

World Organisation for Animal Health

Training Workshop on Animal Disease surveillance

Surveillance Methods and Their Applications in Animal Health

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12-13 November 2026
Manila, The Philippines

Learning Objectives

At the end of this presentation, participants should be able to:

- Explain the importance and purpose of animal health surveillance.
- Understand different surveillance approaches: passive, active, targeted, risk-based, syndromic, participatory
- Explain the principles and applications of each method.
- Understand sampling, diagnostic testing, data management and interpretation.
- Select appropriate surveillance methods for different animal diseases.
- Translate surveillance findings into early warning, investigation and control action

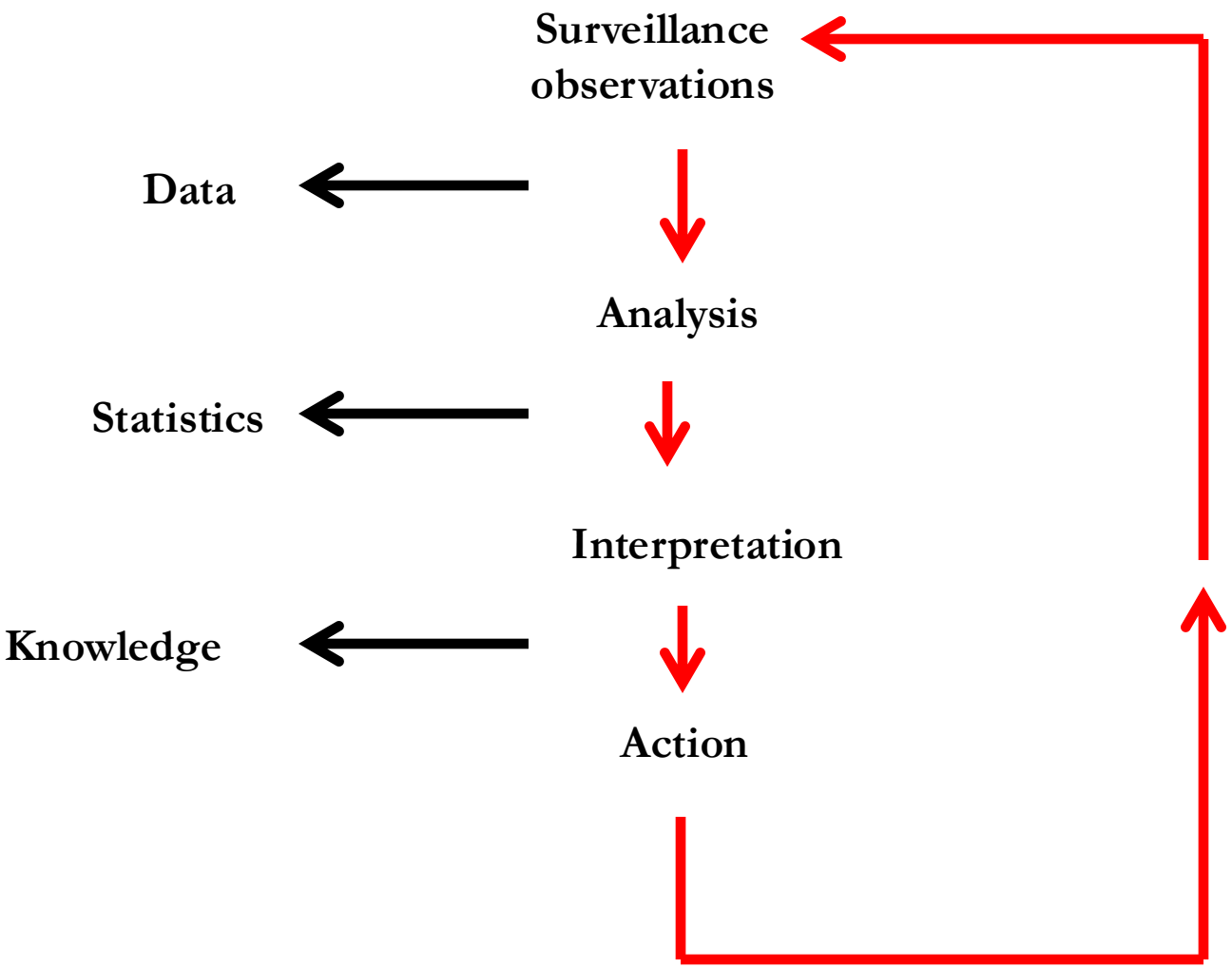
Animal Health Surveillance

- WOAH definition of surveillance:
  - ‘the systematic ongoing **collection, collation**, and **analysis of information** related to animal health, and the **timely dissemination of information** to those who need to know so that **action can be taken**.’

- Monitoring: regularly observing the health of a population to identify trends

- Surveillance: observing the health/disease status of a population and taking action when disease frequency reaches a specified threshold

The animal health surveillance 'cycle'.



Animal Health Surveillance Objectives

Early Warning

Detect incursions, outbreaks, emerging and re-emerging diseases.

Epidemiological Intelligence

Estimate prevalence, incidence, trends, seasonality and distribution.

Disease Status & Risk Management

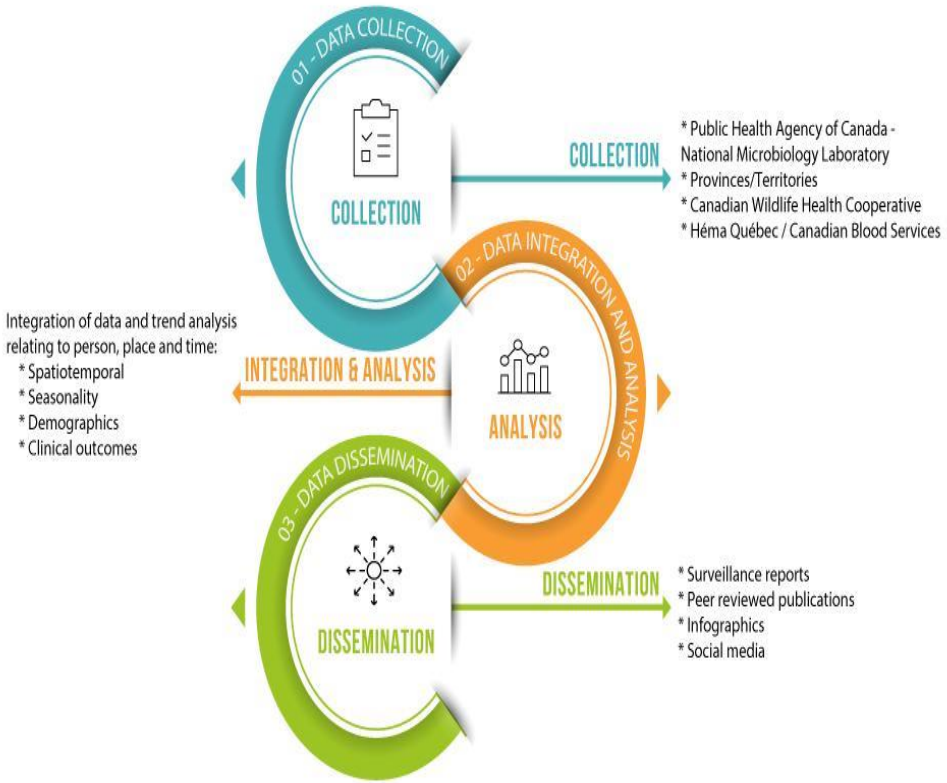
Demonstrate freedom from disease; and identify high-risk populations and systems.

Policy, Control & Trade Support

Evaluate interventions and support transparency, reporting and safe trade.

Surveillance provides the evidence needed for prevention, preparedness, response and safe trade.

Components of an Animal Health Surveillance System



Surveillance is not complete until the collected information is used for decision-making and action

- **The main components include:**
  - ✓clearly defined objectives
  - ✓definition of the hazard or health state under surveillance
  - ✓case definitions (who, what, when and where)
  - ✓definition of surveillance unit(s): regions, herds-flocks, animals
  - ✓surveillance design and sampling strategy
  - ✓data management: capture, collation and cleaning
  - ✓data analysis: setting triggers for action ; interpretation of findings
  - ✓feedback/reporting and dissemination of surveillance results to stakeholders.
  - ✓response and intervention
  - ✓monitoring and evaluation.

Defining the Surveillance Objective

A surveillance programme should clearly define:

Element	Example
Disease	Foot-and-mouth disease
Target population	Susceptible domestic livestock
Geographical area	Country or defined zone
Epidemiological/Surveillance unit	Herd or farm or Village
Objective	Demonstrate freedom from infection
Design prevalence	Specified proportion of infected herds
Confidence	Specified probability of detection
Surveillance period	Defined assessment period
Surveillance methods	Active, passive and risk-based surveillance

Purposes of Animal Health Surveillance

Disease Present

Describe Disease Occurrence

- Measure prevalence and distribution
- Identify risk factors and hotspots

Detect Cases & Trigger Action

- Detect infected animals/herds
- Support control and response measures

Disease Absent

Early Detection

- Detect exotic, emerging or re-emerging diseases
- Identify incursions rapidly

Demonstrate Freedom

- Provide evidence of disease freedom
- Support trade and market access

Key message: Surveillance objectives depend on disease status in the population.

Types of Animal Health Surveillance

- Types of surveillance system
  - active, passive
  - scanning, targeted
  - risk-based
  - syndromic
  - sentinel
  - participatory

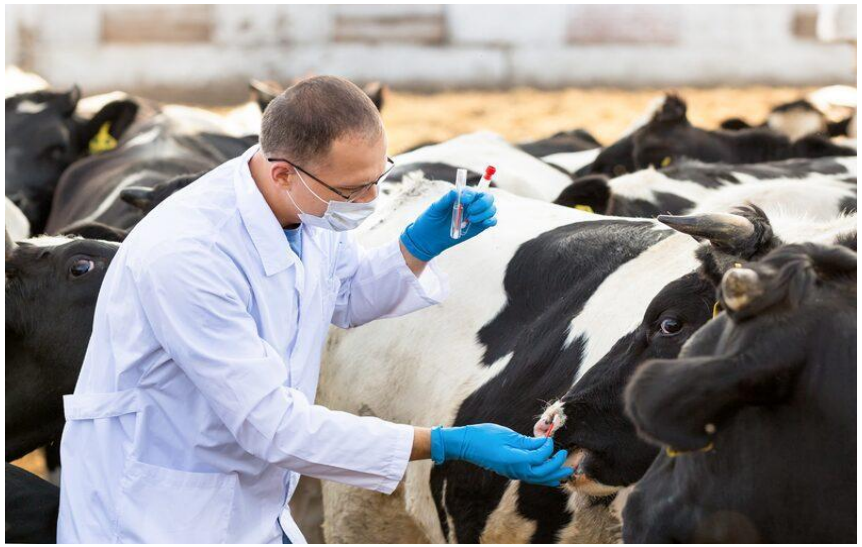




Types of Animal Health Surveillance

Active surveillance

- **The main users of the information make active efforts to collect data**
- **Activities:**
  - Visiting farms and livestock markets.
  - Conducting animal examinations.
  - Collecting blood and tissue samples.
  - Interviewing livestock owners.
  - Conducting structured surveys.



- **Examples**- Serological survey to assess the prevalence of PPR; A survey with questionnaires to identify the level of mortality on a farm.
- **Advantage**-provides high quality data and fit-for- the purpose of the program,
- **Disadvantage**- expensive; requires trained personnel, and time-consuming

Types of Animal Health Surveillance

Passive surveillance

- **Main users of the information take no action to initiate the collection of data (they just wait for data to come to them)**
- **Uses data that have already been collected for some other purpose.**
- **Data Sources:**
  - Veterinary clinics, Livestock owners, Farm managers, Abattoirs, Diagnostic laboratories, Government veterinary services
- **Examples-** a farmer disease reporting system; abattoir meat inspection data reporting
- **Advantage-** Relatively inexpensive, can provide continuous information, uses existing veterinary infrastructure.
- **Disadvantage-** data quality may not be of high quality, underreporting, delayed notification, incomplete data, dependence on disease awareness and reporting behaviour.

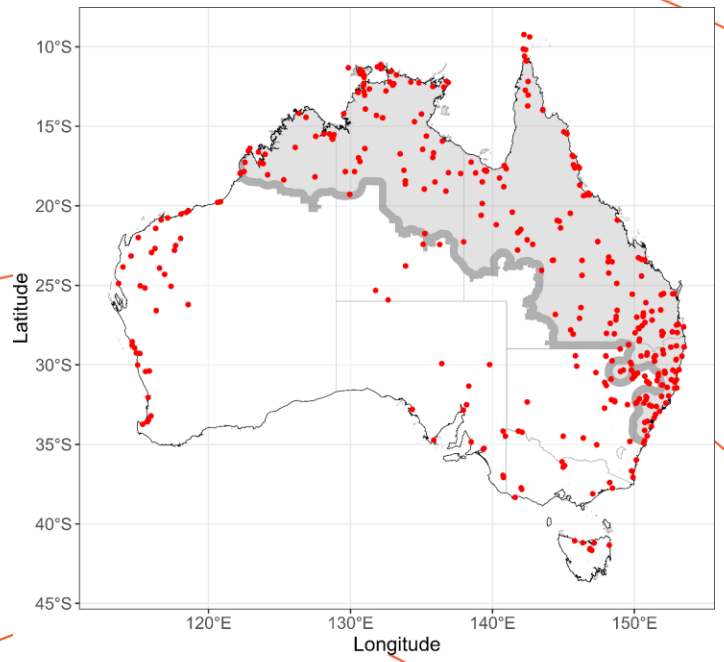
ACTIVE VERSUS PASSIVE SURVEILLANCE

Characteristics	Active	Passive
Data collection	Proactive	Routine reporting
Initiator	Surveillance authority	Reporter or observer
Cost	Relatively high	Relatively low
Sampling	Planned	Often opportunistic
Timeliness	Depends on survey design	Depends on reporting
Coverage	Can be targeted	Depends on reporting network
Main application	Prevalence estimation	Routine disease monitoring

Types of Animal Health Surveillance

Sentinel surveillance

- sentinel flocks/herds of animals from the population of interest are regularly tested for disease or antibodies to disease
- sentinels are initially free of disease at the start of the surveillance period
- when a positive is returned, it is known that the disease is circulating in the source population
- testing is focussed on just the sentinels, so cost effective



Location of sentinel herds for the National Arbovirus Monitoring Program (●).

Types of Animal Health Surveillance

Risk-based Surveillance

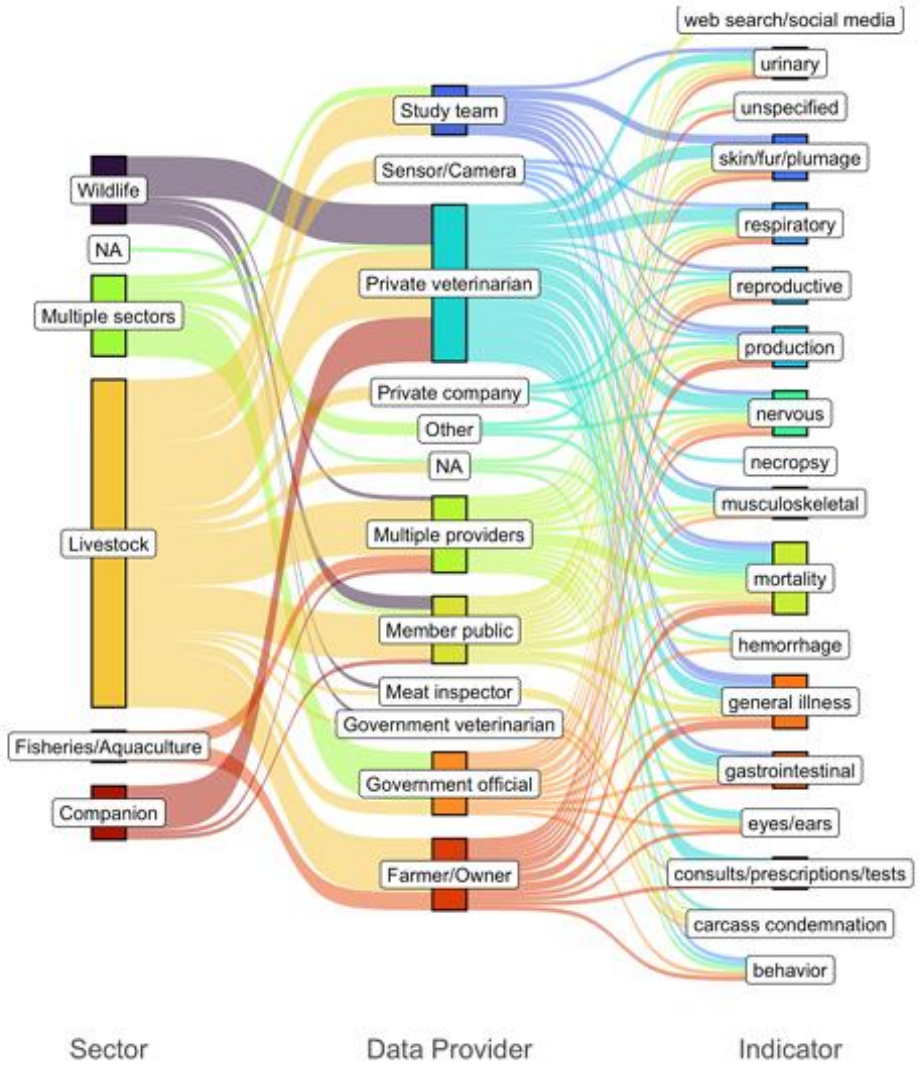
- two meanings to the word ‘risk’ in this context
  - preferential surveillance for hazards that have more serious consequences
  - preferential testing in sub-populations that have a higher risk of having disease
- you look for disease in 'high risk' locations (i.e., the places you're likely to find it)
- **Applications:**



  - FMD surveillance around livestock movement routes.
  - Avian influenza monitoring near wetlands/migratory bird habitats.
  - ASF surveillance in areas with wild boar populations.
  - Targeted surveillance at livestock border entry points.
- **Main advantage:** Efficient use of limited surveillance resources

Types of Animal Health Surveillance

SYNDROMIC SURVEILLANCE



https://www.sciencedirect.com/science/article/pii/S0167587725001175

- A syndrome is a cluster of observable clinical signs (e.g., abortion storms, acute neurological issues, high mortality) rather than a specific lab-identified pathogen
- **Limitation:** Clinical signs are often non-specific and require laboratory confirmation.

Syndrome	Possible diseases
Sudden death	Anthrax, ASF, avian influenza
Neurological signs	Rabies, Newcastle disease
Respiratory signs	FMD, influenza, respiratory infections
Reproductive disorders	Brucellosis, leptospirosis
Haemorrhagic signs	ASF, classical swine fever

Types of Animal Health Surveillance

TARGETED SURVEILLANCE

Targeted surveillance describes surveillance that is focused on a specific disease or pathogen.

Targeted surveillance in animal health is a proactive strategy that focuses monitoring, testing, and data collection on specific **high-risk populations, geographic areas, or animal sub-groups rather than surveying an entire population at random**



Example	Description	Purpose
1. Avian influenza surveillance	Testing poultry farms, live bird markets, and wild birds for avian influenza viruses.	Early detection and prevention of outbreaks.
2. Bovine tuberculosis surveillance	Testing cattle herds in areas with a history of bovine tuberculosis.	Identify infected herds and prevent disease spread.
3. Brucellosis surveillance	Testing dairy and beef cattle in regions where brucellosis is endemic.	Identify infected animals and protect public health.
4. Antimicrobial resistance surveillance	Collecting bacterial samples from livestock, poultry, and aquaculture operations and testing their antimicrobial susceptibility.	Monitor resistance patterns and guide responsible antibiotic use.
5. Foot-and-mouth disease surveillance	Monitoring livestock in border regions, areas near previous outbreaks, or regions with high animal movement.	Detect disease introduction and support rapid response.

Types of Animal Health Surveillance

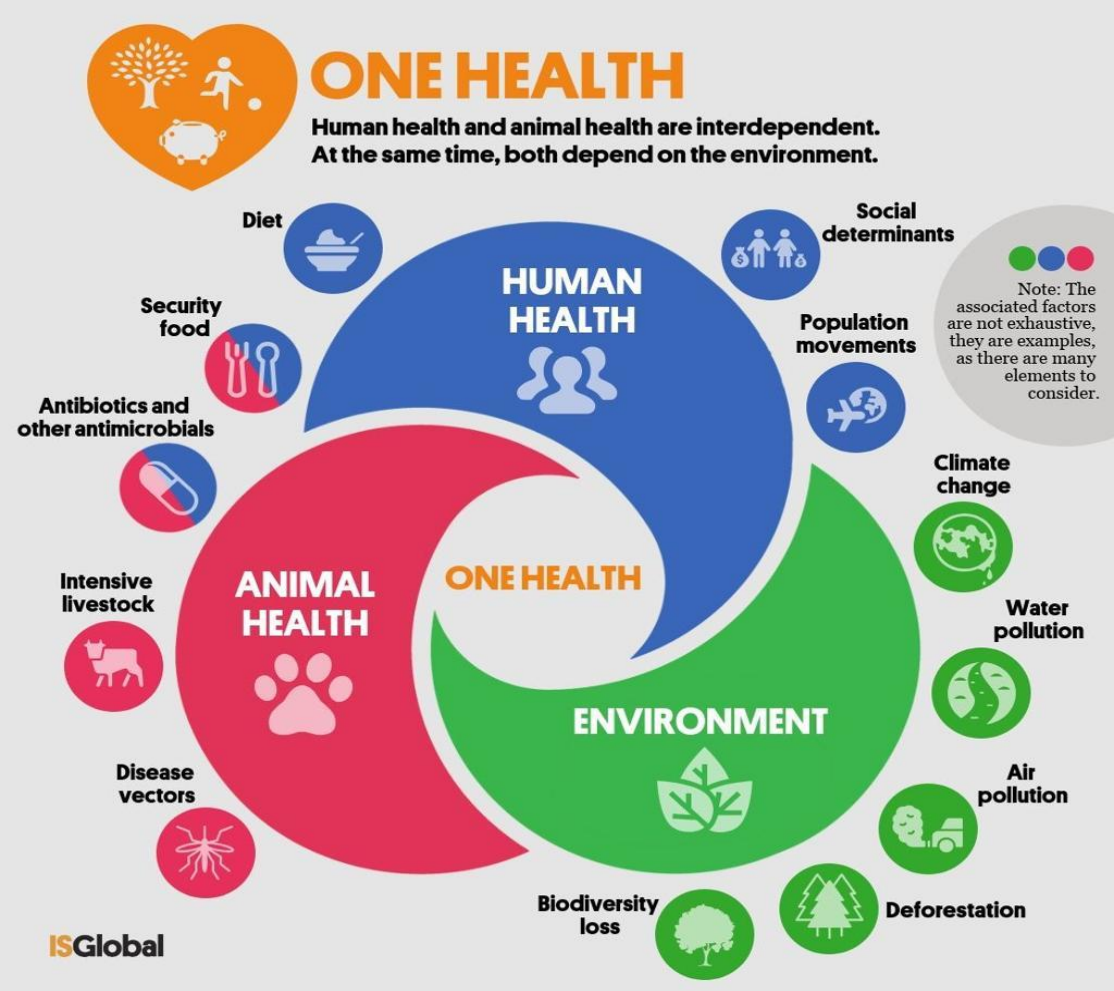
Participatory surveillance



- a form of active surveillance
- relies on community consultation; resource intensive
- provides a qualitative understanding of context and disease/response at the community level
- Techniques used:
  - community interviews, probing, Focus group discussions, transect walking and mapping
- Applications:
  - Monitoring livestock diseases in remote communities.
  - Identifying unusual livestock mortality.
  - Monitoring transboundary animal diseases.
  - Understanding local disease patterns.

Types of Animal Health Surveillance

INTEGRATED ONE-HEALTH SURVEILLANCE



Integrated surveillance combines information from animal, human and environmental health sectors.

One Health surveillance focuses on:

- Zoonotic diseases.
- Antimicrobial resistance.
- Food safety.
- Vector-borne infections.
- Emerging infectious diseases.

Examples:

- ✓Rabies surveillance in dogs and humans.
- ✓Avian influenza monitoring in poultry, wild birds and exposed humans.
- ✓Antimicrobial resistance monitoring in livestock, food and humans.

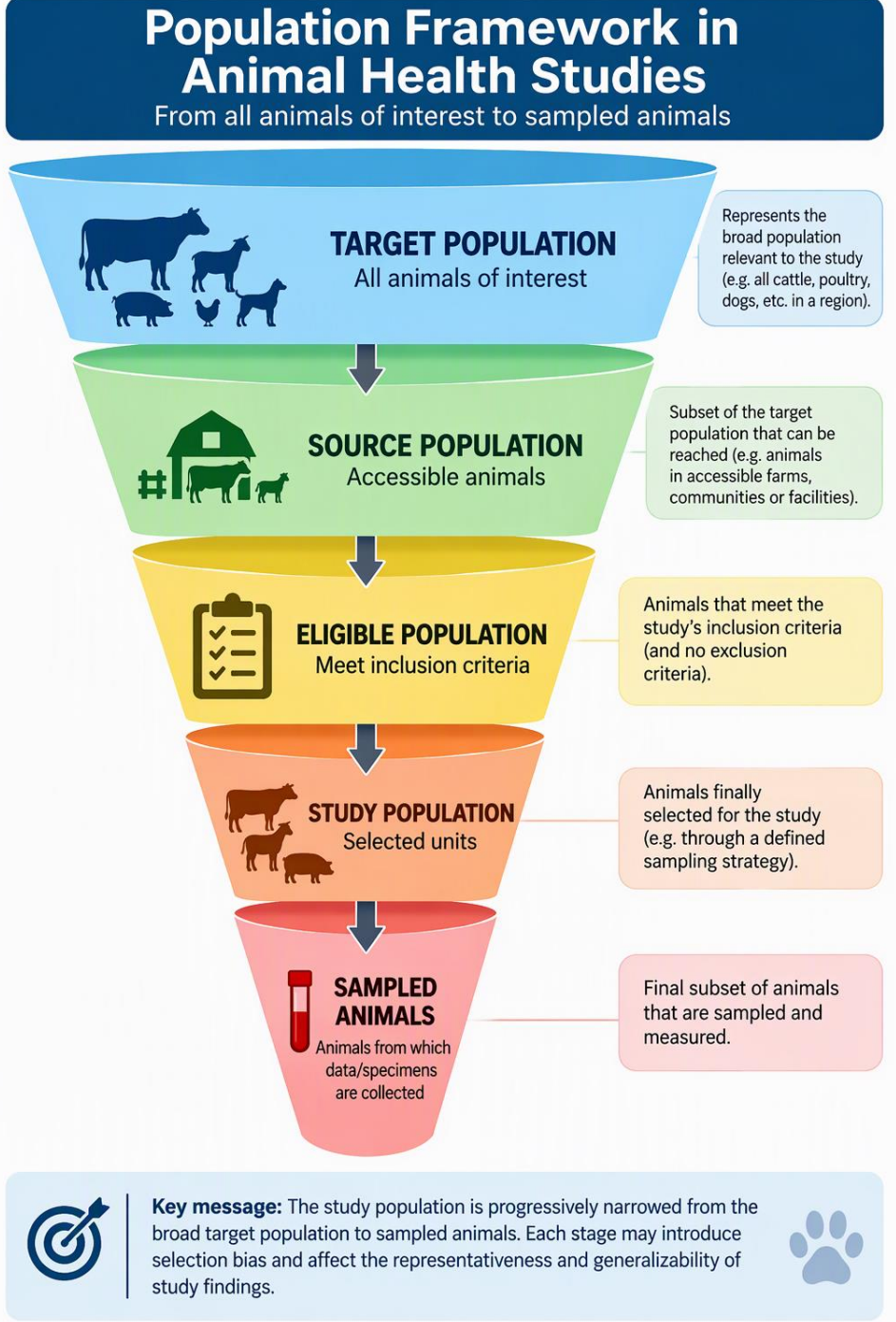
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Populations in Surveillance

Example: HPAI Surveillance in Poultry

Target	All poultry in the country
Source	Registered poultry farms
Eligible	Commercial farms >500 birds
Study	Selected risk-based farms
Sampled	30 birds tested per farm

Key message: Results can only be generalized to the population represented by the sampling design.



Sampling: turning objectives into a defensible design

- **Define the target population** — species, age groups, production systems, geography and time period.
- **Define the sampling unit —** animal, herd/flock, farm, village, market, abattoir, wildlife population or administrative area.
- **Choose the sampling approach** — census, simple random, systematic, stratified, cluster, two-stage or risk-based sampling.
- **Set sample size** — based on objective, expected prevalence, desired confidence and precision, population size, clustering and test characteristics.
- **Set frequency and timing** — one-off, periodic, continuous or event-triggered; consider seasonality, incubation period and disease dynamics.
- **Plan logistics** — sampling frame, specimen type, transport, cold chain, biosafety, consent, costs and laboratory capacity



Diagnostic testing and laboratory integration

- **Choose tests to match the purpose** — screening, confirmation, exposure assessment, pathogen detection, surveillance for freedom or investigation.
- **Understand test performance** — sensitivity, specificity, predictive values and the effect of prevalence on interpretation.
- **Use a testing algorithm** — screening followed by confirmatory testing where appropriate; define how inconclusive results are handled.
- **Assure quality** — validated methods, trained staff, internal quality control, proficiency testing, biosafety and reliable reporting.
- **Connect field and laboratory data** — unique sample identifiers, animal/herd details, dates, locations, test methods and results.
- **Interpret in context -** a negative result does not always exclude infection; consider timing, sample quality, test limitations and prior vaccination



Sensitivity & Specificity of Diagnostic Tests

How well does a test identify infected and uninfected animals?

SENSITIVITY

Among truly infected animals, the proportion that test positive.
High sensitivity = few false negatives.

SPECIFICITY

Among truly uninfected animals, the proportion that test negative.
High specificity = few false positives.

Example: 200 animals tested (100 infected and 100 uninfected)

	Test positive	Test negative
Truly infected	90 True positive (TP)	10 False negative (FN)
Truly uninfected	20 False positive (FP)	80 True negative (TN)

THE CALCULATIONS

Sensitivity
= TP ÷ (TP + FN)
= 90 ÷ 100 = 90%

Specificity
= TN ÷ (TN + FP)
= 80 ÷ 100 = 80%

Remember: Sensitivity measures detection of disease; specificity measures correct exclusion of disease.

From field data to actionable intelligence

- **Capture** — standardised forms, mobile tools, laboratory information systems and reporting channels.
- **Validate and clean** — check completeness, consistency, duplicates, dates, locations, denominators and plausible values.
- **Analyse** — describe cases by time, place and animal/person-at-risk characteristics; calculate rates, Relative risks, Odds Ratio where denominators are available.
- **Visualise** — epidemic curves, maps, dashboards, tables and trend charts.
- **Interpret** — assess data quality, biases, representativeness, uncertainty and alternative explanations.
- **Disseminate** — provide timely, audience-appropriate feedback and alerts, with clear recommendations for action.



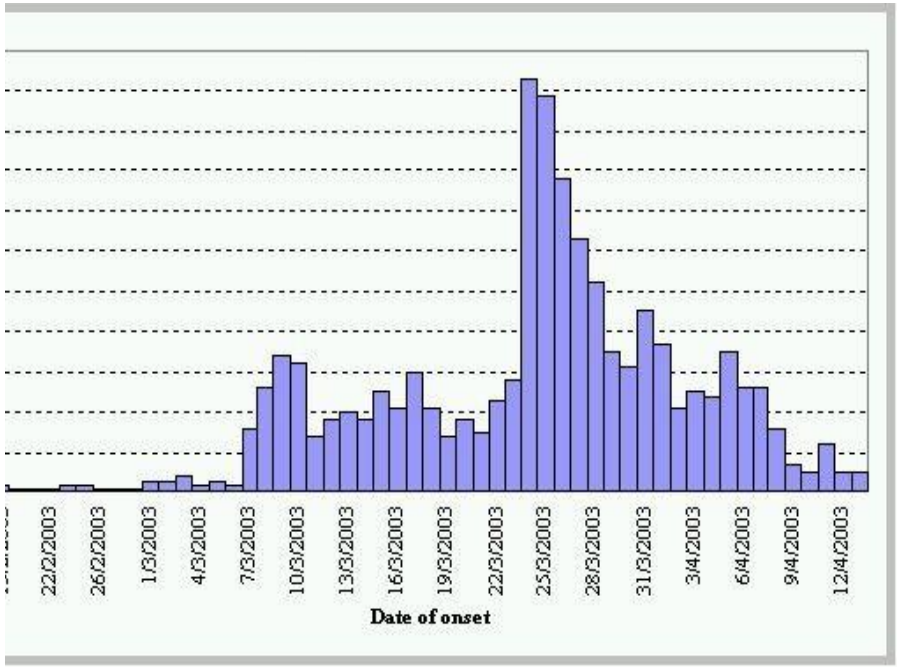
Describing disease trend

Describe the occurrence of disease in terms of

- Individual
- Place (Spatial trend)
- Time (temporal trend)







Measure of disease frequency

Measure of disease	
Incidence risk	Occurrence of ne disease in a popul specified period.
Prevalence	Proportion of po a disease at a parti time (Point preval specified period (p prevalence)
Mortality rate	Frequency of dea over specified per
Case fatality rate	Death amoung dis
Attack rate	Proportion affecte outbreak

Measures of Disease

Quantifying how much disease exists in a population

1. Incidence

New cases of a disease



Incidence Proportion (Risk)

$$\text{Risk} = \frac{\text{New cases}}{\text{Population at risk}}$$

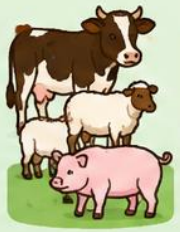


Incidence Rate

$$\text{IR} = \frac{\text{New cases}}{\text{Person-time at risk}}$$

2. Prevalence

All existing cases



Point/Period Prevalence

$$\text{Prevalence} = \frac{\text{All existing cases}}{\text{Total population}}$$

3. Mortality Rate

Deaths in a population



$$\text{Mortality Rate} = \frac{\text{Number of deaths}}{\text{Population at risk}}$$

4. Case Fatality Rate (CFR)

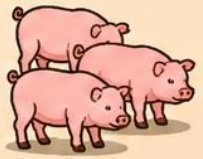
Deaths among diagnosed cases



$$\text{CFR} = \frac{\text{Deaths due to disease}}{\text{Total diagnosed cases}} \times 100$$

5. Attack Rate

Proportion affected during an outbreak



$$\text{Attack Rate} = \frac{\text{New cases during outbreak}}{\text{Population at risk}} \times 100$$

Key Takeaways

- **Incidence:** How quickly new disease occurs
- **Prevalence:** How much disease exists
- **Mortality:** How many die
- **Case Fatality:** How deadly the disease is
- **Attack Rate:** Proportion affected in an outbreak

Measures of association - Relative Risk and Odds Ratio

	Disease (+)	Disease (-)	Total
Exposed (+)	a	b	a+b
Exposed (-)	c	d	c+d
Total	a+c	b+d	N

Relative Risk (RR) = [a/(a+b)] / [c/(c+d)]

$$OR = \frac{a/b}{c/d} \qquad OR = \frac{ad}{bc}$$

Odds Ratio (OR) = ad/bc

RR: compares risk
OR: compares odds

Relative Risk (RR) is ratio of the risk of developing disease among exposed to the risk amoung un-exposed individuals.
How many times more (or less) likely are exposed animals to develop the disease compared with unexposed animals?

Odds Ratio (OR): the odds of disease in exposed versus unexposed animal.
In simple terms: How much higher (or lower) are the odds of disease among exposed animals compared with unexposed animals?

Interpretation: RR or OR = 1 (no association); >1 (higher risk/odds); <1 (protective effect).

Descriptive statistics and analysis

Diagnostic test contingency table

	Disease +	Disease -
Test +	90	20
Test -	10	80

	Test positive	Test negative
Truly infected	90 True positive (TP)	10 False negative (FN)
Truly uninfected	20 False positive (FP)	80 True negative (TN)

Enter data

	Disease+	Disease-	Total
Exposure+	13	2163	2176
Exposure-	5	3349	3354
Total	18	5512	5530

https://mvs.unimelb.edu.au/research/veterinary-epidemiology-melbourne/resources

Worked example: early detection of an FMD incursion

- **Objective** — detect FMD as early as possible in a defined high-risk border area.
- **Signals** — farmer reports of salivation, oral/foot lesions or sudden lameness; unusual market or abattoir findings.
- **Verification** — veterinary investigation using a standard case definition, epidemiological history and appropriate specimens.
- **Laboratory** — test samples using the national reference laboratory algorithm; ensure sample traceability and timely results.
- **Analysis** — map suspect and confirmed premises; construct an epidemic curve; assess movements and epidemiological links.
- **Action** — notify according to national and international requirements; implement movement controls, biosecurity and other measures based on risk.
- **Learning** — review reporting delays, investigation coverage, diagnostic turnaround a effectiveness of feedback



Appropriate selection of Surveillance Methods and Surveillance Challenges

Selection of appropriate method depends on:

- Surveillance objective
- Disease characteristics
- Animal population size
- Geographical distribution
- Available financial resources
- Diagnostic test availability
- Disease transmission pathways
- Expected prevalence
- Required confidence and sensitivity
- Time available for detection

Major challenges include:

- Shortage of trained veterinary personnel at the grass-root level
- Selection of an appropriate surveillance unit- *herd, village, animal*
- Lack of animal population data – *denominator*
- Data analysis and triggers for action
- Feedback and dissemination
- Coordination among stakeholders
- Laboratory capacity in the region
- Limited community participation
- Inadequate financial resources.

Matching surveillance methods to animal health priorities

Disease / threat	Illustrative surveillance mix	Main application
FMD	Passive notifications + active/risk-based sampling at movement corridors and outbreak areas	Early detection; outbreak investigation; monitoring spread
ASF	Passive mortality reporting + targeted farm investigation + wild boar surveillance	Rapid detection; identify introduction pathways; guide control
PPR	Passive reporting + active serological/virological surveillance in small ruminants	Detect circulation; assess vaccination impact; support status evidence
LSD	Passive clinical reporting + targeted vector-season and border-area surveillance	Detect incursion; map spread; assess seasonal risk
Avian influenza	Event-based wild bird reports + market surveillance + targeted poultry sampling	Early warning at wildlife–poultry and market interfaces
Rabies	Bite/animal event reporting + laboratory confirmation + targeted dog population surveillance	Detect transmission; guide vaccination and dog population interventions

Essential components of a functional surveillance system

- **Purpose and scope** — objectives, hazard definition, target population, case definitions and surveillance units.
- **Operational design** — method selection, sampling strategy, frequency, field protocols and laboratory arrangements.
- **Information infrastructure** — data capture, unique identifiers, data standards, management, analysis and visualisation.
- **People and partnerships** — veterinary services, laboratories, private veterinarians, farmers, wildlife/environmental agencies and other partners.
- **Decision and response** — thresholds, notification pathways, investigation protocols, feedback and control actions.
- **System improvement** — monitoring, evaluation, training, quality assurance and sustainable resourcing.

Thank you

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