Tools for Prioritizing Food Safety Concerns: An FDA Perspective

Robert L. Buchanan, Ph.D.
HHS Food and Drug Administration
Center for Food Safety and Applied Nutrition
Risk Management Challenges for FDA
Managing Food Safety Risk

- Each year CFSAN is called upon to deal with a series of new challenges in the areas of
  - Food Safety
  - Food Defense
  - Nutrition
  - Dietary Supplements
  - Cosmetics and Colors

- Additional have to maintain our ability to managed known foodborne hazards
Managing Food Safety Risk

- Melamine
- Spinach/EHEC
- Clostridium botulinum/Carrot juice
- Lettuce/EHEC
- FALCPA Implementation
- Raw milk cheeses/Listeria
- Tomatoes/Salmonella
- Norovirus/Cruise ships
- Nanotechnology/Cosmetics
- Lead/Candy
- Perchlorate
- Raw milk/Salmonella
Managing Food Safety Risk

- Within each of those categories there are subsets of hazards areas that are distinctly different in terms of adverse effects, relative risk, potential for mitigation:
  - Chemical contaminants
  - Microbiological contaminants
  - Nutritional formulations
  - Food additives
  - Allergens
  - Many others
Managing Food Safety Risk

- We have a full table
- Trying to do everything means that nothing gets done well
- Have to make decisions on what hazards we will focus our efforts
Managing Food Safety Risk

- Have various drivers that push us in different directions
  - Public health threats
  - Administration goals
  - Congress
  - Press
  - Consumer groups
  - Industry
  - International trade
While FDA will always have to respond to changing priorities and stakeholder concerns, it would benefit greatly from a more objective considerations of risks and our potential for mitigation.

Particularly important for 3 - 5 year budget planning.
Risk Ranking
Risk Ranking

- Currently one of the most active areas of non-laboratory research is “risk ranking” risk assessment techniques as a means of finding more objective comparisons of risks to aid in the allocation of scarce food safety resources

  - Risk ranking risk assessment
  - IFT Contract for the Food and Drug Administration
  - Food Safety Research Consortium “Attribution and Risk Ranking” Project
Risk Ranking Terminology

Also known as

- Hazard Ranking
- Risk Attribution
- Risk-Based Priority-Setting
- Comparative Risk Assessment (CRA)
- Maintaining a “Risk Register”

Primary purpose is priority setting
Risk Ranking

- Technique that has been used for the past 20 years for priority setting
- Early work in U.S. focused on priority setting for environmental hazards
- Largely started as a qualitative or semi-quantitative approach
- Confused risk management and risk assessment - initially as a series of risk profiles - got a tarnished reputation as a result
Risk Ranking

- Can span the entire qualitative to quantitative spectrum with all the benefits and limitations of each

- Complexity increases with number of:
  - Class of agents (e.g., chemical, microbiological)
  - Agents within a class
  - Biological end points associated with an agent
  - Food classes
  - Diversity of foods within a class
  - Diversity in susceptibility of population
Risk Ranking Risk Assessments

- Propose six levels based on increasing difficulty
  - Level 1: Single agent in multiple food classes
  - Level 2: Single class of agents in a single food class
  - Level 3: Single class of agents in multiple food classes
  - Level 4: Multiple classes of agents in a single food
  - Level 5: Multiple classes of agents in a single food class
  - Level 6: Multiple classes of agents in multiple classes of foods
Risk Ranking

- When going beyond a single class of hazards, the greatest challenge is finding a single metric that can be used to compare risk with different characteristics
  - Chemical vs. Microbiological vs. Allergens vs. Nutrition vs. ........
  - Acute vs. Chronic
  - Threshold vs. Non-threshold
  - Intentional vs. Non-intentional
  - Potential for mitigation
Personal Thoughts on Framework for Risk Ranking that “Works” for Regulatory Agencies
Thoughts on Risk Ranking

\[ f(\text{Exposure}) \times f(\text{Dose Response}) = \text{Adverse Events} \]

- For each risk there is a relationship between exposure and adverse events
- Ideally solve for \( f(E) \) and \( f(DR) \) to predict AE and then validate against independent measure of AE
  - If know two of the factors, can determine the third
  - Differences in risk assessment modeling approaches reflect which two factors are known and to what degree
- Know how to do this fairly well for single agents
Thoughts on Risk Ranking

• Have not done as well in considering severity
• One potential approach is to consider multiple biological end points:

\[
\begin{align*}
    f(E_1) \times f(DR_1) &= AE_1 \\
    f(E_2) \times f(DR_2) &= AE_2 \\
    f(E_3) \times f(DR_3) &= AE_3 \\
    f(E_n) \times f(DR_n) &= AE_n
\end{align*}
\]
Thoughts on Risk Ranking

Would then have weight the impact of each biological end point so they can be summed:

\[ \text{Severity } (S_0) = \text{AE}_1 \times \text{WF}_1 + \text{AE}_2 \times \text{WF}_2 + \text{AE}_3 \times \text{WF}_3 + \ldots + \text{AE}_n \times \text{WF}_n \]

- \( \times \text{WF} \) = weighting factor for each biological end point
- Could be relative public health consequences, economic impact, etc. - find common metric
Thoughts on Risk Ranking

- To be fully useful to risk managers for priority setting, need consideration of potential for control
  - Inherent risk vs. loss of control (compliance)
  - Potential for risk reduction - finding the low hanging fruit vs. this is as good as it gets
## Example: Role of Compliance

<table>
<thead>
<tr>
<th>% Defectives $(10^6 \text{ cfu/g})$</th>
<th>Criteria: 0.04 CFU/g</th>
<th>Criteria: 100 CFU/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000000</td>
<td>0.5*</td>
<td>5.7</td>
</tr>
<tr>
<td>0.000001</td>
<td>1.7</td>
<td>6.9</td>
</tr>
<tr>
<td>0.00010</td>
<td>12.3</td>
<td>17.4</td>
</tr>
<tr>
<td>0.00100</td>
<td>119</td>
<td>124</td>
</tr>
<tr>
<td>0.01000</td>
<td>1,185</td>
<td>1,191</td>
</tr>
<tr>
<td>0.01800</td>
<td>2,133</td>
<td>2,133</td>
</tr>
<tr>
<td>0.10000</td>
<td>11,837</td>
<td>11,848</td>
</tr>
<tr>
<td>1.00000</td>
<td>117,300</td>
<td>117,363</td>
</tr>
</tbody>
</table>

FAO/WHO *Listeria monocytogenes* risk assessment
Thoughts on Risk Ranking

- Consideration of risk management options
  - Need to consider multiple options within each hazard
  - WTO SPS agreements requires consideration of equivalent options
    - Developed nations vs. Developing nations
      - May have to do sufficient “what-if scenarios” to characterize impact of risk management options for each hazard
- Avoid making risk management decisions within the risk assessment - focus on a uncertainty neutral risk assessment
Thoughts on Risk Ranking

\[ S_R = S_o \times MP \]

- In order to make informed decision about program priorities, need to assess “mitigation potential” (MP) on the extent of the severity reduction \( (S_R) \) achieved through an intervention.

- Need to compare the MPs for each hazard.

- Within a hazard, ranking of MPs could be the best basis for:
  - Short term goals
  - Investments in research for intermediate term goals
  - Identifying what areas require entirely different approaches (long term goals)
  - Differentiating need for enhanced compliance vs. development of new risk reduction strategies
Thoughts on Risk Ranking

- For hazards where there are multiple risk management options, may have to consider multiple control measures

\[ S_R = S_o \left[ MP_1 \times Opt_1 + MP_2 \times Opt_2 \ldots + MP_n \times Opt_n \right] \]

Opt_{1\rightarrow n} = \% of food serving produced using control measure 1\rightarrow n
Thoughts on Risk Ranking

\[ S_F = S_o - S_R = S_o(1 - MP) \]

- Could base longer term food safety activities on final (residual) severity \( (S_F) \) magnitude based on differential between \( S_o \) and \( S_R \)
## Risk Ranking: Hypothetical Example

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Diarrheal Cases</th>
<th>Septicemia Cases</th>
<th>Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonellosis</td>
<td>1,000,000</td>
<td>1000</td>
<td>10</td>
</tr>
<tr>
<td>Listeriosis</td>
<td>200</td>
<td>2000</td>
<td>400</td>
</tr>
<tr>
<td>Campylobacteriosis</td>
<td>2,000,000</td>
<td>1000</td>
<td>5</td>
</tr>
<tr>
<td><em>Mycobacterium bovis</em> tuberculous</td>
<td>0</td>
<td>100</td>
<td>2</td>
</tr>
</tbody>
</table>
## Risk Ranking Example

Diarrhea: 1X, Septicemia: 10X, Death: 1000X

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Diarrheal Cases</th>
<th>Septicemia Cases</th>
<th>Death</th>
<th>S_o</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sal.</td>
<td>$10^6$</td>
<td>10,000</td>
<td>10,000</td>
<td>1.020 X $10^6$</td>
</tr>
<tr>
<td>List.</td>
<td>200</td>
<td>20,000</td>
<td>4 X $10^5$</td>
<td>4.20 X $10^5$</td>
</tr>
<tr>
<td>Camp.</td>
<td>2 X $10^6$</td>
<td>10,000</td>
<td>5,000</td>
<td>2.015 X $10^6$</td>
</tr>
<tr>
<td>TB</td>
<td>0</td>
<td>1000</td>
<td>2000</td>
<td>3.00 X $10^3$</td>
</tr>
</tbody>
</table>
## Risk Ranking Example

<table>
<thead>
<tr>
<th>Hazard</th>
<th>$S_o$</th>
<th>MP</th>
<th>$S_R$</th>
<th>$S_F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sal.</td>
<td>1.020 X $10^6$</td>
<td>0.30</td>
<td>3.06 X $10^5$</td>
<td>7.14 X $10^5$</td>
</tr>
<tr>
<td>List.</td>
<td>4.20 X $10^5$</td>
<td>0.50</td>
<td>2.10 X $10^5$</td>
<td>2.10 X $10^5$</td>
</tr>
<tr>
<td>Camp.</td>
<td>2.015 X $10^6$</td>
<td>0.10</td>
<td>2.015 X $10^5$</td>
<td>1.80 X $10^6$</td>
</tr>
<tr>
<td>TB</td>
<td>3.0 X $10^3$</td>
<td>0.90</td>
<td>2.7 X $10^3$</td>
<td>3.0 X $10^2$</td>
</tr>
</tbody>
</table>
Thoughts on Risk Ranking

- At some point “ability to pay” and “return on investment” will have to be factored into the analysis.

- Costs are not just $$$
Thoughts on Risk Ranking

- Do we worry too much about dose-response relations?
  - In most cases risk mitigation involves changing exposure and does not involve changing host susceptibility
  - Still conceptual challenges with
    - Modeling subpopulations that are more susceptible
    - Dealing with agents where a portion of the population is not susceptible

- Potential area for simplification
Thoughts on Risk Ranking

- **Challenges**
  - Increasing the ability to quantify risk rankings
  - Finding a common metric (Daly? Qaly? PseduoQaly?)
  - Comparing long and short term risks
  - Comparing hazards with different risk perceptions
  - Conducting “uncertainty neutral” risk rankings
Thoughts on Risk Ranking

- Our future success in advancing risk ranking techniques beyond level 2 is going to be highly dependent on finding a common metrics that is reasonable, understandable to the public, and easy to use