Food Safety
Key Issues and Challenges:
International, Including SAARC

Nimish Shah
Member, Scientific Advisory Committee on Food Safety, ILSI-India
Outline

- Introduction
- Key Risk Areas
- Risk-based approach for food safety management
  - Illustrations
- Focus for SAARC
Others

- Lower water & Land availability for cultivation
- Rising Food demand and costs
- Shrinking fishery resources
- Many other changes that are ....
- Rapid
- Widespread
- Affecting all
  - The world
  - Asia
  - SAARC
    - You and Me

& Have a bearing on FOOD SAFETY
How changes may influence outcomes – Some examples

- Irrigation water being a source of pathogens
  - Polluted/ Recycled waters may enhance the risk

- Pathogens survive in environments and can potentially contaminate foods
  - Global warming – higher temperatures increase survival opportunities and infective potential

- Consumer interest in exotic foods
  - Exposure to newer microbiological and toxicological risks

- Increasing travel and eating out
  - Global transmission of disease – Pandemics
    - SARS/ Bird Flu
So much Food
So many choices
So many issues
How to handle?
How to manage?

Regulator/Consumer

Nothing is absolutely safe
Whether a material will cause any adverse impact depends a number of factors

Risk Assessment
Risk Assessment

- Scientific evaluation of known or potential adverse effects resulting from human exposure to food-borne hazards.

It consists of
- Hazard Identification
- Hazard characterization
- Exposure assessment
- Risk characterization
Risk Management

**Identify & Characterize hazards**
- What biological, chemical, and physical agents are we dealing with?
- With which foods is it associated?
- What illnesses can be caused, associated with which dose and for which population?

**Characterize risks**
- How likely is it that an individual or population will be exposed to a chemical/biological hazard and what amount of the is likely to be ingested?

**Manage risks**
- Control measures (safety by design)
- Regulation
- Communication

**Integrate the results**
- Assigning probabilities and uncertainties

**Epidemiology**
- Toxicology/Microbiology
- Generate Data/predictions
Quantifying Risks - Modeling

- Residues
- Severity of effect
- Uncertainty
- Consumption
- Fraction of the population at risk
Chemical (Tox.) v/s Microbiological

**Chemicals:**
- Levels unchanged
- May not be destroyed by cooking
- Often homogeneous distribution
- Not transmitted
- Consumer has less responsibility for safety
- Mostly chronic exposure

**Microorganisms:**
- Can change in concentration
- Many destroyed by cooking
- Heterogeneous distribution
- Not transmitted
- Person-to-person transmission important
- Role of the consumer in ensuring safety is essential
- Mostly acute
Toxicity Endpoints

- Carcinogenicity
- Mutations
- Altered immune function
  - Food Allergy
- Teratogenicity
- Altered reproductive function
- Neuro-behavioral toxicity
- Organ-specific effects
- Ecological effects (wildlife, environmental persistence)

Toxicology studies how external chemicals interact with your body’s chemicals to cause damage or illness.
Appropriate Hazard Data

- Choose most sensitive endpoint for effects
  1. sub-chronic study,
  2. reproduction/development study,
  3. neurotoxicity,
  4. lifetime exposure (thresholded tumours)

- Determine the NOEL (no observed effect level) or the NOAEL (no observed adverse effect level)

Input to risk-based decision making
# No-observable Adverse Effect Levels (NOAELs)

<table>
<thead>
<tr>
<th></th>
<th>90 day rat NOAEL (mg/kg/day)</th>
<th>90 day dog NOAEL (mg/kg/day)</th>
<th>1-year dog NOAEL (mg/kg/day)</th>
<th>2-year rat NOAEL (mg/kg/day)</th>
<th>Lowest NOAEL (mg/kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4 D</td>
<td>15</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Acetochlor</td>
<td>80</td>
<td>10</td>
<td>2</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Atrazine</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>3.5</td>
<td>1</td>
</tr>
<tr>
<td>Carbaryl</td>
<td>125</td>
<td>1</td>
<td>3.1</td>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>
Health Impact Categorisation
Risk Prioritization: Health Impact in the population

Health Impact Chart: Pesticides

- No health impact
  - NHI: 87.3%
  - HI: 12.7%

- Health impact
  - LHI: 10.5%
  - MHI: 1.6%
  - SHI: 0.6%

- Low health impact

- Moderate health impact

- Severe health impact
Microbiological Risks
<table>
<thead>
<tr>
<th>DRIVERS</th>
<th>SOURCES</th>
<th>PATHWAYS</th>
<th>OUTCOMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Globalization</td>
<td>Reduced geographical barriers to spread</td>
<td>Inadequate sanitation: higher</td>
<td>Increased risk</td>
</tr>
<tr>
<td></td>
<td>(of new variants)</td>
<td>pathogen loads Global sourcing</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Intensified contact structures</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Varying hygiene levels</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food price/income level</td>
<td>Less profit margins; decreased investment in</td>
<td>Preference for cheaper alternatives</td>
<td>Risk not clear</td>
</tr>
<tr>
<td></td>
<td>food safety</td>
<td>(e.g. less meat and butter;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>discounters; home brands)</td>
<td></td>
</tr>
<tr>
<td>Science and technology and</td>
<td>Minimally Preserved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>industry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal processing</td>
<td>Adaptation</td>
<td>Less kill steps</td>
<td>Increased risk if not well</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>controlled</td>
</tr>
<tr>
<td>Innovation</td>
<td>New food animal species</td>
<td>Step change food innovation</td>
<td>Risk not clear</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Smart packaging</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bacteriophages</td>
<td></td>
</tr>
<tr>
<td>Laboratory methods</td>
<td>Discovery of new pathogens or variants</td>
<td></td>
<td>Increased observed risk</td>
</tr>
<tr>
<td></td>
<td>Omics approaches</td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

**More Natural Minimally Preserved**

**Sustainability: Lower Processing**

**Microbial Resilience Food-Microbe Interaction**
Emerging Pathogens - Common Features

- Many (75%) have an animal reservoir
- Many can infect multiple hosts
- Do not often cause disease in host animals
- Rapid spread, on a global basis
- Many have antibiotic resistance capabilities
- Some have low infectious dose
- Sharing of virulence genes
- Some cause severe illness
- We don’t have much knowledge about ecology and methods for detection/enumeration and control
Why have new food-borne diseases emerged?

<table>
<thead>
<tr>
<th>Rank</th>
<th>Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Changes in land use or agricultural practices</td>
</tr>
<tr>
<td>2</td>
<td>Changes in human demographics and society</td>
</tr>
<tr>
<td>3</td>
<td>Poor population health (e.g. HIV, malnutrition)</td>
</tr>
<tr>
<td>4</td>
<td>Hospitals and medical procedures</td>
</tr>
<tr>
<td>5</td>
<td>Pathogen evolution</td>
</tr>
<tr>
<td>6</td>
<td>Contamination of food sources or water supplies</td>
</tr>
<tr>
<td>7</td>
<td>International travel</td>
</tr>
<tr>
<td>8</td>
<td>Failure of public health programmes</td>
</tr>
<tr>
<td>9</td>
<td>International trade</td>
</tr>
<tr>
<td>10</td>
<td>Climate change</td>
</tr>
</tbody>
</table>

What should we be worried about?

- Helminths - complex, with complex life cycles, long generation times, not extremely virulent/pathogenic
- Viruses - difficult to prevent spread, high mutation rates, generation times short, quicker to evolve/adapt, RNA viruses more easily transmissible across species/orders
- Bacteria - somewhere in between

All human pathogens (1415)

- Helminths 20%
- Fungi 22%
- Bacteria 38%
- Viruses 15%
- Protozoa 5%

Emerging human pathogens (175)

- Helminths 11%
- Fungi 9%
- Bacteria 30%
- Viruses 44%
- Protozoa 6%

Cleaveland et al, Phil. Trans. R. Soc Lond. B 2001, 356, 991-995
**Salmonella**

- Easy to kill
  - Thermal*
    - Easily inactivated

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Time (min.)</th>
<th>Temp°C</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Salmonella</em></td>
<td>4.3</td>
<td>60</td>
</tr>
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</table>

*Thermal death time* is a concept used to determine how long it takes to kill a specific bacteria at a specific temperature.
Salmonella

- Can survive for months to years in low moisture foods
  - nonfat dry milk, peanut butter, chocolate

- Small numbers of this bacterium can produce illness when consumed in high-fat foods
  - chocolate (< 1 Salmonella/g), peanut butter, cheese

Hypotheses:
1) Entrapment of Salmonella within hydrophobic lipid micelles protection against the bactericidal action of gastric acidity

2) Rapid emptying of fat based gastric contents.
### Thermal Inactivation of *Salmonella* in Peanut Butter

<table>
<thead>
<tr>
<th>Internal Temperature (°C/°F)</th>
<th>3-log reduction (min)</th>
<th>5-log reduction (min)</th>
<th>7-log reduction (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>71 / 160</td>
<td>107</td>
<td>402</td>
<td>965</td>
</tr>
<tr>
<td>77 / 170</td>
<td>62</td>
<td>197</td>
<td>423</td>
</tr>
<tr>
<td>83 / 181</td>
<td>33</td>
<td>110</td>
<td>227</td>
</tr>
<tr>
<td>90 / 194</td>
<td>21</td>
<td>49</td>
<td>120</td>
</tr>
</tbody>
</table>

*a Commercial, creamy-style peanut butter; $a_w = 0.45$, pH = 5.1

Ma et al., J. Food Protect. July 2009

### Bacteria Time (min.) Temp°C

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Equivalence in Food Safety Management

- New Technologies for food processing
  - Ultrasonic waves
  - Pulse field
  - High Pressure
  - Radio Frequencies

- Equivalent level of risk reduction needs to be ensured
SAARC – Reported Gaps

- Strengthen health surveillance systems
  - Poor assessment of health issues linked to foods

- Strengthen to conduct detailed risk assessment
  - Lack of exposure assessment data
  - Laboratory infrastructure
  - Know-how to analyze a wide range of contaminants

- Focus on easily measurable target
  - E.g. Bacterial pathogens. What about viruses/other types of pathogens in foods?
- Adequacy of in-house controls
  - Hazard Analysis and Critical Control Points (HACCP) system
    - science-based, systematic, Food Safety management system
  - Establishment of
    - Traceability and recall systems
    - Understanding of hazard analysis
    - Pest control and proofing
    - Water treatment system maintenance
    - Staff hygiene facilities
How Do We Go About

- Recognize - Food-related illnesses have a significant impact not only on health but also on development
- Put food safety high on national priorities E.g. Establishment of FSSAI in India
- Identify critical gaps in technical expertise
- Make available Financial resources and infrastructure to address gaps and implement food safety policies
- Support the development of risk-based, sustainable, integrated food safety systems
- Devise science-based measures along the entire food production chain
  - prevent exposure to unacceptable levels of microbiological agents and chemicals in food
- Assess and manage risks and communicate information, in cooperation with other sectors and partners.
Utilize & Exploit excellent intellectual resources already available
  - Knowledge on behavior of microorganisms in foods
  - Toxicological endpoints

Interdisciplinary network of experts
  - Mathematics/ Microbiology/ Toxicology/ Epidemiology ++
  - Country/ Regional

R&D to generate new knowledge enabling scientific risk assessment
  - E.g. Ethnic foods
  - Hazards ‘creeping in’ on account of evolving supply chain

- Food MicroModel [http://www.leatherheadfood.com](http://www.leatherheadfood.com)
- Sym’previus [http://www.symprevius.net/](http://www.symprevius.net/)
- Freeware packages:
  - Pathogen Modeling Program (PMP) [http://www.arserrc.gov/mfs/pathogen.htm](http://www.arserrc.gov/mfs/pathogen.htm)
  - Growth Predictor (GP) [http://www.ifr.ac.uk/Safety/GrowthPredictor/](http://www.ifr.ac.uk/Safety/GrowthPredictor/)
  - Seafood Spoilage & Safety Predictor (SSSP) [http://www.dfu.min.dk/micro/sssp/](http://www.dfu.min.dk/micro/sssp/)
THANK YOU