Targeted / Risk-based disease surveillance

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

Javier Guitian

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

1

Learning objectives and session outline

Understanding the difference between conventional and risk-based surveillance and the role of risk assessment as part of risk-based surveillance.

Session outline:

- Surveillance
- Surveillance attributes
- Surveillance types
- Risk assessment and risk-based surveillance

2

Surveillance

Surveillance

means the systematic ongoing collection, collation, and analysis of information related to animal health and the timely dissemination of information so that action can be taken. (WOAH Terrestrial Animal Health Code Glossary).

- Ongoing (not a 'one-of' activity).
- Systematic (as opposed to unplanned).
- Involves data (collection, analysis, interpretation).
- Timely dissemination to inform action (disease prevention, control).

3

Surveillance objectives

In the context of animal health, surveillance is carried out in order to inform disease prevention and control measures.

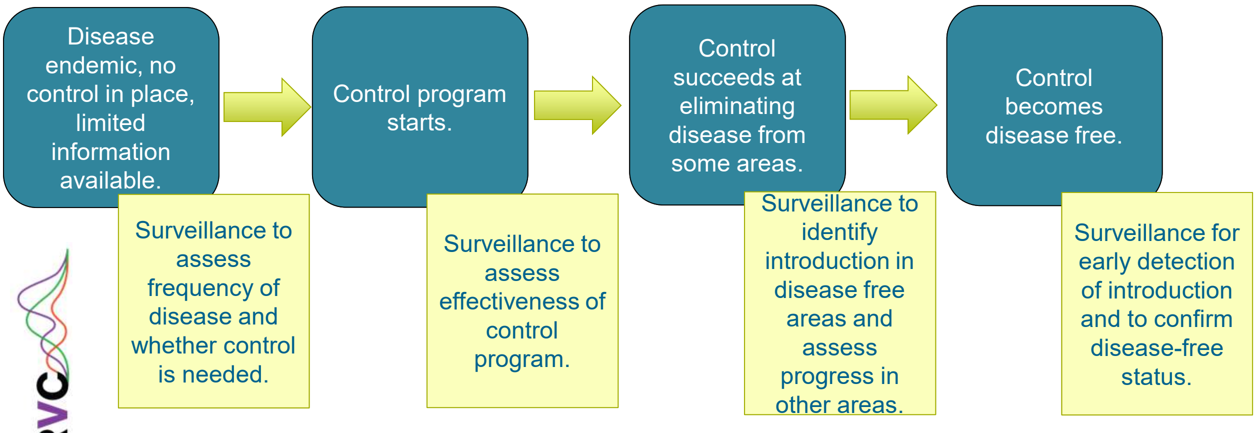
Surveillance for new and emerging diseases aims at detection, early warning and demonstration of disease freedom.

For endemic diseases, surveillance aims at assessing changes in the frequency of disease occurrence (which may result in the introduction of new controls) and evaluating the impact of control measures already in place.

4

Surveillance objectives

Objectives of surveillance change as progress is made in controlling the disease.



5

Surveillance: case definition

An animal or unit that fulfils the specific definition based on clinical, laboratory or epidemiological characteristics.

Clinical criteria: sometimes used to define "suspect cases" that become "confirmed cases" following laboratory confirmation (i.e. laboratory criteria added)

Epidemiological criteria: e.g. FMD control, farms defined as potential cases on the basis of location with respect infected farms or dangerous contacts with infected farms.

6

Surveillance attributes

1. Sensitivity
2. Timeliness
3. Positive predictive value
4. Representativeness
5. Data quality
6. Simplicity
7. Flexibility
8. Acceptability

Centers for Disease Control and Prevention (CDC) updated guidelines for surveillance system evaluation as cited in RS Hopkins and JW Buehler. Pubic Health Surveillance. Lash, Tyler, VanderWeele, Haneuse, Rothman. Modern Epidemiology. 2021.

7

Surveillance attributes

CDC updated guidelines for surveillance system evaluation as cited in RS Hopkins & JW Buehler. Pubic Health Surveillance. Lash, Tyler, VanderWeele, Haneuse, Rothman. Modern Epidemiology.

1. **Sensitivity**
   Extent to which the system identifies the targeted events.
   e.g. a surveillance system targeting cattle exhibiting neurological signs compatible with BSE in a country will have high sensitivity if a high proportion of cattle exhibiting neurological signs compatible with BSE (targeted events) are identified by the surveillance system.
   When evaluating trends, consistency of sensitivity is also important.
2. **Timeliness**
   Timeliness entails quick flow of information from the occurrence of the event of interest to action. Different health issues under surveillance may have different requirements in terms of the speed of this process depending on the urgency of the measures to be taken.
3. **Positive predictive value**
   To what extent are the events being detected the events being targeted.
   e.g. if the surveillance system relies on identification criteria (clinical signs, results of diagnostic tests…) of low specificity, a high proportion of the events are detected are in fact 'false positives', resulting in low positive predictive value.

8

4. **Representativeness**
   To what extent the events being detected represent animals, herds, flocks… with the condition of interest in the target population with respect to different characteristics of interest (e.g. backyard vs. commercial flocks, turkey vs. chicken flocks…).
   Representativeness is compromised if the sensitivity of the system differs systematically for different subgroups in the population (i.e. different ability of the system to detect events in different types of flocks).
5. **Data quality**
   Accuracy (what is being measured or recorded is 'close' to the true value) and completeness of record-level data.
6. **Simplicity**
   Simple systems tend to be more reliable as there are fewer points at which things may go wrong.
7. **Flexibility**
   Flexible systems are more easily adaptable to changes (e.g. in diagnostic procedures, disease frequency or ways in which information is being collected).
8. **Acceptability**
   Surveillance systems involve many stakeholders and their engagement, which relies on perception of the value of the system, is critical.

9

Surveillance types

Passive vs. Active surveillance

Passive surveillance:
- Based on reporting (by the public, farmers, veterinarians…)
- Simpler and cheaper
- Variable sensitivity, completeness… depending on awareness, motivation

Active surveillance:
- Based on structured sampling
- More costly but usually more complete and less variable quality
- Includes for example risk-based surveillance, sentinel surveillance

10

Surveillance types

Sentinel surveillance

Usually involves continuous monitoring of herds selected based on risk, to be able to detect introduction of infection as early as possible, it has been used for example for early detection of vector-borne diseases.

Transboundary and Emerging Diseases

ORIGINAL ARTICLE

Post-outbreak African horse sickness surveillance: A scenario tree evaluation in South Africa's controlled area

John Duncan Grewar, Thibaud Porphyre, Evan S. Sergeant, Camilla Theresa Weyer, Peter Neil Thompson

First published: 08 April 2020 | https://doi.org/10.1111/tbed.13566

Preventive Veterinary Medicine
Volume 106, Issues 3–4, 1 October 2012, Pages 235-243

Bluetongue sentinel surveillance program and cross-sectional serological survey in cattle in Belgium in 2010–2011

I. Vangeel[a], I. De Leeuw[b], E. Méroc[a], F. Vandenbussche[b], F. Riocreux[a], J. Hooyberghs[c], M. Raemaekers[c], P. Houdart[c], Y. Van der Stede[a], K. De Clercq[b]

11

Surveillance types

Syndromic surveillance

Relies on non-specific diagnostic indicators, such as one or more clinical signs or production parameters, as opposed to laboratory confirmation of disease. This approach may result in low positive predictive value and as a result too many 'false alarms'.

PLOS | NEGLECTED TROPICAL DISEASES

RESEARCH ARTICLE

Enhanced surveillance for Rift Valley Fever in livestock during El Niño rains and threat of RVF outbreak, Kenya, 2015-2016

Harry Oyas[1©], Lindsey Holmstrom[2©], Naomi P. Kemunto[3], Matthew Muturi[4], Athman Mwatondo[4], Eric Osoro[4], Austine Bitek[4], Bernard Bett[5], Jane W. Githinji[1], Samuel M. Thumbi[3], Marc-Alain Widdowson[6], Peninah M. Munyua[6], M. Kariuki Njenga[3]*

1 Veterinary Epidemiology and Economics Unit, Kenya Ministry of Agriculture, livestock and Fisheries, Nairobi, Kenya, 2 College of Veterinary Medicine, Kansas State University, Manhattan, Kansas, United States of America, 3 Washington State University Global Health Program-Kenya, Washington State University, Nairobi, Kenya, 4 Kenya Zoonotic Disease Unit, Ministry of Health and Ministry of Agriculture, Livestock and Fisheries, Nairobi, Kenya, 5 Animal and Human Health Program, International Livestock Research Institute, Nairobi, Kenya, 6 Division of Global Health Protection, United States' Centers for Disease Control and Prevention, Nairobi, Kenya

Check for updates

12

Surveillance types

Risk-based surveillance

A surveillance programme in the design of which exposure and risk assessment methods have been applied together with traditional design approaches in order to assure appropriate and cost-effective data collection.

13

Surveillance types

Risk-based surveillance

A surveillance programme in the design of which exposure and risk assessment methods have been applied together with traditional design approaches in order to assure appropriate and cost-effective data collection.

Risk based surveillance involves preferential testing in sub-populations that have higher probability of being infected.

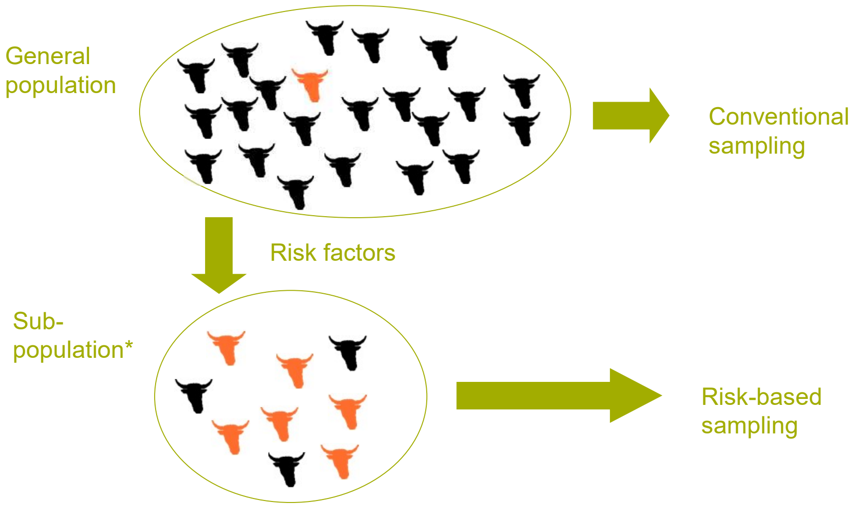
Selection of the sub-populations to be preferentially tested is informed by risk assessment.

Risk assessment methods can also be used to inform other elements of risk surveillance systems such as:

- selection of hazards
- selection of products or commodities to be tested

14

Conventional vs. risk based sampling



*if disease is present, the prevalence in this population will be highest

15

Conventional vs. risk-based surveillance (1)

Steps / elements	Conventional surveillance	Risk-based surveillance
Objectives	The objectives of a surveillance programme are a key determinant of the design.	The objectives of a surveillance programme are a key determinant of the design.
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	Case definition is based on available diagnostic procedures.	Case definition is based on available diagnostic procedures.
Test procedures	Sensitivity and specificity of the diagnostic tests are major determinants of the validity of the surveillance results.	Sensitivity and specificity of the diagnostic tests are major determinants of the validity of the surveillance results.

16

Conventional vs. risk-based surveillance (2)

Steps / elements	Conventional surveillance	Risk-based surveillance
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.

17

Conventional vs. risk-based surveillance (3)

Steps / elements	Conventional surveillance	Risk-based surveillance
Statistical analysis, outcome	Standard statistical analyses	Standard statistical analyses and additional analyses for comparison to conventional surveillance
Communication of results	A series of options are available: Oral, written, web, media etc.	A series of options are available: Oral, written, web, media etc.
Consequences of positive outcome	The action steps following positive results need to be determined and organized.	The action steps following positive results need to be determined and organized.
Feedback mechanisms	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.

18

Conventional vs. risk-based surveillance: advantages and disadvantages

Conventional

+ Methods available
+ Well validated
+ Commonly accepted
- Expensive
- Low information content (all negative)
- Not efficient

Risk-based

+ Higher benefit-cost ratio
+ More efficient
+ Suitable for rare events
- Data availability?
- Analytical methods to be developed
- Specific for each region
- Acceptance?

RVC

19

Example 1

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]

Abstract

Background Bluetongue (BT) is a viral disease of ruminants and camelids which can have a significant impact on animal health and welfare and cause severe economic loss. The UK has been officially free of bluetongue virus (BTV) since 2011. In 2015, BTV-8 re-emerged in France and since then BTV has been spreading throughout Europe. In response to this outbreak, risk-based active surveillance was carried out at the end of the vector seasons in 2017 and 2018 to assess the risk of incursion of BTV into Great Britain.

Method Atmospheric dispersion modelling identified counties on the south coast of England at higher risk of an incursion. Blood samples were collected from cattle in five counties based on a sample size designed to detect at least one positive if the prevalence was 5 per cent or greater, with 95 per cent confidence.

Results No virus was detected in the 478 samples collected from 32 farms at the end of the 2017 vector season or in the 646 samples collected from 43 farms at the end of the 2018 vector season, when tested by RT-qPCR.

Conclusion The negative results from this risk-based survey provided evidence to support the continuation of the UK's official BTV-free status.

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

20

Example 1

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

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.

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

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 and transmission of BTV in Europe…

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

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 VET RECORD | 3 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).

21

Example 2

Risk-based inspection as a cost-effective strategy to reduce human exposure to cysticerci of *Taenia saginata* in low-prevalence settings

https://parasitesandvectors.biomedcentral.com/articles/10.1186/s13071-018-2839-z

Bhagyalakshmi Chengat Prakashbabu[1*], Laura Rebecca Marshall[2], Matteo Crotta[1], William Gilbert[1], Jade Cherry Johnson[1], Lis Alban[3] and Javier Guitian[1]

Background: Taenia saginata cysticercus is the larval stage of the zoonotic parasite Taenia saginata, with a life-cycle involving both cattle and humans. The public health impact is considered low. The current surveillance system, based on post-mortem inspection of carcasses has low sensitivity and leads to considerable economic burden. Therefore, in the interests of public health and food production efficiency, this study aims to explore the potential of risk-based and cost-effective meat inspection activities for the detection and control of T. saginata cysticercus in low prevalence settings.

Methods: Building on the findings of a study on risk factors for T. saginata cysticercus infection in cattle in Great Britain, we simulated scenarios using a stochastic scenario tree model, where animals are allocated to different risk categories based on their age, sex and movement history. These animals underwent different types of meat inspection (alternative or current) depending on their risk category. Expert elicitation was conducted to assess feasibility of scenarios and provide data for economic analysis. The cost-effectiveness of these scenarios was calculated as an incremental cost-effectiveness ratio, using the number of infected carcasses detected as the technical outcome.

Results: Targeting the high-risk population with more incisions into the heart while abandoning incisions into the masseter muscles was found to reduce the total number of inspections and cost, while simultaneously increasing the number of infected carcasses found.

Conclusions: The results suggest that, under reasonable assumptions regarding potential improvements to current inspection methods, a more efficient and sensitive meat inspection system could be used on animals categorised according to their risk of harbouring T. saginata cysticercus at slaughter. Such a system could reduce associated cost to the beef industry and lower microbial contamination of beef products, improving public health outcomes.

22

Example 2

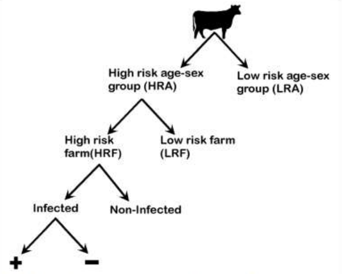


Fig. 1 Scenario tree representation of the risk-based meat inspection system. Animals are divided into different risk categories based on the presence of high-risk farms in their movement history and the age-sex category to which they belong. Each step was assumed to be independent of others

Table 2 Outcomes from simulation modelling and economic analysis for the current situation and different scenarios simulated

Outcomes	Baseline All animals undergo current inspection	Scenario A HRF&HRA: Enhanced LRF&HRA: Normal HRF&LRA: Enhanced LR: no inspection	Scenario B HRF&HRA: Enhanced LRF&HRA: Normal HRF&LRA: Normal LR: Normal	Scenario C HRF&HRA: Enhanced LRF&HRA: Normal HRF&LRA: Enhanced LR: Normal	Scenario D Enhanced inspection in all animals
Total number of infected carcasses	2354 (1645–4247)	2354 (1645–4247)	2354 (1645–4247)	2354 (1645–4247)	2354 (1645–4247)
Number of infected carcasses detected	348 (336–360)	438 (338–668)	445 (352–656)	454 (353–690)	583 (361–1091)
Percent of infected carcasses detected	15 (8–21)	19 (14–23)	19 (14–24)	19 (15–24)	25 (18–31)
Number of inspections needed to find one infected carcass	7183 (6944–7440)	4630 (3050–5997)	5605 (3822–7082)	5494 (3665–7082)	4288 (2302–6887)
Number of normal inspections	2,500,000	1,657,096	2,206,747	2,123,729	0
Number of enhanced inspections	–	375,768	293,253	376,271	2,500,000
Number of animals not inspected	0	467,136	0	0	0
Total costs in million (£)	8.53 (8.52–8.54)	7.08 (7.02–7.24)	8.63 (8.57–8.77)	8.64 (8.58–8.79)	8.99 (8.84–9.33)
X = Cost of scenario – Cost of baseline	–	-1.44 (-1.51– -1.29)	0.10 (0.04–0.23)	0.11 (0.06–0.25)	0.46 (0.32–0.79)
Y = Outcome of scenario – Outcome of baseline	–	92 (2–319)	98 (6–307)	107 (16–334)	237 (25–743)
ICER = X/Y (in million £ per carcass detected)	–	-0.013 (-0.093– -0.069)	0.001 (0.0007–0.003)	0.001 (0.0007–0.003)	0.002 (0.0009–0.008)

Abbreviations: HRF/LRF, animals with/without a history of high-risk farms in their movement respectively; HRA/LRA, animals belonging/not belonging to high risk age-sex category, respectively; LR, low risk animals
Baseline represents current situation. Median values and 95% confidence intervals of the outcomes are presentedBaseline represents current situation. Median values and 95% confidence intervals of the outcomes are presented

Note how scenario B, which selectively targets high risk farms and animals, can result in a larger number of contaminated carcases being detected at a lower cost than the baseline scenario of conventional inspection.

23

Additional documents and reading

- Example of syndromic surveillance: Oyas H, Holmstrom L, Kemunto NP, Muturi M, Mwatondo A, Osoro E, Bitek A, Bett B, Githinji JW, Thumbi SM, Widdowson MA, Munyua PM, Njenga MK. Enhanced surveillance for Rift Valley Fever in livestock during El Niño rains and threat of RVF outbreak, Kenya, 2015-2016. PLoS Negl Trop Dis. 2018 Apr 26;12(4):e0006353. doi: 10.1371/journal.pntd.0006353. PMID: 29698487; PMCID: PMC5919633.
- Example of risk-based surveillance: Grace KEF, Papadopoulou C, Floyd T, Avigad R, Collins S, White E, Batten C, Flannery J, Gubbins S, Carpenter ST. Risk-based surveillance for bluetongue virus in cattle on the south coast of England in 2017 and 2018. Vet Rec. 2020 Nov 28;187(11):e96. doi: 10.1136/vr.106016. Epub 2020 Sep 11. PMID: 32917835; PMCID: PMC7786256.
- Example of risk-based inspection: Chengat Prakashbabu B, Marshall LR, Crotta M, Gilbert W, Johnson JC, Alban L, Guitian J. Risk-based inspection as a cost-effective strategy to reduce human exposure to cysticerci of Taenia saginata in low-prevalence settings. Parasit Vectors. 2018 Apr 19;11(1):257. doi: 10.1186/s13071-018-2839-z. PMID: 29673385; PMCID: PMC5907745.

RVC

24