a reduction of the number *Campylobacter* bacteria on chicken products has a somewhat more complex relationship with the estimate of risk. For highly contaminated products, moderate reductions in the contamination level have relatively mild effects. As the contamination level is further reduced, further reductions will have an increasing impact and eventually yield significant reductions in public health risk. The issue of cross-contamination will complicate these conclusions.

The two risk assessments on *Salmonella* in pork by the biological hazards panel of European Food safety authority (EFSA) in two opinions from 2006 and 2010 which illustrates how qualitative and quantitative approaches complement each other.

The 1st opinion noted that all *Salmonella* serovars from pork are public health hazards, while *S.* Typhimurium is most common. The control measures should be addressed to (i) the prevention of introduction of *Salmonella* into the herd, (ii) the prevention of in-herd transmission, and (iii) the increase of the resistance to the infection e.g., vaccination.

No universal mitigation option capable of eliminating *Salmonella* entirely from the harvest and post-harvest level was identified. A combination of measures aimed at the prevention of vertical and horizontal transmission is likely to be the most effective approach, as is the case with most other foodborne pathogens. Logistic slaughter is a further option for reducing the pathogen load on the carcasses of slaughtered pigs and carcass decontamination may be considered in specified situations.

The next question from the risk manager (European Commission) was then what was the quantitative impact which was needed to assess the benefits and costs of the possible mitigation measures.

In the 2nd opinion in 2010 some of these questions were addressed. One was the relative importance of the *Salmonella* in pork problem in the EU, and based on a descriptive and comparable analysis of the serovar distribution in animal sources and humans, around 10-20% of human *Salmonella* infections in EU may be attributable to the pig reservoir. However, the percentage might be larger today as *Salmonella* in eggs has been increasingly controlled. An 80% or 90% reduction of

lymph node prevalence should result in a comparable reduction in the number of human cases attributable to pork.

To achieve control of *Salmonella* in slaughter pigs the two major sources should be controlled: (1) *Salmonella*-infected breeder pig herds, and (2) *Salmonella*-contaminated feed. In high prevalence countries by ensuring that breeder pigs are *Salmonella*-free a reduction of 70-80% of lymph node prevalence was foreseen, while only a 10-20% reduction in low prevalence countries. In low prevalence countries by feeding only *Salmonella*-free feedstuffs, a reduction of 60-70% while only a 10-20% in high prevalence countries was foreseen.

Therefore a hierarchy of control measures was suggested - a high prevalence in breeder pigs needs to be addressed first, followed by control of feed and then control of environmental contamination. A reduction of two logs (99%) of *Salmonella* numbers on contaminated carcasses would result in a more than 90% reduction of the number of human salmonellosis cases attributable to pork. This could be achieved through measures preventing direct and/or indirect faecal contamination during transport, lairage and, particularly, slaughter and dressing processes; and/or by effective carcass decontamination.

Quantitative Microbiological Risk Assesment needs and challenges

Based on the experiences of the EFSA Biological hazards panel 2003-2012 (EFSA, 2012) the critical control points for risk assessments and modelling include a) the process where mandates are defined and distributed to Panels, b) the selection of modelling approaches to support answering the mandate, c) the decisions on the criteria for data inclusion/exclusion, d) the review of the output of the QMRA and e) the communication of the opinions to risk managers. Therefore, before doing a risk assessment a scoping exercise is recommended. The scoping exercise could include an assessment of the risk assessment questions and their risk management implications as well as possible interpretations of the terms of reference, deadlines, the modelling approaches possible and the data requirements.

With regard to the interface between risk management and assessment, the mutual understanding of quantitative risk expressions and their associated uncertainties by both risk assessors and risk managers are crucial for the ability to ask informed risk assessment questions and to take informed risk management decisions. Certain expressions such as “negligible”, “concern” and “unlikely” should be used carefully with a clearly defined context and criteria for their use or avoided.

The advantages of quantitative approaches are several:

- Quantitative models in risk assessments were found to be essential for providing an output that could be used by risk managers to support a proportionate response to a situation and/or to balance risks and costs. Therefore, models and modelling activities are likely to be at the core of the future scientific risk assessments,
- Compared to qualitative models, QMRA models have given better insights into and enabled quantitative predictions of the impact of interventions within the food chain.
- QMRA models identify important data gaps or lacks of knowledge thereby indicating future research priorities

The challenges involved are also several:

- QMRA is a developing field which creates methodological uncertainties and therefore preferences for types of models cannot be specified. New approaches need to be identified and considered all the time, and there is a need for smarter and simpler and robust risk assessment models.
- QMRA models are often novel, complex and not always peer-reviewed before being presented. Sometimes model are developed by external contractors and are described in a report. However, the report may not be detailed enough to understand a complex model and to carry out a peer-review, with the consequence that mistakes in the model code are only discovered after the

publication of the risk assessment, which questions the robustness and usefulness of the QMRA approach.

  - In this regard it might be noted that relative conclusions (percentage reduction) are usually more robust than absolute numbers.

- Fit for purpose and simplicity are and will remain key consideration (Occam's razor – keep it simple please) when developing QMRA models.
- Expertise, data, as well as time and resources, have been limiting factors for QMRA exercises.

In conclusion, a quantitative risk assessment offers a structured method of incorporating current knowledge enabling more precise quantitative answers, which in particular are needed when discussing proportionate risk management responses and/or balancing risks and costs. Moreover a quantitative analysis can suggest practical approaches to risk management such as hierarchies of control measures – i.e., where to start. For EU food safety questions quantitative assessments should be used whenever feasible and practical to get more precise answers on microbial risks for food safety (Havelaar, 2005 and EFSA 2012).

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