Royal Veterinary College
University of London

WOAH Collaborating Centre for
Risk Analysis & Modelling

Animal Disease Risk Assessment and Risk Management & Simulation Exercises
Abu Dhabi - October 2023

# Transmission pathways and comparative ranking of exotic and endemic diseases

Javier Guitian

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## 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

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## 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.

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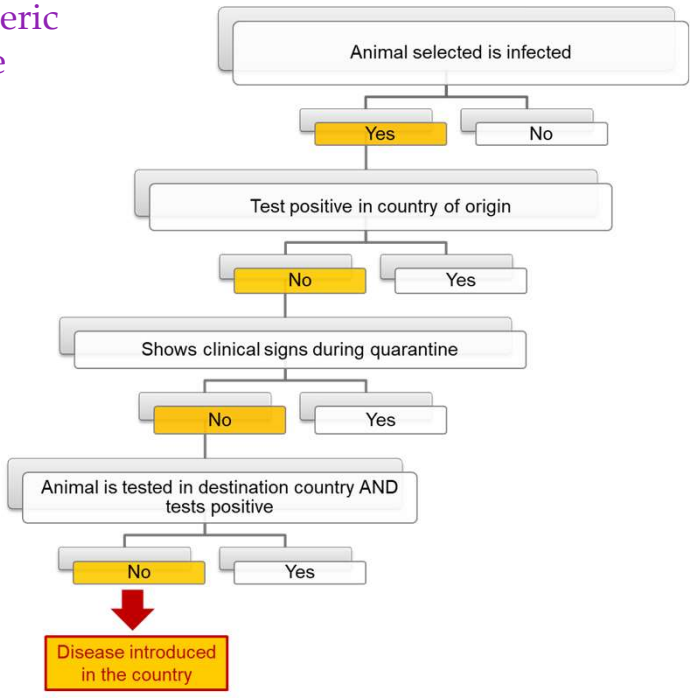
## Risk pathway: generic example of disease introduction

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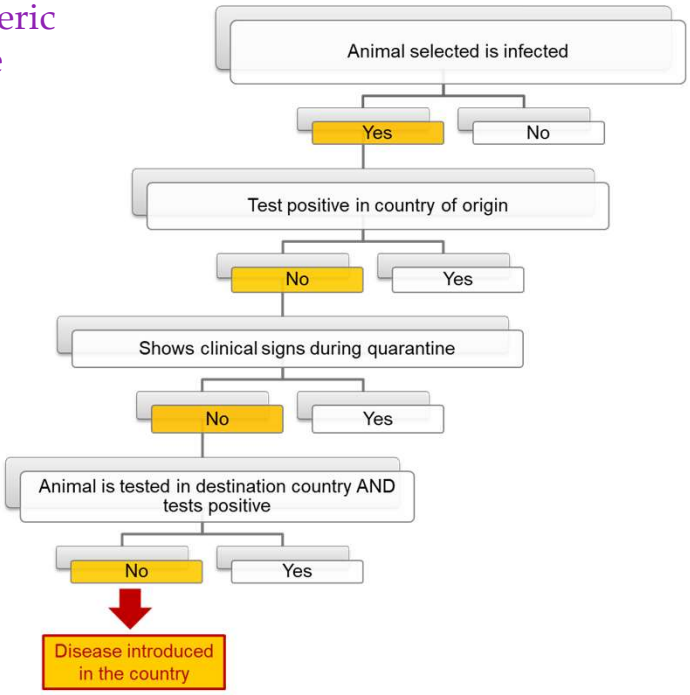
## Risk pathway: generic example of disease introduction




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.

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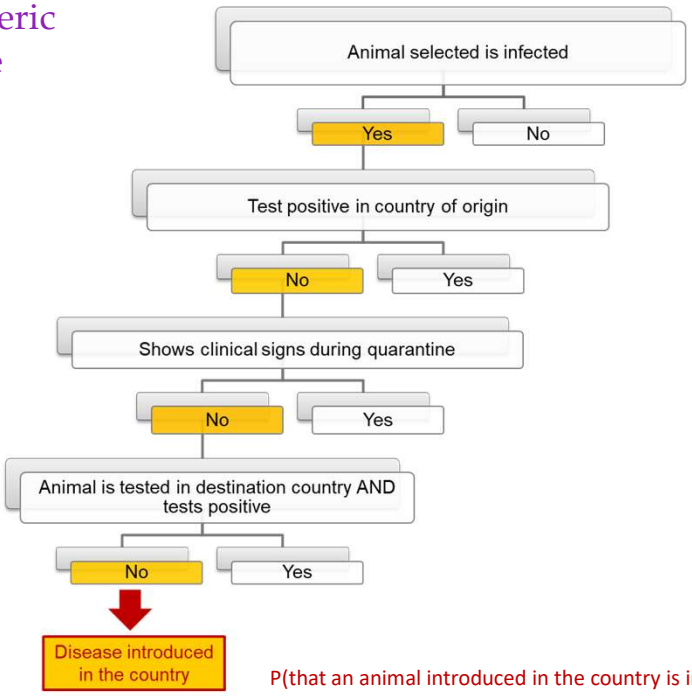
## Risk pathway: generic example of disease introduction




P1=P(infected)

P2=P(false negative O)

P3=P(subclinical)

P4=P(no positive test D)

P(that an animal introduced in the country is infected) = P1 × P2 × P3 × P4

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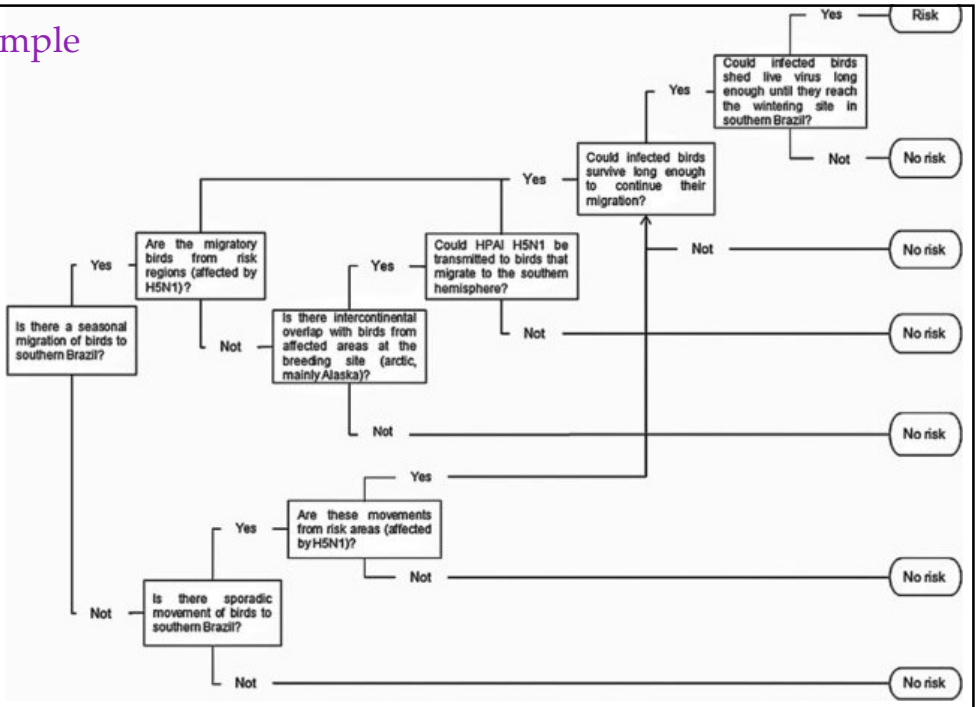
## Risk pathway example

Corbellini LG, Pellegrini DC, Dias RA, Reckziegel A, Todeschini B, Bencke GA. Risk assessment of the introduction of H5N1 highly pathogenic avian influenza as a tool to be applied in prevention strategy plan. Transbound Emerg Dis. 2012 Apr;59(2):106-16. doi: 10.1111/j.1865-1682.2011.01246.x. Epub 2011 Jul 24. PMID: 21787379.

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## 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.

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## 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”.

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## Example 1

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

- 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.

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## Example 1

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https://www.frontiersin.org/articles/10.3389/fvets.2022.963758/full

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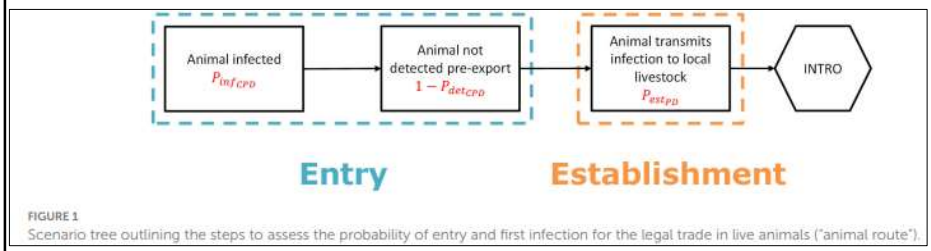


FIGURE 1
Scenario tree outlining the steps to assess the probability of entry and first infection for the legal trade in live animals ("animal route").

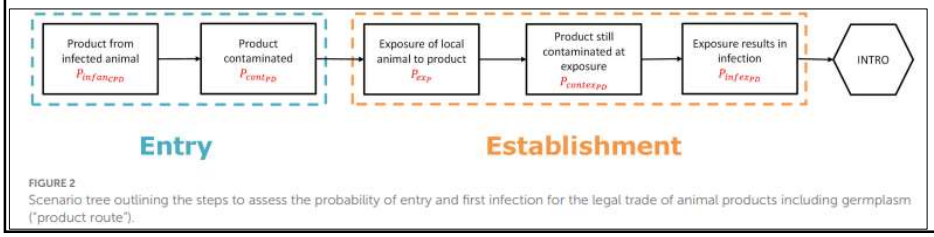


FIGURE 2
Scenario tree outlining the steps to assess the probability of entry and first infection for the legal trade of animal products including germplasm ("product route").

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

"Animal route"

"Product route"

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

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

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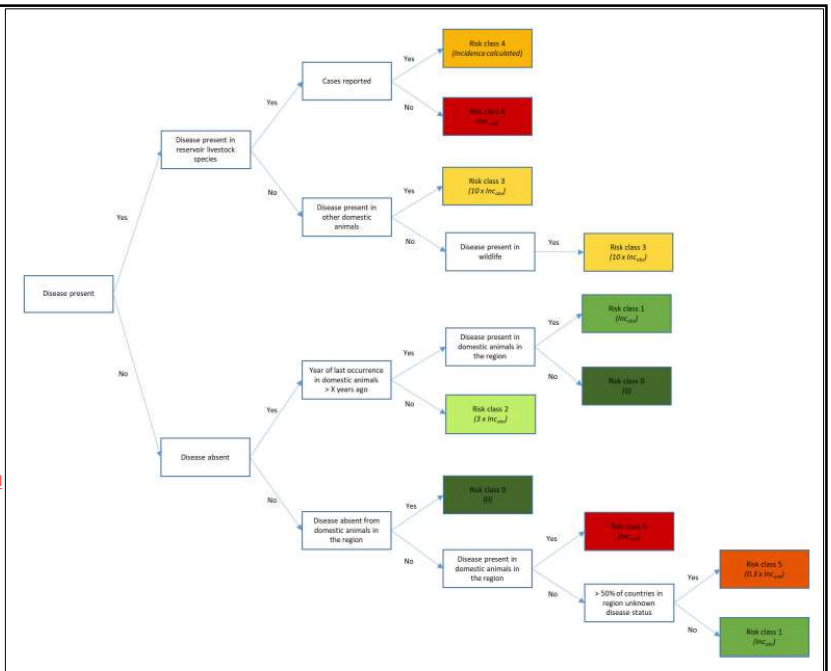


FIGURE 3
Decision tree to assign countries to one out of seven risk classes regarding disease incidence, considering the information available in the OIE annual reports (7).

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## Example 2

## Rapidly assessing the risks of infectious diseases to wildlife species

Wendy Beauvais[1,2], Steffen Zuther[3,4], Chantal Villeneuve[1], Richard Kock[1] and Javier Guitian[1]

[1]Royal Veterinary College, Hatfield, UK
[2]Cornell University College of Veterinary Medicine, Ithaca, NY, USA
[3]Association for the Conservation of Biodiversity of Kazakhstan, Astana, Kazakhstan
[4]Frankfurt Zoological Society, Frankfurt am Main, Germany

WB, 0000-0001-7634-3331

- 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.

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- Rapid risk assessment tool (RRAT)
- Aim is to prioritize livestock pathogens based on the risk they pose to wildlife.
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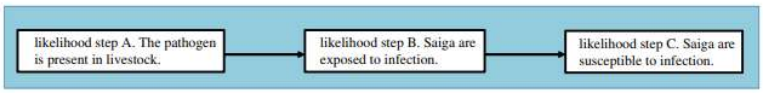


Risk pathway for exposure

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

| The time that had elapsed after the livestock left, and before the saiga arrived ($t$) | The distance between the location where saiga arrive, and the location were livestock had been ($d$). | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 m | 50 m | 100 m | 500 m | 1000 m | 10 km | 50 km |
| 1 h | | | | | | | |
| 1 day | | | | | | | |
| 1 week | | | | | | | |
| 1 month | | | | | | | |
| 3 months | | | | | | | |

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Risk by season, area and disease

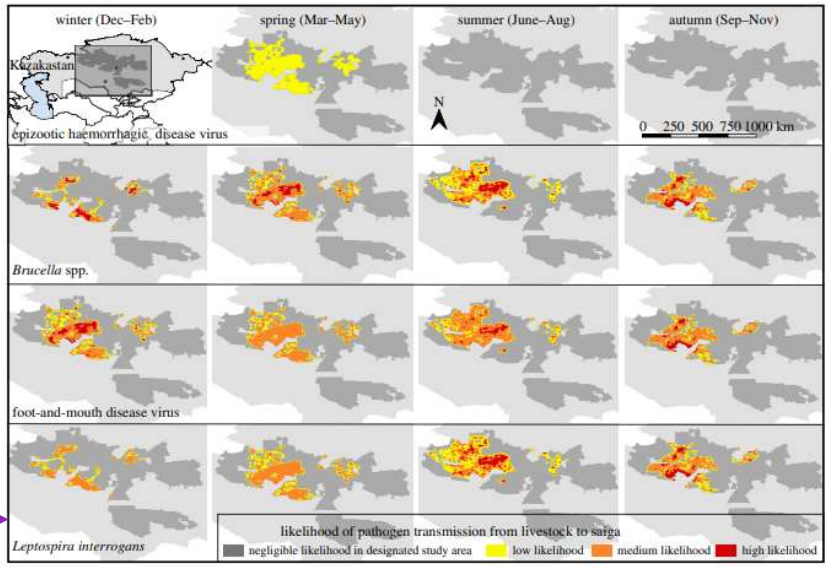


**Figure 5.** Maps of the study area in rangelands of Betpak-Dala saiga showing likelihood of saiga being exposed and susceptible t different livestock pathogens.

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

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## Example 3

ELSEVIER

Food Control
Volume 141, November 2022, 109152

### Microbiological risk ranking of foodborne pathogens and food products in scarce-data settings

Matteo Crotta[a], Bhagyalakshmi Chengat Prakashbabu[a], Hannah Holt[a], Ben Swift[a], Venkata Chaitanya Pedada[b], Thahir Basha Shaik[b], Paviter Kaur[c], Jasbir Singh Bedi[d], Srinivasa Rao Tumati[b], Javier Guitian[a]

*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.*

https://www.sciencedirect.com/science/article/pii/S0956713522003450?via%3Dihub

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Source and type of knowledge used to inform prioritization of hazards and food products.

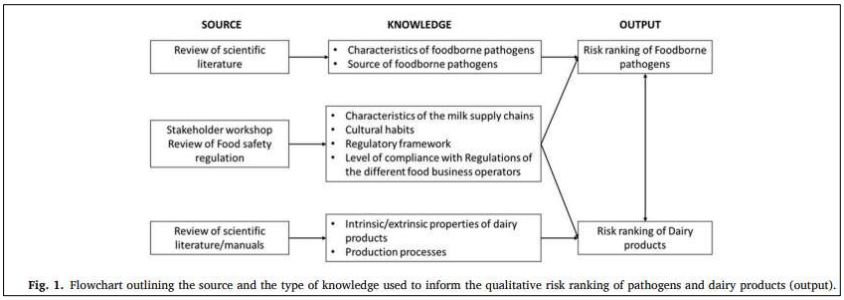


Fig. 1. Flowchart outlining the source and the type of knowledge used to inform the qualitative risk ranking of pathogens and dairy products (output).

https://www.sciencedirect.com/science/article/pii/S0956713522003450?via%3Dihub

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

**Table 4**
Risk ranking of dairy products. Dairy products are classified as "Extremely low", "Very low", "Low", "Moderate" or "High" risk of consumer exposure to microbiological hazard; classification is informed by integrating the intrinsic/extrinsic characteristics of the products with the additional risk of microbiological contamination arising from the FBO. n.a. = product not normally produced/retailed by the FBO.

| PRODUCT | FBO1 | FBO2 | FBO3 |
|---|---|---|---|
| Chhana-murki | HIGH | MODERATE | VERY LOW |
| Kalakand | HIGH | MODERATE | VERY LOW |
| Paneer | HIGH | MODERATE | VERY LOW |
| Flavoured milk | HIGH | MODERATE | EXTREMELY LOW |
| Junnu | HIGH | MODERATE | EXTREMELY LOW |
| Khoa | HIGH | MODERATE | EXTREMELY LOW |
| Buttermilk | HIGH | LOW | VERY LOW |
| Burfi | HIGH | LOW | VERY LOW |
| Dahi | HIGH | LOW | VERY LOW |
| Ice cream | HIGH | LOW | VERY LOW |
| Kulfi | HIGH | LOW | VERY LOW |
| Lassi | HIGH | LOW | VERY LOW |
| Mishti dahi | HIGH | LOW | VERY LOW |
| Peda | HIGH | LOW | VERY LOW |
| Gulabjamun | HIGH | LOW | EXTREMELY LOW |
| Yogurt | n.a. | LOW | VERY LOW |
| Ghee (butter) | HIGH | n.a. | n.a. |
| Milk cake | n.a. | MODERATE | VERY LOW |
| Rasmalai | n.a. | MODERATE | VERY LOW |
| Cream | n.a. | MODERATE | EXTREMELY LOW |
| Rasgulla | n.a. | MODERATE | EXTREMELY LOW |
| Junnu powder | n.a. | LOW | EXTREMELY LOW |
| Kalajamun | n.a. | LOW | EXTREMELY LOW |
| Milk powder | n.a. | LOW | EXTREMELY LOW |
| Ghee (cream) | n.a. | LOW | EXTREMELY LOW |
| Basundi | n.a. | LOW | VERY LOW |
| Condensed milk | n.a. | n.a. | EXTREMELY LOW |
| Pasteurised milk | n.a. | n.a. | EXTREMELY LOW |
| Recombined milk | n.a. | n.a. | EXTREMELY LOW |
| Reconstituted milk | n.a. | n.a. | EXTREMELY LOW |
| Standardised milk | n.a. | n.a. | EXTREMELY LOW |
| Toned milk | n.a. | n.a. | EXTREMELY LOW |
| UHT lassi | n.a. | n.a. | EXTREMELY LOW |
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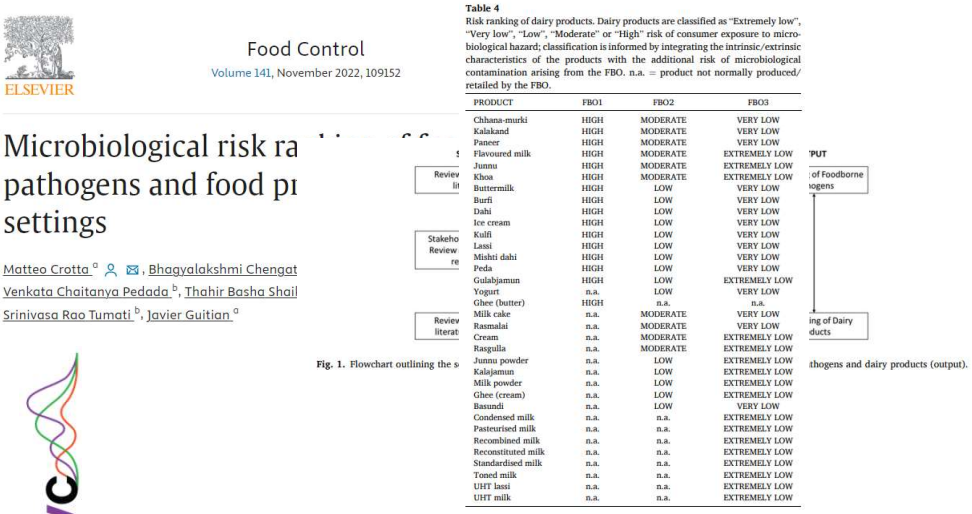

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Fig. 1. Flowchart outlining the s… …thogens and dairy products (output).

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## Recent review of disease ranking tools

**EXTERNAL SCIENTIFIC REPORT**

APPROVED: 13 September 2022

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[1], Ezio Ferroglio, Alessandra Avagnina, Patricia Barroso, Francesco Benatti, Beatriz Cardoso, Azahara Gómez, Catarina Goncalves, Aleksija Neimanis, Manuela Poncina, Carmen Ruiz Rodríguez, Rachele Vada, Joaquín Vicente, Stefania Zanet, Dolores-Gavier-Widén

https://efsa.onlinelibrary.wiley.com/doi/pdf/10.2903/sp.efsa.2022.EN-7578

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EXTERNAL SCIENTIFIC REPORT

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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.

https://efsa.onlinelibrary.wiley.com/doi/pdf/10.2903/sp.efsa.2022.EN-7578

*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.*

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*Methods have advantages and disadvantages*

Disease ranking tools

- In summary:
  - For a comprehensive risk ranking including novel, emerging and established infections, ECDC recommends MCDA or Delphi methods, which provide comprehensive methods for risk ranking. If resources are restricted, limiting the number of criteria or the number of diseases for ranking should be considered.
  - H-index or qualitative algorithm are recommended when a rapid or large-scale risk ranking for large number of pathogens is needed or as a scoping exercise to generate an initial ranking for further study.
  - In case of emerging infections with little published data, ECDC states that h-index can indicate a level of professional interest/concern which may be used as an informal proxy measure of disease impact.
  - Qualitative algorithms are particularly useful in emerging infections where decisions may be more based on expert opinion than epidemiological data, and to identify gaps in knowledge or areas for further work that could lead to improved evidence for future decisions, for the latter, questionnaires can also be used.
  - MCDA can incorporate information from a variety of sources, which is useful in emerging infections where information is sparse and there is less certainty about the potential impact of the disease. Also, new information can be incorporated as it emerges, without needing to re-run the entire ranking exercise.
  - Finally, we evidenced many approaches rather than specific methods, protocols or tools, or a mix or combination of them. Every study has its specificities (but in some cases methodologies were replicated, e.g., in a different region/country). All tools, regardless of methodology, are reliant on the quality and availability of evidence upon which to base judgements. Multi-criteria decision analysis (MCDA) and Delphi techniques are the frameworks that better fit the sequence of logical steps and can be used in comprehensive ranking exercises. MCDA reproducibility an approach with potential to be developed centrally at a European level, and then adapted to suit local context within Member States.

https://efsa.onlinelibrary.wiley.com/doi/pdf/10.2903/sp.efsa.2022.EN-7578

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## Additional documents and reading

- Example of rapid risk assessment tool to prioritize livestock diseases for risk management: de Vos CJ, Petie R, van Klink EGM, Swanenburg M. Rapid risk assessment tool (RRAT) to prioritize emerging and re-emerging livestock diseases for risk management. Front Vet Sci. 2022 Sep 7;9:963758. doi: 10.3389/fvets.2022.963758. PMID: 36157188; PMCID: PMC9490411.
- Example of rapid risk assessment tool to prioritize diseases based on risk posed to wildlife: Beauvais W, Zuther S, Villeneuve C, Kock R, Guitian J. Rapidly assessing the risks of infectious diseases to wildlife species. R Soc Open Sci. 2019 Jan 16;6(1):181043. doi: 10.1098/rsos.181043. PMID: 30800356; PMCID: PMC6366200.
- EFSA external scientific report: https://efsa.onlinelibrary.wiley.com/doi/pdf/10.2903/sp.efsa.2022.EN-7578

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