An Introduction to the Biological Stressors Specialty Group

www.biostressors.org

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Biological stressors are…

- Living organisms accidentally or purposely introduced into an area or ecosystem that they would not normally inhabit, (or that we do not want there e.g. food chain)
  - Results in adverse impacts
  - Biostressors for short
- An extremely diverse, and distinct class of hazards

….A Broad Group with Common Features

- Diverse biological stressors share many common features
- Unlike chemical or physical hazards, biological stressors:
  - grow, reproduce, and die
  - disperse both actively and passively
  - interact with other biological populations in the ecosystem
  - evolve
- This is the key rationale for the classification in a single specialty group

Examples of Biostressors

- human pathogens
  - transmitted via food, water, air, organs (including blood), and body fluids and excretions
- zoonotic pathogens
- biologically produced disease agents
  - (such as allergens and mycotoxins)
- plant and animal pathogens
- plant and animal pests
- invasive species
- invasive genetic material

Specific Examples

- **Human pathogens:**

  via food: Salmonella, Listeria monocytogenes
  via water: Cryptosporidium parvum, Vibrio cholerae
  via air: Bacillus anthracis, Mycobacterium tuberculosis
  via blood and other organs: Hepatitis C, Creutzfeldt-Jakob disease (CJD) agent
  via other body fluids and excretions: norovirus (vomit), Staphylococcus aureus (pus)

- **Zoonotic pathogens:** pathogens transmitted from animals to humans such as the West Nile Fever virus, avian influenza A (H5N1) virus
- **Biologically produced disease agents:** allergens, mycotoxins, seafood toxins
- **Plant pathogens:** Phakopsora pachyrhizi (the fungus that causes Asian soybean rust), tobacco mosaic virus (e.g., in tomatoes)
- **Animal pathogens:** Classical Swine Fever (Hog Cholera) virus, Newcastle disease virus (e.g., in poultry)
- **Plant pests:** Ceratitis capitata (Mediterranean fruit fly), nematodes
- **Animal pests:** Cochliomyia hominivorax (screw-worm fly, an ectoparasite of warm-blooded animals), Haematobia irritans (hom fly, a bloodfeeding pest of cattle)
- **Invasive species:** Dreissena polymorpha (zebra mussel), Pueraria montana (kudzu)
- **Invasive genetic material:** promiscuous plasmids that confer antibiotic resistance
- Note – grouping is somewhat subjective – for example exotic animal pathogens are sometimes also called invasive species , an example is FMD

Why do Risk Assessment?

- Biological stressors impose many burdens on society:
  - Public health/disease burden
  - Agricultural impacts
    - Invasive species, exotic & domestic animal disease, plant pests and disease…..
  - Trade impacts/barriers
    - Exotic diseases, invasive species
- International regulation also "requires" risk assessment approaches
  - SPS agreement of WTO
    - SPS measures must be based upon either a relevant international standard or a scientific risk assessment

UK FMD Outbreak

www.guardian.co.uk

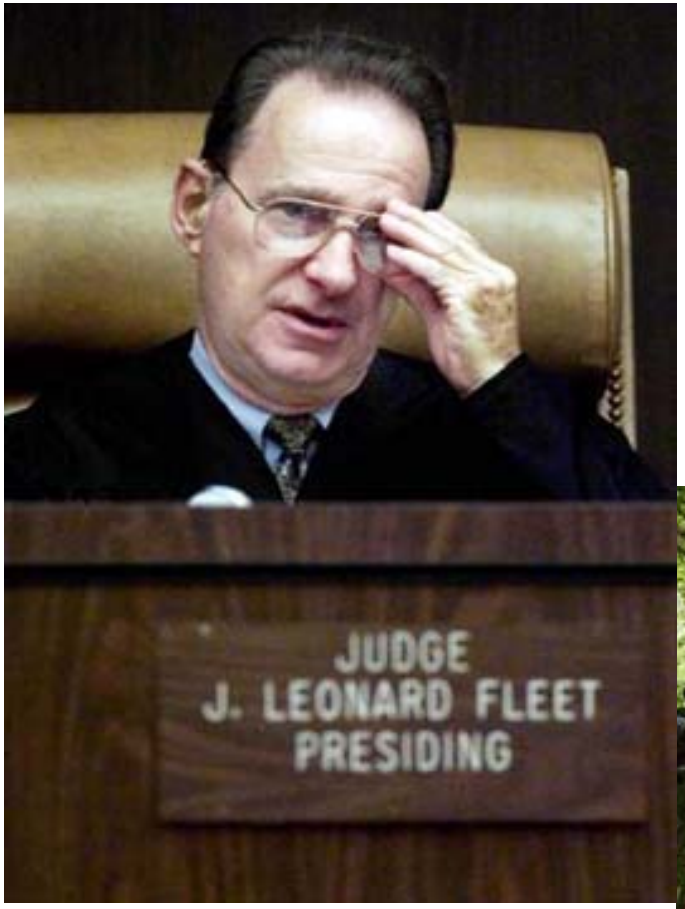
Slide courtesy of M. Powell

Citrus Canker Eradication

www.Sun-Sentinel.com

Slide courtesy of M. Powell

Citrus Canker Controversy



Sun-Sentinel.com

Slide courtesy of M. Powell

Salvinia molesta

invasivespecies.gov

nature.org

Slide courtesy of M. Powell

More on SPS Agreement

- Member countries of WTO can choose own standards but..
- …SPS Agreement requires them to apply those measures only to the extent required to protect health
- It does not permit Member Governments to discriminate by applying different requirements to different countries where the same or similar conditions prevail
  - unless there is sufficient scientific justification for doing so SPS agreement defines what qualifies as an adequate risk assessment
- Recognizes OIE, IPPC, Codex as international standard setting bodies

Key components of SPS Agreement

- Agreement defines what qualifies as a satisfactory risk assessment (for trade purposes)
- Article 5.1
  - SPS measures be based on an assessment of the risks to human, animal or plant life or health
- Article 5.3
  - "..in assessing the risk to animal or plant life or health and determining the measure to be applied for achieving the appropriate level of sanitary or phytosanitary protection from such risk, members shall take into account…..the potential damage in terms of loss of production or sales in the event of entry, establishment or spread of a pest or disease, the costs of control or eradication ….and the relative cost-effectiveness of alternative approaches to limiting risks"
- Members are free to set own standards but there is an obligation to consider damages, control costs and alternatives

Main Drivers for Risk Assessment

- Main drivers are to
  - Understand magnitude of the risk
  - Understand how complex pathways and mechanisms contribute to the risk
    - Biological stressors often have complex relationships with the environment and the realization of risk
      - Example: “farm-to-fork continuum” in food safety, geographical and spatial spread of invasive species
  - Identify methods to minimize/control the risk
    - Example: “farm-to-fork” – farm management practices, slaughter plant operations, consumer behavior, etc…

Risk assessment "systems"

- Risk assessment approach often split into number of stages
- Different "systems" for doing this for different types of biostressor
  - OIE , CODEX, IPPC,….
  - No common framework
- Differences relate to terminology
- Developed in different areas with different requirements

Overlap with other specialty groups

- Comprehensive risk assessments often include:
- Exposure assessment
  - Probability people ingest pathogen in food (and level)
  - Probability exposed to pathogen in blood
- Dose-response assessment
  - Consequence assessment
- Life cycle of assessment will often include economic analysis
  - In particular when used in policy and regulation
  - Often a different group of assessors/modelers

Use of Risk Assessment for Biostressors

- Often related to a regulatory or policy decision
  - Frequently aimed at controlling/reducing population health burden
    - Human, animal (inc. aquatic), plant,..
- International agreements mandate science-based arguments which lead to implementation of risk assessment
- SPS agreement of WTO

Types of Problems Tackled for Biostressors

- Often related to a regulatory or policy decision
  - Frequently aimed at controlling/reducing population health burden
    - Human, animal (inc. aquatic), plant,..
- Foodborne – examine the likelihood that presence of biostressors in food chain cause illness
  - Variety of pathogens have been explored
  - Campylobacter, Salmonella, E. coli, listeria, antibiotic resistance…
  - Aims: many aims, ultimately to reduce population health burden

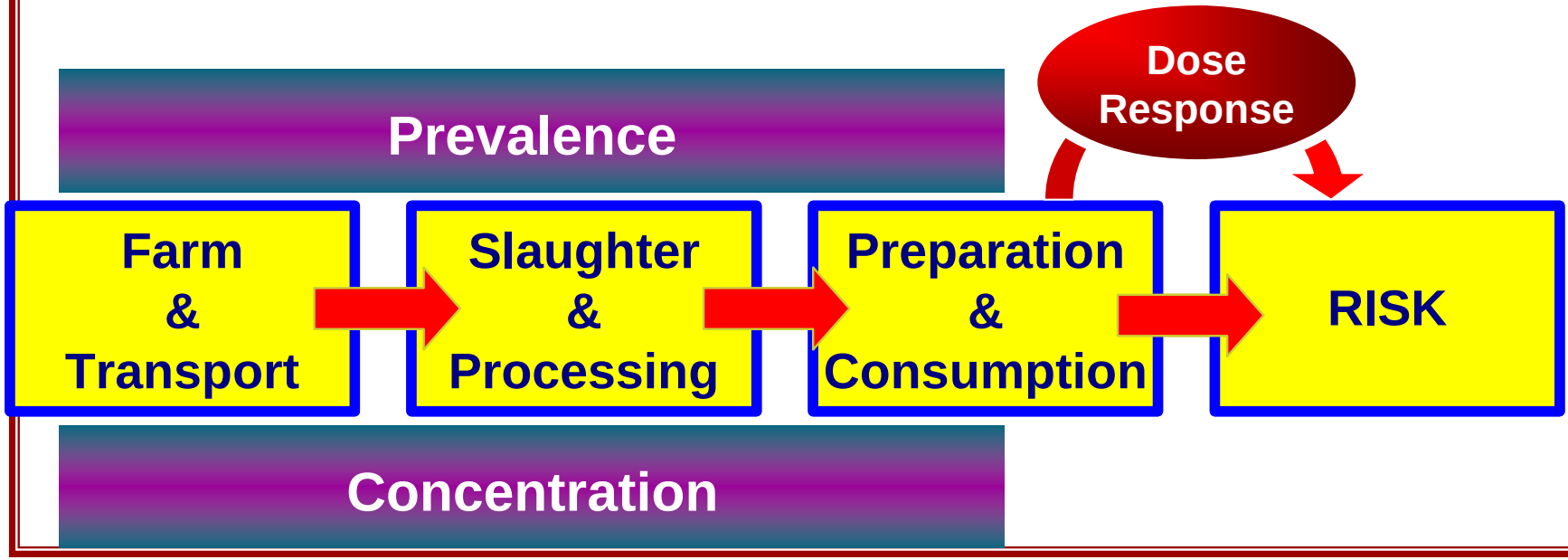
- Animal health – domestic and exotic
  - Considers impact of introduction and/or spread of pathogens in wild and domestic animal populations
  - Aims: protect animal health, trade agreements, food security, inform risk-based border controls, …
- Invasive species - used to support exclusion of species, or assess impact of established invasive species
  - Aim: to reduce economical, environmental, and ecological damage
- Bloodborne – to assess the risks of transmission of pathogens via blood
  - Blood transfusions, needle use,…
  - Hazards considered include nvCJD, live vaccines & bioterrorism agents

Example Risk Assessments for Biological stressors

Foodborne - Campylobacter in Poultry

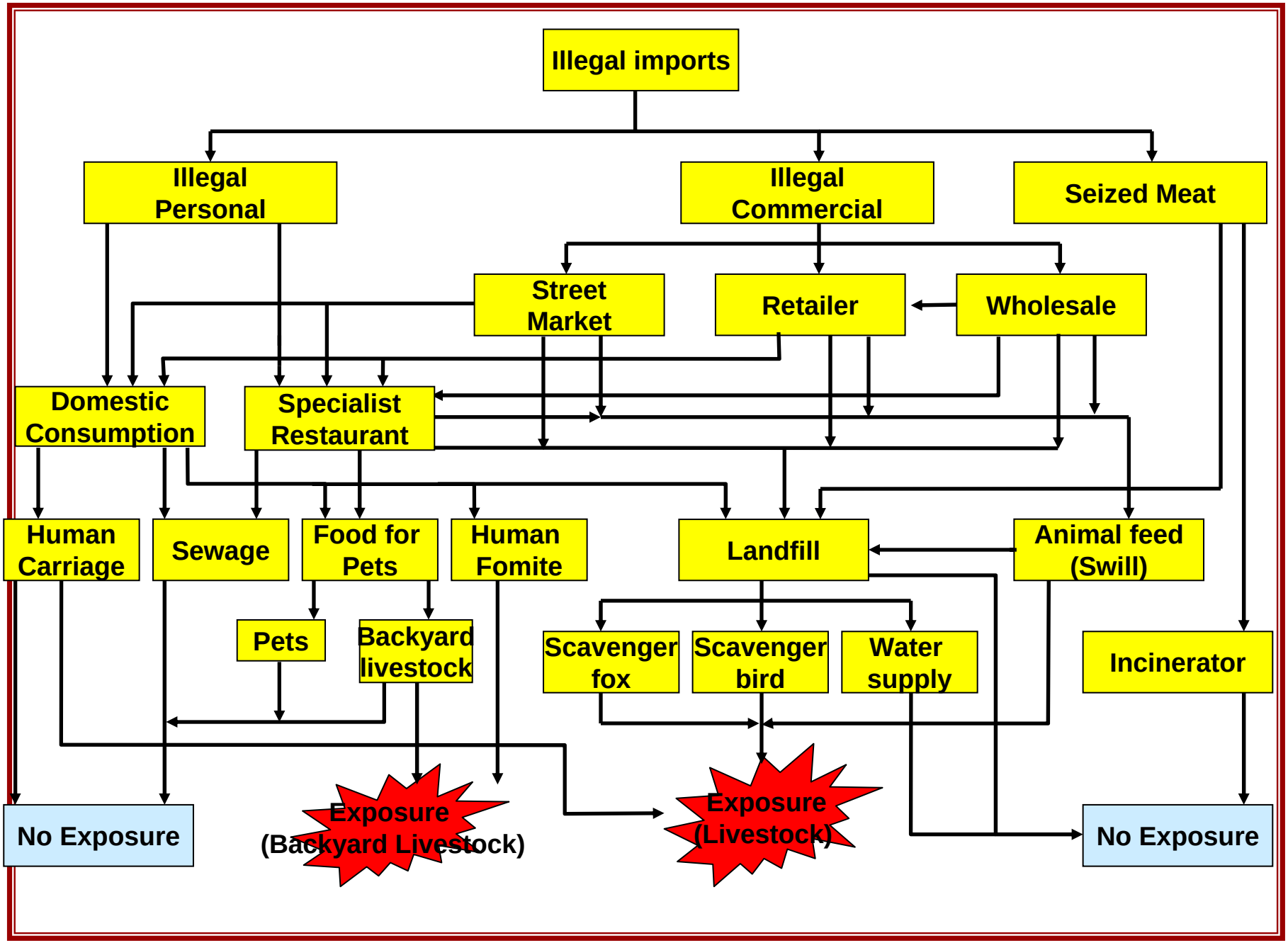
- Campylobacter is commonest cause of foodborne gastroenteritis world wide
- Many countries have developed risk assessments for Campylobacter in poultry (mainly chicken)
  - To quantify and mitigate the risk of human illness
  - UK, The Netherlands, Denmark, Iceland, New Zealand, Canada, WHO/FAO, USA (in progress)….
- All are trying to develop strategies for reducing the population health burden

- Usually farm-to-fork approach
  - Requires mathematical description of complex pathway
    - Leads to complex models!
  - Estimate risk of illness from consumption of chicken



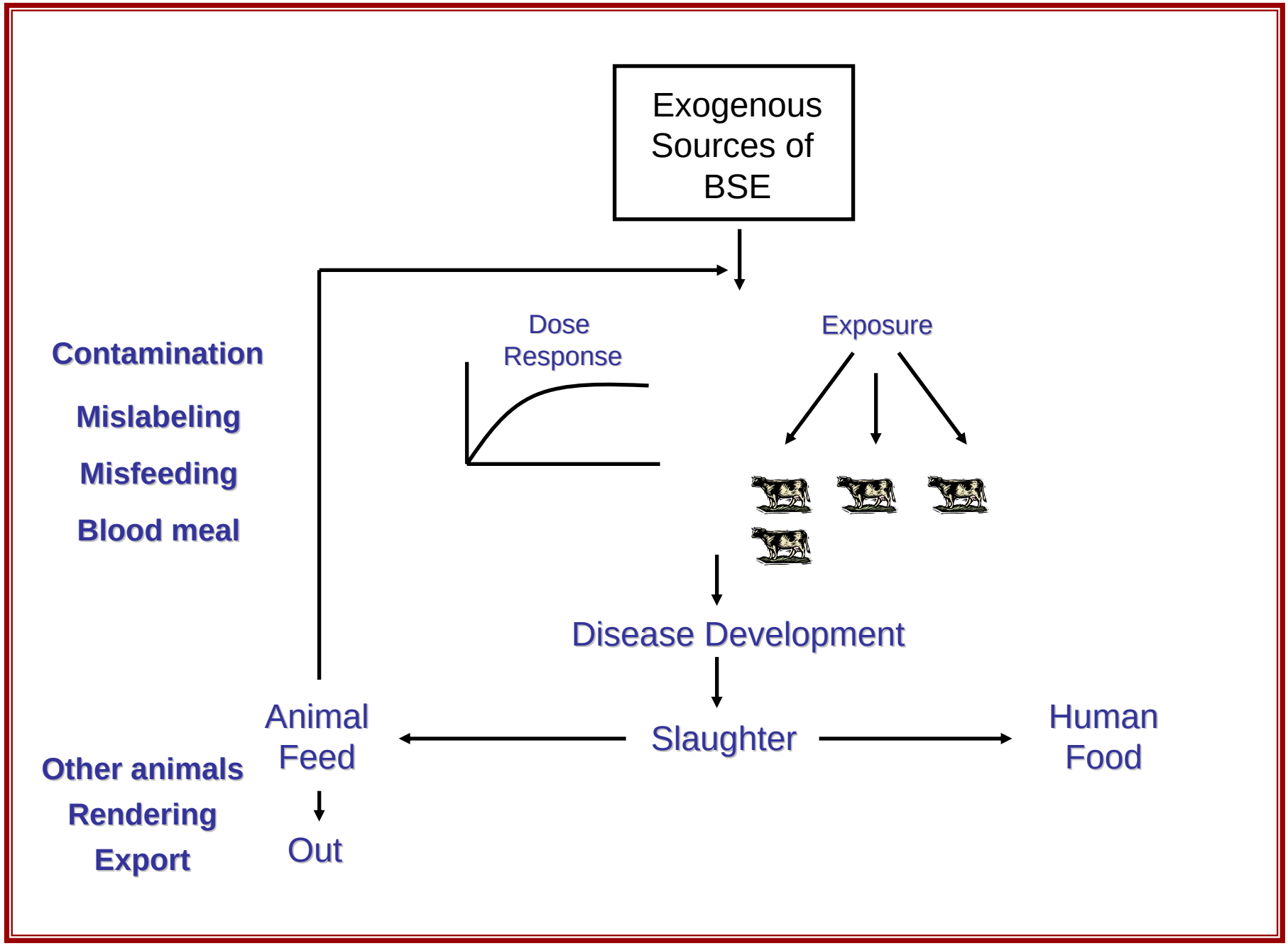
Import Risk Assessment : Foot and Mouth Disease

- FMD outbreaks have massive implications
  - Trade barriers, animal welfare, tourism…..
- Comprehensive assessment carried out in UK
  - Hartnett et al (2007) Risk Anal. 27(1)
- Considers the introduction of FMD through the illegal importation of meat (smuggled)
- Aims include to understand risk, and enhance risk-based border controls
- Vast scope
  - Considered all meat and meat products and all populated territories of the world
- Very complex pathway from country of origin to introduction to infection of domestic livestock


Illegal imports
Illegal Personal
Illegal Commercial
Seized Meat
Street Market
Retailer
Wholesale
Domestic Consumption
Specialist Restaurant
Human Carriage
Sewage
Food for Pets
Human Fomite
Landfill
Animal feed (Swill)
Pets
Backyard livestock
Scavenger fox
Scavenger bird
Water supply
Incinerator
No Exposure
Exposure (Backyard Livestock)
Exposure (Livestock)
No Exposure

Harvard BSE Risk Assessment

- Bovine spongiform encephalopathy (BSE) has trade implications and potential human health implications
- Considers the consequences of the import of BSE infectivity
  - Infected meat or bone meal
  - Distinct from import assessment
- The pathways of exposure to the BSE agent that were evaluated include
  - Potential cattle exposure through BSE-contaminated feed on the farm
  - Potential human exposure through BSE-contaminated beef products
- Allows the determination of main factors protecting against the amplification or the spread of the BSE agent within their borders


Exogenous Sources of BSE
Contamination
Mislabeling
Misfeeding
Blood meal
Dose Response
Exposure
Disease Development
Animal Feed
Slaughter
Human Food
Other animals
Rendering
Export
Out

Summary

- Common themes for biostressor RA often include the complexity of the problem
- Added complexity comes from the intrinsic characteristics of biological stressors
  - Ability to grow, die, evolve….
- Managing the tension between complexity and utility is likely to remain an ongoing challenge for the field of risk assessment for biostressors

Example References

Campylobacter

- The Netherlands - Nauta et al (2007). Risk Anal. 27(4):845-861
- Denmark - Rosenquist et al (2003). Int J Food Microbiol. 83(1):87-103
- UK – Hartnett (2001). Human infection with Campylobacter spp. from chicken consumption: a quantitative risk assessment (PhD thesis). University of Strathglyde, Glasgow, UK.
- Canada – Fazil et al. (1999). Quantitative Risk assessment model for Campylobacter jejuni in chicken. 10th International Workshop on CHRO. abstract CF10, pp 65.

Import Risk Assessment FMD

- Hartnett et al (2007). Risk Anal. 27(1):187-202
- Wooldridge et al (2007). Rev. sci. tech. Off. int. Epiz., 2006, 25 (1), 105-117

BSE

- Available at http://www.fsis.usda.gov/Science/Risk_Assessments/index.asp