

World Organisation for Animal Health

Australian Aid

Training Workshop on Animal Disease Surveillance

Risk-Based Approach and Practical applications to Animal Health Surveillance

Why, How, and When to Use It

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Opening – Quick show of hands

Your country wishes to maximize the probability of early detection of a newly introduced transboundary animal disease. However, resources are available to actively inspect only 10% of farms.

- Where would you allocate most of your surveillance effort?
  - Randomly across farms
  - Border areas
  - Quarantine stations/border inspection posts
  - High-density production areas
  - Live animal markets



Learning objectives



Following this presentation, we expect you to:

- **Understand** the principles of risk-based approach and where it can be applied in planning and designing animal health surveillance
- **Identify situations** where risk-based surveillance (RBS) adds value
- **Describe key steps** in designing an RBS system
- **Recognize strengths and limitations** of RBS

Presentation outline

- **Why** do we *need* Risk-Based Surveillance (RBS) ?
- What do we love in RBS?
- **What is RBS**? Comparison table with conventional surveillance
- **When** we should use RBS? (surveillance objectives)
- Core design process including need for risk assessment
- **Examples** of RBS designs for early detection and facilitate control
  - Demonstration of freedom→ Day 2
- Benefits and challenges associated with RBS
- Take-home messages
- Further readings

Why do we need Risk-Based Surveillance (RBS) ?

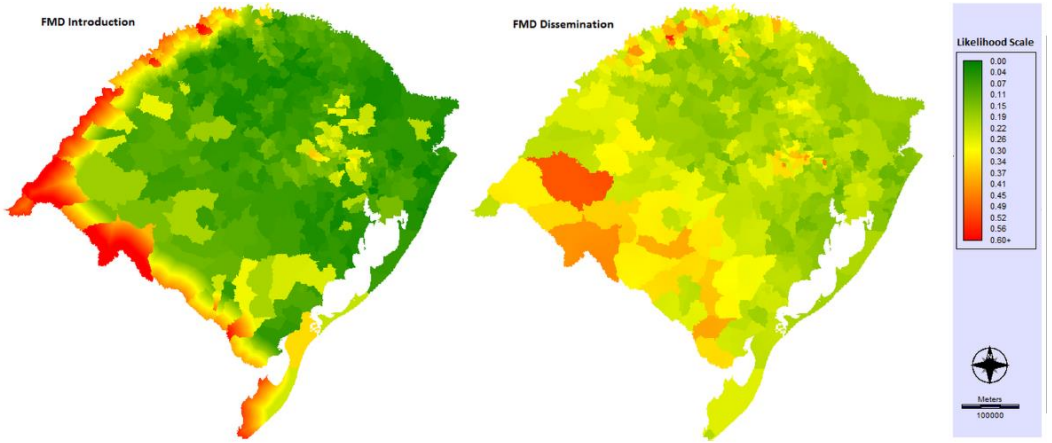


Fig 3. Likelihood of FMD introduction and FMD dissemination maps in Rio Grande do Sul.

https://doi.org/10.1371/journal.pone.0178464.g003

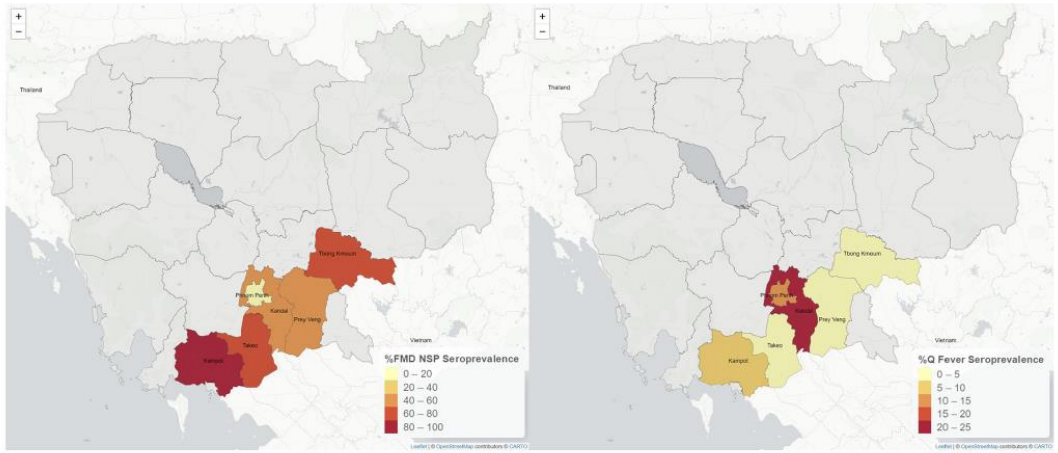


Fig 4. True FMDV NSP and Q Fever seroprevalence at the provincial level. Map shapefiles sourced from https://www.diva-gis.org/gdata.

https://doi.org/10.1371/journal.pntd.0011244.g004

- Disease occurrence is not random
- Risk distribution is heterogenous
  - Few hotspots generating most risks
- Some populations contribute disproportionately to TADs introduction, spread or persistence
- Resources are limited (*everywhere!*)
- Better targeting can improve surveillance efficiency
- International guidance/standards increasingly encourages surveillance that is fit-for-purpose and efficient.

Understanding risks is a pre-requisite for RBS

What do we  in RBS

- Set priorities so that resource use is optimised

- Improve efficiency
  - by collecting more information at same cost, **or**
  - the same information at a reduced cost

- Consider probability of the hazard (e.g. disease) occurring

- **Could also consider the impact or consequences** of disease
  - If the disease has a greater impact in the dairy sector, it might be more efficient to target surveillance efforts there
  - Focus on units that are highly connected and where any introduction of disease would spread rapidly through the population e.g. production systems with a high level of biosecurity where units are highly connected, e.g. swineherds at the top of the breeding pyramid, grandparent poultry flocks etc.
  - Particularly important for early detection (less, for demonstration of freedom)

What is Risk-Based Surveillance?

« Surveillance that allocates effort to populations, locations or periods with higher probability of disease occurrence or detection »

Sampling approaches	Disease prevalence (P) in sample	Animals to be sampled	Surveillance Sensitivity
Representative	= $P_{population}$	Ref	Ref Known, quantifiable
Risk-based	> $P_{population}$	= or ↘	= or ↗ Known, quantifiable (if assumptions are correct)
Biased	≠ $P_{population}$	+/-	Unknown, cannot be reliably quantified

The probability that surveillance will detect at least one infected animal if the population is infected

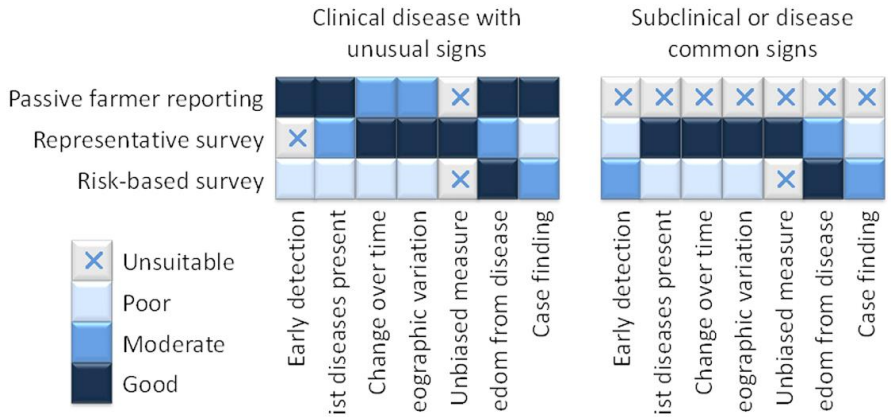
By selecting animals with higher probability of being infected or detected if there are infected, the sensitivity of the surveillance can be increased without increasing the total number of animals to be tested

Improved efficiency, by collecting more information at same cost, or the same information at a reduced cost

Manual of Basic Animal Disease Surveillance, Angus Cameron (2012)

Conventional vs Risk-Based Surveillance

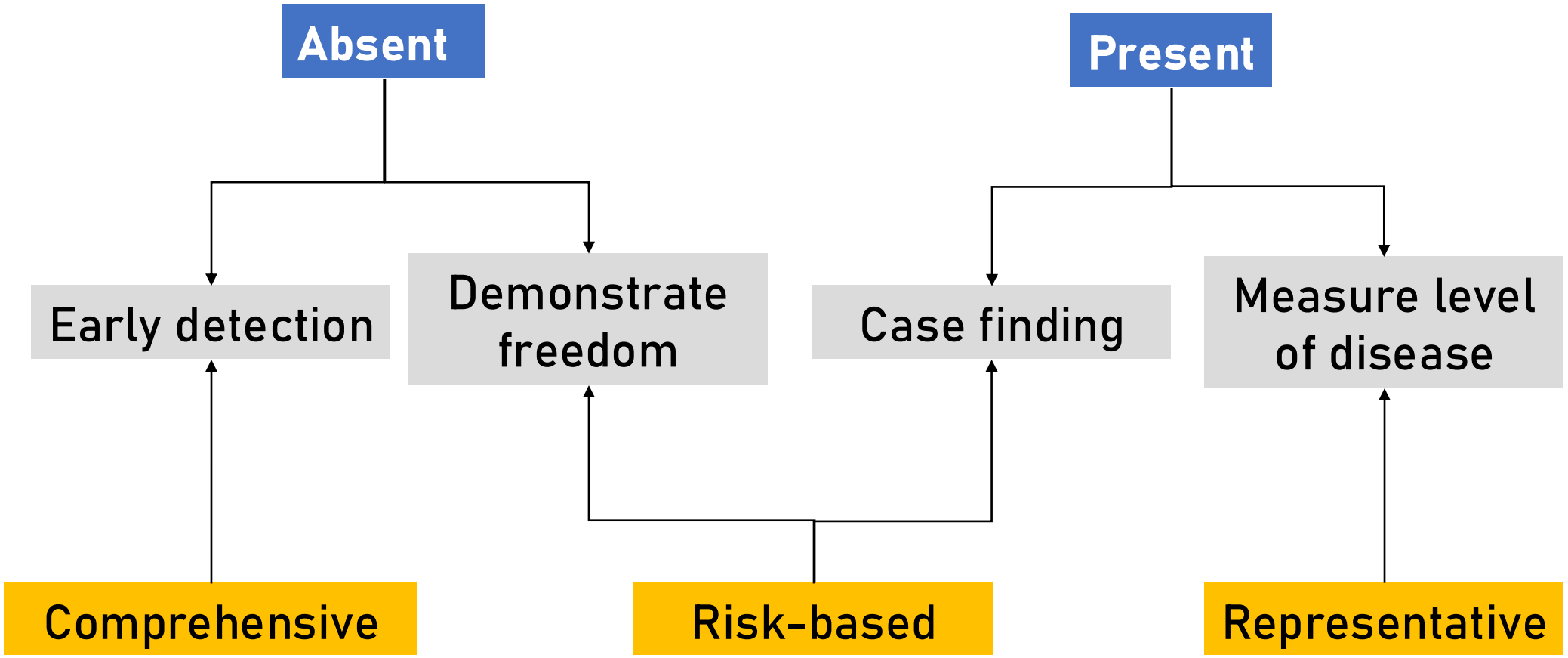
Conventionnal	Risk-Based
Methods available, well validated, commonly accepted	Data availability ? Analytical methods under development. Specific for each region. Acceptance ?
Representative Large coverage	Targeted Low coverage
Often larger sample	Potentially smaller sample / more efficient
Greater operational costs / expensive	Potentially smaller costs / higher cost-benefit ratio
Good for **prevalence estimates**	Good for **early detection (rare events)** and/or **demonstration of freedom**



Manual of Basic Animal Disease Surveillance, Angus Cameron (2012)

Neither is "better"; they serve different objectives.

When should you use RBS?



Disease/Pathogen



Objective



Sampling



Adapted from Manual of Basic Animal Disease Surveillance, Angus Cameron (2012)

Core design process



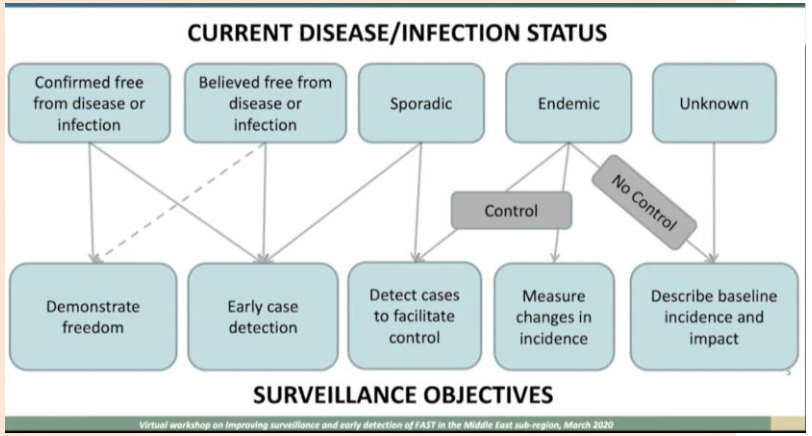
Document your decisions, assumptions and calculations in a surveillance plan

- Support collaborative work, iterative process
- Support knowledge transfer
- For trading partners – support transparency on decision mades, methods used to allow assessing the accuracy and degree of uncertainty of any assumptions and input parameters used as part of the design

Core design process

Define hazard(s) and surveillance objective(s) → Identify risk factors → Rank populations → Allocate surveillance effort → Evaluate and update

- Current disease status
- Hazard prioritization (based on impact)
- Target Single vs multiple hazards
- Primary vs secondary surveillance system objectives **
  - Early case detection
  - Substantiate freedom from disease or infection
  - Describe the baseline level, distribution and impact
  - Describe changes in the level of disease in a population
  - Detect cases to facilitate control



Source: EuFMD, 2022. Introduction to Animal Health surveillance, Nick Lyons for a Virtual Workshop for the Middle East, Dr Nick Lyons discusses the types and differences of surveillance for FAST diseases. https://youtu.be/uiC_-RTGTLM?si=BQPmmlzl6zjx83vr

Risk factors

A broad range of factors can be used as long as they are associated with disease occurrence, i.e. they are risk factors.

Define hazard(s) and surveillance objective(s) → **Identify risk factors** → Rank populations → Allocate surveillance effort → Evaluate and update

Geographic and natural factors



POROUS BORDER AREA
LIVESTOCK/FARM DISTRIBUTION
WETLANDS
BIRD MIGRATION CORRIDOR
…

Management factors



HISTORICAL OUTBREAKS
BIOSECURITY LEVEL
COMMUNAL GRAZING
WILDLIFE INTERACTION
ANTIMICROBIAL USAGE
….

Risk factor

Variables, conditions, or events that increase the likelihood of a pathogen entering, establishing, or spreading within a new population or geographic region.

Socioeconomic factors



FESTIVALS / TEMPORAL CONSIDERATIONS
TRANSBOUNDARY TRADE
ANIMAL MOVEMENTS / CONNECTIVITY
LIVE ANIMAL MARKET
…

Herd level



PRODUCTION SYSTEM
HERD SIZE
…

Animal level



SPECIES
BREED
AGE
VACCINATION STATUS
…

Risk factors - Examples



HPAI Surveillance

Risk hotspots:

- Duck production systems
- Wetland areas
- Live bird markets
- Migratory bird habitats

ASF Surveillance

Risk hotspots:

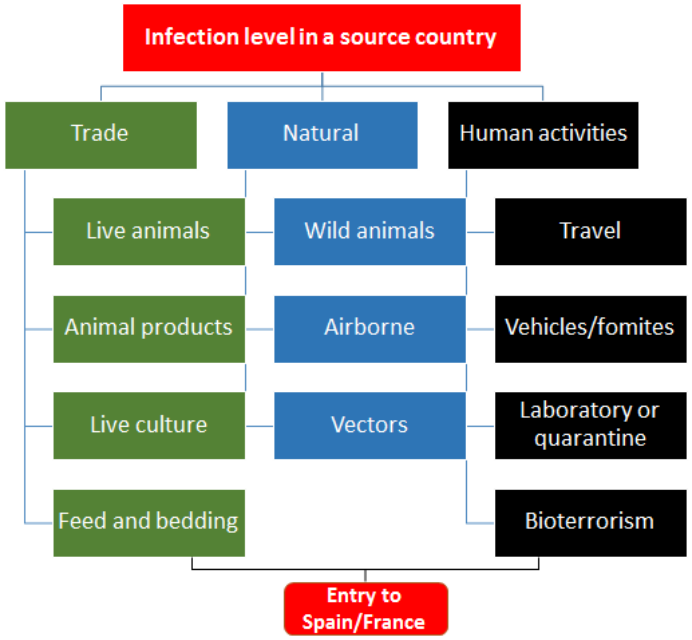
- Backyard pig production
- Border districts
- Areas with swill feeding
- High pig movement corridors

How to collect information about the risks

Define hazard(s) and surveillance objective(s) → **Identify risk factors** → Rank populations → Allocate surveillance effort → Evaluate and update

- Studies quantifiying the associaton between dissease occurrence and the factor under consideration (crude estimates shoud be used)
- Expert opinion
- Participatory approaches
- Anterior Risk Assessment
  - Can be rapid, (semi)qualitative
  - Ranking/weighting risk factors via expert opinion
  - Use Value Chain approach and outline Risk Pathways to quantify likelihood of introduction or spread, and identify hotspots
    - Design implications

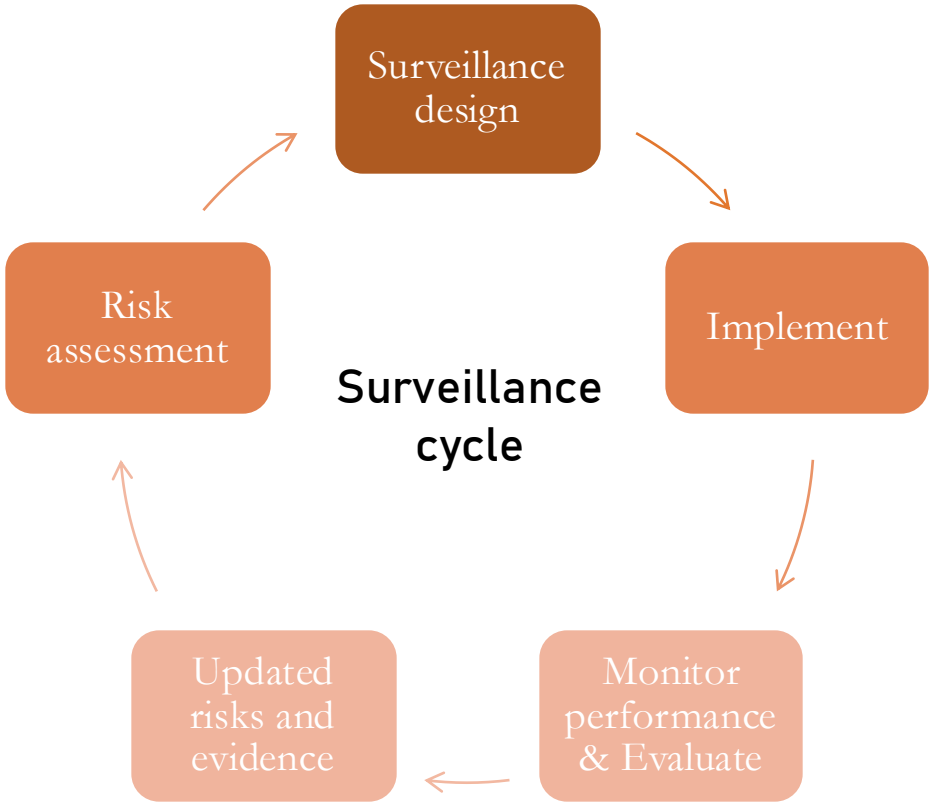
- Based on the "best available data"
- Inherent to it, UNCERTAINTY
- It takes time, it takes a team



Source: All theoretical introduction pathways for FMD and Similar Transboundary Animal Diseases pathogens, Omid Nekouej, EuFMD

RBS is an adaptative process





- Disease risks change over time
  - trade patterns
  - production systems
  - seasonality
  - disease distribution
  - control measures
- Evaluate whether surveillance is achieving its objective
  - Early detection?
  - Case finding?
  - Demonstration of freedom?
- Update assumptions, risk factors and sampling strategy
- Reallocate surveillance effort when new evidence becomes available

Risk Assessment methods can be used to inform several elements of RBS systems

Surveillance Planning Steps	Conventional surveillance	RBS
Objective		
Hazard selection	The hazard of interest (virus, bacteria, disease syndrome) is selected	**The hazard of interest (virus, bacteria, disease syndrome) is selected using risk assessment.**
Case definition		
Test procedures		
Target population(s)		
Region, location	Usually selected at random	**Selected based on risk factor studies.**
Species	Selected based on hazard biology	**Selected based hazard biology and risk factor studies.**
Farms	Usually selected at random	**Selected based on risk factor studies.**
Animals	Usually selected at random	**Selected based on risk factor studies.**
Timing Interval	Usually selected based on the epidemiology of the agent and considering infection dynamics.	**Usually selected based on the epidemiology of the agent and considering infection dynamics, risk factor studies.**
Statistical analysis, outcome	Standard statistical analyses	**Standard statistical analyses and additional analyses for comparison to conventional surveillance**
Communication of results		
Consequence of positive outcome		
Feedback mechanism	Feedback to the people involved in data collection is essential for quality assurance.	**Feedback to the people involved in data collection is essential for quality assurance. Inclusion in risk assessment.**

Adapted from Targeted/Risk-based disease surveillance, Animal Disease risk assessment and risk management and simulation exercises, Abu Dhabi, October 2023, Javier Guitan, RVC

RBS strategies – design example (1/3)

- Cambodia
- HPAI (H5N1)
- Objective: Early detection to facilitate control and minimize impact (animal health & public health)
- Poultry (chicken & ducks) trade networks, SNA

“

Understanding poultry movement is essential to develop appropriate and targeted surveillance recommendations for active HPAI/H5N1 surveillance programs […] premises involved in poultry trade are closely linked via middlemen carrying live poultry over long distances and that the unidirectional movement of poultry into Phnom Penh make LBM in Phnom Penh a potential hub for the spread of H5N1. Domestic poultry outbreaks of H5N1 have occurred in the areas of the main network and therefore ***Phnom Penh LBM, namely wet markets where live poultry are slaughtered at the market, would be ideal for surveillance and control***

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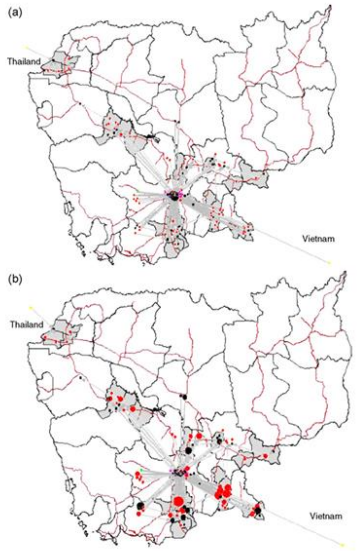


Fig. 2. Chicken trading network in Cambodia with nodes weighted by (a) in-degree and (b) out-degree. The figure illustrates node sizes weighted by in-degree (a) above and the same network weights nodes by OUT-degree (b) below. Node color indicates location type (black = market, purple = stock house, red = rural farm or household, light green = commercial farm, grey = semi-commercial farm, yellow = foreign source), ties show direction as indicated by the arrow and tie strength is indicated by the thickness of the arrow (the thicker the arrow, the more poultry passing between the two nodes). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

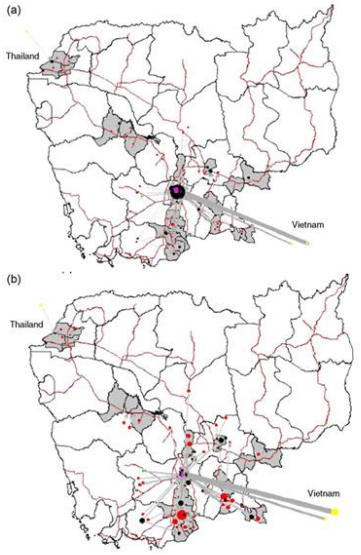


Fig. 3. Duck trading network in Cambodia with nodes weighted by (a) in-degree and (b) out-degree. The figure illustrates node sizes weighted by in-degree (a) above and the same network weights nodes by out-degree (b) below. Node color indicates location type (black = market, purple = stock house, red = rural farm or household, light green = commercial farm, grey = semi-commercial farm, yellow = foreign source), ties show direction as indicated by the arrow and tie strength is indicated by the thickness of the arrow (the thicker the arrow, the more poultry passing between the two nodes). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

Van Kerkhove MD, Vong S, Guitian J, Holl D, Mangtani P, San S, Ghani AC. Poultry movement networks in Cambodia: implications for surveillance and control of highly pathogenic avian influenza (HPAI/H5N1). Vaccine. 2009 Oct 23;27(45):6345-52. doi: 10.1016/j.vaccine.2009.05.004. PMID: 19840671.

RBS strategies – design example (2/3)

- Targeted RBS of cattle in South of England to detect possible incursion of BTV-8
- Note how the subpopulation to be sampled is selected to increase likelihood of detection: sampling in months, geographical regions, species, farms and animals at highest risk.

Methods

A risk-based, cross-sectional study was carried out in cattle in five counties on the southern coast of England in 2017. In 2018, the study was repeated using the same methodology, with increased sampling in the larger counties of Kent and Hampshire.

In 2017, it was predicted that the most likely period in which transmission of BTV could occur in the GB would be from May to October taking into account both high rates of seasonal vector activity[14] and transmission of BTV in Europe[17]: BTV RNA is detectable by RT-qPCR in blood for five months after infection,[18] therefore if blood samples were collected at the end of the season, RT-qPCR could detect evidence of infection during the highest risk period of the expected season.

Counties were used as the geographical unit of reference for the purposes of BTV monitoring and surveillance, as these are similar in size to the 45×45 km (2000 km²) units specified in Commission Implementing Decision 456/2012, and are well known units which facilitated the implementation of the sampling plans. International disease monitoring and simulations of midge movement from neighbouring countries indicated that incursions of BTV were most likely to occur along the southern coast of England. Therefore, farms along the coast of Kent, East Sussex, West Sussex, Hampshire and Dorset were the focus for sampling.

Surveillance was focused on cattle as their larger body size results in a greater range of attraction to *Culicoides* than sheep, and they are therefore more likely to be involved in virus transmission.[19 20] Additionally, cattle holdings are likely to be attractive to midges as they tend to contain a range of habitats suitable for *Culicoides* larval development, including dung heaps. A list of all registered premises with cattle was obtained from the APHA customer data base (SAM), Arc GIS (ESRI Arc GIS V.10.2) was used to identify cattle farms within 5–10 miles of the coast in each of the five counties of interest. This distance was chosen on the basis that *Culicoides* would be likely to land immediately following crossing large water bodies and that local dispersal over land is limited to relatively short flights.[21]

Large farms in areas of high cattle density were considered for inclusion in the study if they had over 20 cattle aged between six months and four years, which had never been vaccinated against BT, had been resident on the farm for more than six months and had access to pasture at dawn and dusk (as this increased the likelihood they would have been exposed to *Culicoides* due to their crepuscular adult activity profile). Farms on which cattle were home bred were prioritised for inclusion in the study as this would increase that likelihood that they would have been located in the geographic area of interest throughout the vector season and there would be complete knowledge of their vaccination history.

As there had not been an outbreak of BTV in the

Risk-based surveillance for bluetongue virus in cattle on the south coast of England in 2017 and 2018

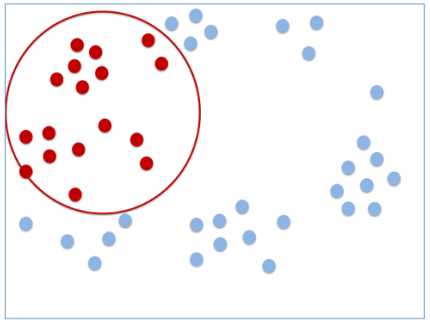
Katherine Elinor Felicity Grace ,[1] Christina Papadopoulou,[1] Tobias Floyd,[2] Rachelle Avigad,[3] Steve Collins,[4] Elizabeth White,[4] Carrie Batten,[5] John Flannery ,[5] Simon Gubbins,[6] Simon T Carpenter[7]

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7786256/pdf/vetrec-2020-106016.pdf

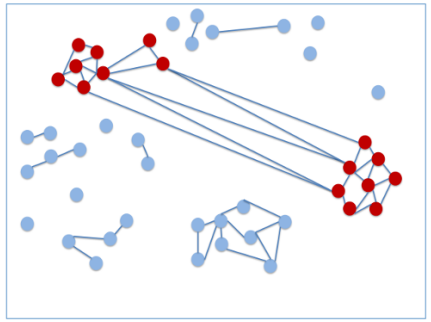
RBS strategies – design example (3/3)

- The PPR episystem approach proposes a shift in PPR surveillance and control

  - Episystem defines interconnected populations maintaining virus transmission indefinitely.
  - Undertsanding episystems allows
    - Identification of populations critical for PPR
    - Targeting surveillance and vaccination to interconnected populations rather than just geographical areas.
    - Identify how to break chains of transmission, essential for elimination.
  - Geographically based to Epidemiologically-based



Purely geographical approach – connectivity ignored.



Episystem approach – connectivity considered.

Risk-based surveillance and addressing PPR risk pathways through the episystem approach, Javier Guitan, FAO PPR Secretariat (2025)

Benefits and challenges of RB approach in surveillance

Advantages	Challenges
Cost-effective	Quality risk data required – inherent uncertainty
More sensitive	Complexity
Better use of resources	Bias
Supports freedom claims (Standards)	Need for periodic review



Note: Benefits of RB approach goes beyond surveillance
& improve preparedness/prevention and control aspects

Take-home messages for RBS design

- **Risk is rarely evenly distributed**
  - Surveillance should reflect this. Knowing the disease and associated risks is essential.
- **Start with a clear surveillance objective**
  - RBS design depends on what you are trying to achieve.
- **RBS complements** passive surveillance and outbreak investigation
  - It does not replace it.
- RBS design is a **multidisciplinary team effort** and should be an iterative process.

Further readings

- **FAO**. 2014. *Risk-based disease surveillance – A manual for veterinarians on the design and analysis of surveillance for demonstration of freedom from disease*. FAO Animal Production and Health Manual No. 17. Rome, Italy. https://epimundi.com/industry/publications/risk-based-surveillance/

- **Risk Sur**, 2014. *Best practices for risk-based and cost-effective animal health surveillance in the European Union. https://www.fp7-risksur.eu/sites/default/files/documents/publications/riskbasedsurv_BPdoc_FINAL_formatted_03.pdf*

- **Metwally, S., Drewe, J.A., Ferrari, G., Gonzales, J.L., Mclaws, M., Salman, M. & Wagner, B**. 2024. *Practical surveillance guidelines for the progressive control of foot-and-mouth disease and other transboundary animal diseases.* FAO Animal Production and Health Guidelines 36. Rome, FAO. https://doi.org/10.4060/cd2138en

Thank you

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