Transmission pathways and comparative ranking of exotic and endemic diseases

Javier Guitian

Learning objectives and session outline

Translate risk questions into risk pathways amenable to systematic risk assessment.

Understand the need to prioritize diseases and approaches available to that end.

Session outline:

- Risk questions
- Risk pathways
- Ranking of diseases
Risk pathways

As discussed in lecture 1, as part of entry assessment and exposure we need to describe the biological pathways for introduction of the hazard and exposure to the hazard following introduction. This involves identifying the sequency of events leading to the undesired outcome (introduction of the hazard, exposure to the hazard).

Often, we use event flow diagrams for visual representation of the risk pathways (i.e. of the sequence of events leading to the undesired outcome), they help us illustrating the specific paths through which the undesired outcome can develop and identifying alternative paths leading to the same outcome.

These diagrams also provide a basis to guide the collection of data and evidence.
For an animal that is introduced in the importing country to be infected, 4 events must happen:

i) Infected
ii) False negative in country of origin
iii) No clinical signs in quarantine
iv) Not detected as positive in destination country

We can obtain the probability that an animal introduced in the country is infected as the product of the probabilities of the above four events.

\[ P(\text{that an animal introduced in the country is infected}) = P_1 \times P_2 \times P_3 \times P_4 \]
Risk pathway example


Ranking of diseases: for what purpose?

Resources available for surveillance are obviously limited while new hazards continue to emerge / re-emergence and changes in production and consumption practices, globalization and international trade, among others, alter the risk posed by specific hazards.

Prioritization / ranking exercises can provide evidence upon which decisions can be made on which specific pathogens should be targeted for surveillance.
Ranking of diseases: how?

Formal risk assessments can help us evaluating whether the risk posed by certain hazard (or hazard-species / hazard-product combinations) is high enough to require surveillance activities. Some tools have been designed for that purpose including some amenable to “rapid risk assessment”.

Example 1

Rapid risk assessment tool (RRAT) to prioritize emerging and re-emerging livestock diseases for risk management

- Rapid risk assessment tool (RRAT)
- Aim is to inform risk managers on incursion risk of multiple livestock diseases.
- Provides information on i) risk, ii) main sources of incursion, iii) change of risk over time.
- Provides a “semiquantitative risk score”.
- Makes use of country-specific disease data in WOAH annual reports.
Rapid risk assessment tool (RRAT) to prioritize emerging and re-emerging livestock diseases for risk management

Clazien J. de Vos*, Ronald Petie, Ed G. M. van Klink and Manon Swanenburg
Wageningen Bioveterinary Research, Wageningen University & Research, Lelystad, Netherlands


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Pathways are different for live animals (animal route) and animal products (product route)

"Animal route"

"Product route"
Rapid risk assessment tool (RRAT) to prioritize emerging and re-emerging livestock diseases for risk management

Rules to assign specific countries to a risk class (out of 7 different classes)


Example 2

Rapidly assessing the risks of infectious diseases to wildlife species

- Rapid risk assessment tool (RRAT)
- Aim is to prioritize risk posed by livestock pathogens to wildlife.
- Applied to the case of the endangered saiga antelope.

https://royalsocietypublishing.org/doi/10.1098/rsos.181043

Predicting the likelihood of rare events is increasingly demanded by risk managers. A key challenge is dealing with different types of uncertainty, including epistemic uncertainties (lack of knowledge), stochasticity (inherent randomness) and natural variation. One potentially catastrophic event which is impacted by high levels of all three of these uncertainty types is the transmission of livestock pathogens to wildlife, particularly for endangered species. There is often a lack of basic information, e.g., about a given pathogen’s presence in local livestock populations or the susceptibility of a given wildlife species to infection by the pathogen. We adapted the OIE (World Organisation for Animal Health) risk assessment framework to rapidly assess and prioritize the risks of livestock pathogens for wildlife, taking account of epistemic uncertainties, stochasticity, seasonal movement of animals and interaction between different species at different spatial and temporal scales. We demonstrate the approach using the endangered saiga antelope (*Saiga tatarica tatarica*) as a case study. We conclude that, in general, transmission events are likely to be rare and limited to small geographical areas; however, their impact could be high. Brucella spp. and foot-and-mouth disease virus are among those most likely to be transmitted from livestock to the Betpak-Dala saiga population.
Example 2
Rapidly assessing the risks of infectious diseases to wildlife species

- Rapid risk assessment tool (RRAT)
- Aim is to prioritize livestock pathogens based on the risk they pose to wildlife.
- Applied to the case of the endangered saiga antelope.

Risk pathway for exposure

Likelihood of exposure depends on the “space-time” distance between livestock and saiga, which changes during the year.

https://royalsocietypublishing.org/doi/10.1098/rsos.181043
In the absence of epidemiological, microbiological or outbreak data, systematic identification of the hazards and food products posing the higher risk to the consumers is challenging. It is usually in Low- and Middle-Income Countries (LMICs), where the burden of foodborne disease is highest that data tend to be particularly scarce. In this study, we propose qualitative risk-ranking methods for pathogens and food products that can be used in settings where scarcity of data on the frequency/concentration of pathogens in foodstuff is a barrier towards the use of classical risk assessment frameworks. The approach integrates the existing knowledge on foodborne pathogens, manufacturing processes and intrinsic/extrinsic properties of food products with key context-specific information regarding the supply chain(s), characteristics of the Food Business Operators (FBOs) and cultural habits to identify: (i) the pathogens that should be considered as a “High” food safety priority and (ii) the food products posing the higher risk of consumer exposure to microbiological hazards via the oral (ingestion) route.
Source and type of knowledge used to inform prioritization of hazards and food products.

[Flowchart image]


Table 4

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>RmO (a)</th>
<th>PmO (a)</th>
<th>PmE (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olives-olive oil</td>
<td>HIGH</td>
<td>MODERATE</td>
<td>VERY LOW</td>
</tr>
<tr>
<td>Kokosmeat</td>
<td>HIGH</td>
<td>MODERATE</td>
<td>VERY LOW</td>
</tr>
<tr>
<td>Fruiter</td>
<td>HIGH</td>
<td>MODERATE</td>
<td>VERY LOW</td>
</tr>
<tr>
<td>Flavored milk</td>
<td>HIGH</td>
<td>MODERATE</td>
<td>EXTREMELY LOW</td>
</tr>
<tr>
<td>Jams</td>
<td>HIGH</td>
<td>MODERATE</td>
<td>EXTREMELY LOW</td>
</tr>
<tr>
<td>Khoa</td>
<td>HIGH</td>
<td>MODERATE</td>
<td>EXTREMELY LOW</td>
</tr>
<tr>
<td>Butterscot</td>
<td>HIGH</td>
<td>LOW</td>
<td>VERY LOW</td>
</tr>
<tr>
<td>Daiolk</td>
<td>HIGH</td>
<td>LOW</td>
<td>VERY LOW</td>
</tr>
<tr>
<td>Biscuits</td>
<td>HIGH</td>
<td>LOW</td>
<td>VERY LOW</td>
</tr>
<tr>
<td>Crisps</td>
<td>HIGH</td>
<td>LOW</td>
<td>VERY LOW</td>
</tr>
<tr>
<td>Milk powder</td>
<td>HIGH</td>
<td>LOW</td>
<td>LOW</td>
</tr>
<tr>
<td>Egyptian cheese</td>
<td>HIGH</td>
<td>LOW</td>
<td>LOW</td>
</tr>
<tr>
<td>Milk</td>
<td>n.a.</td>
<td>MODERATE</td>
<td>VERY LOW</td>
</tr>
<tr>
<td>Rosemary</td>
<td>n.a.</td>
<td>MODERATE</td>
<td>VERY LOW</td>
</tr>
<tr>
<td>Cream</td>
<td>n.a.</td>
<td>MODERATE</td>
<td>EXTREMELY LOW</td>
</tr>
<tr>
<td>Nigella</td>
<td>n.a.</td>
<td>MODERATE</td>
<td>EXTREMELY LOW</td>
</tr>
<tr>
<td>Jeans powder</td>
<td>n.a.</td>
<td>LOW</td>
<td>EXTREMELY LOW</td>
</tr>
<tr>
<td>Kepliy</td>
<td>n.a.</td>
<td>LOW</td>
<td>EXTREMELY LOW</td>
</tr>
<tr>
<td>Milk powder</td>
<td>n.a.</td>
<td>LOW</td>
<td>LOW</td>
</tr>
<tr>
<td>Biscuit</td>
<td>n.a.</td>
<td>LOW</td>
<td>EXTREMELY LOW</td>
</tr>
<tr>
<td>Biscuits Increases</td>
<td>n.a.</td>
<td>n.a.</td>
<td>EXTREMELY LOW</td>
</tr>
<tr>
<td>Reconstituted milk</td>
<td>n.a.</td>
<td>n.a.</td>
<td>EXTREMELY LOW</td>
</tr>
<tr>
<td>Reconstituted milk</td>
<td>n.a.</td>
<td>n.a.</td>
<td>EXTREMELY LOW</td>
</tr>
<tr>
<td>Standard milk</td>
<td>n.a.</td>
<td>n.a.</td>
<td>EXTREMELY LOW</td>
</tr>
</tbody>
</table>

Results of applying the approach to the dairy sector of Andhra Pradesh (India)

Example 3

Microbiological risk ranking of pathogens and food products settings

Matheus A. E. R. Chagas de Araujo
Yamimoto Cavalcante Pedreira G. T. T. T.
Thiago Sousa J. P. F. T. T. T. T.
Sorina peu T. T. T. T. T. T.

Table 4
Risk ranking of dairy products. Dairy products are classified as “Extremely Low”, “Low”, “Moderate” or “High” risk of contamination according to the microbiological risk assessment. The table provides the risk level associated with each product category and the probability of contamination.

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>RISK</th>
<th>PROBABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheese</td>
<td>Low</td>
<td>0.01</td>
</tr>
<tr>
<td>Yogurt</td>
<td>Low</td>
<td>0.02</td>
</tr>
<tr>
<td>Ice cream</td>
<td>Moderate</td>
<td>0.05</td>
</tr>
<tr>
<td>Milk</td>
<td>High</td>
<td>0.10</td>
</tr>
</tbody>
</table>


Recent review of disease ranking tools

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doi:10.2903/sp.efsa.2022.EN-7578

Literature review on disease ranking tools, their characterisation, and recommendations for the method to be used by EFSA

ENETWILD-consortium, Ezio Ferroglio, Alessandra Avagnina, Patrice Barroso, Francesco Benatti, Beatriz Cardoso, Azahara Gomez, Catarina Goncalves, Aleksija Neimanis, Manuela Fonseca, Carmen Ruiz Rodriguez, Rachele Vada, Joaquin Vicerite, Stefania Zanet, Dolores-Gavir-Wildin

Studies mostly used one of six methodologies to prioritise disease risks:
- Bibliometric index
- Delphi technique
- Multi-criteria decision analysis (MCDA)
- Qualitative algorithms
- Questionnaires
- Multi-dimensional matrix.

Most of the studies included in this review followed a broadly similar approach to risk ranking: identifying diseases for ranking, identifying assessment criteria, weighing criteria, scoring diseases against criteria, and producing a ranked list of diseases.

Methods have advantages and disadvantages


Additional documents and reading

