

World Organisation for Animal Health

Australian Aid

Training Workshop on Animal Disease Surveillance

Sampling Methods for Animal Disease Surveillance

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Learning objectives



Following this presentation, we expect you to:

- Distinguish **major sampling methods** used in animal health surveillance
- Understand **strengths and limitations** of each method
- Select an **appropriate sampling approach** depending on:
  - surveillance objective
  - disease epidemiology
  - livestock production system
  - population structure
  - operational constraints
- Recognize how sampling design affects **surveillance sensitivity**

Where we are?

- Surveillance objective
- Epi Status and Risk Assessment
- **SAMPLING DESIGN**
- Sample size

« Even the best surveillance objective will fail if animals are sampled inappropriately »

Why do we need to sample ? Sampling vs Census

A census

- involves collecting data from every single unit (such as a human, animal, farm) in the population.
- a true census is a very resource-intensive activity.





What happens if we would like to answer a question such as: '**How frequently is resistance to third-generation cephalosporins identified in *Escherichia coli* isolated from farmed chickens?**'

Is it necessary to collect data on every single chicken in a country to answer this question?

For the majority of research or surveillance, it is not necessary to conduct a census. Instead, we can select an appropriate sample of subjects from the population.

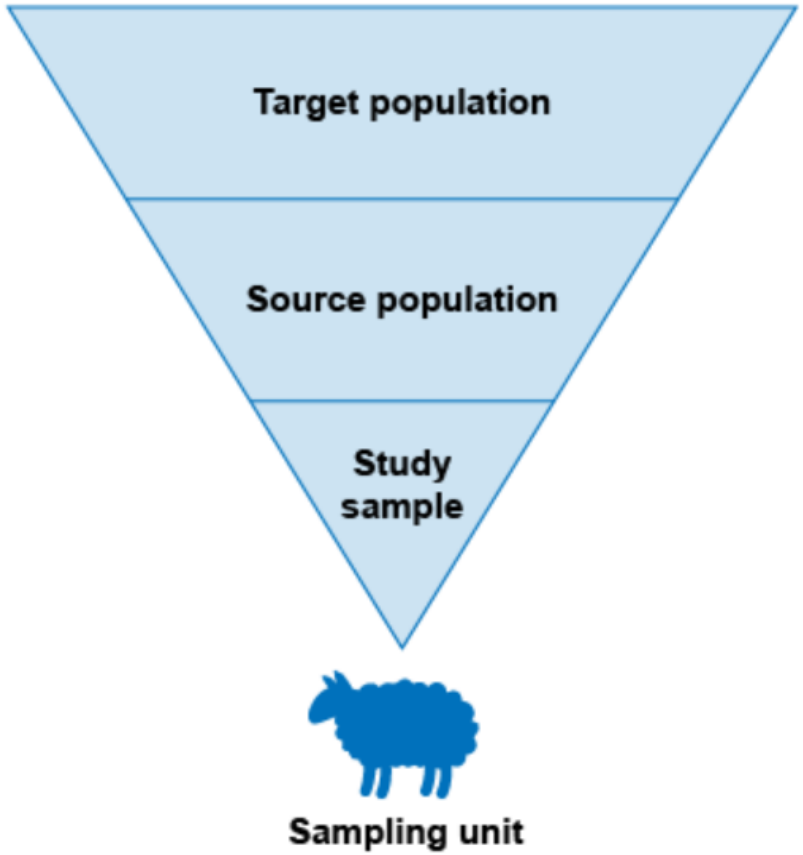
What is actually sampling ?

« Sampling is the process of selecting a subset of units from a larger population in order to make decisions or draw conclusions about that population. »

Sampling **decisions** may concern:

- **Population** (which animals?)
- **Geographic location** (where?)
- **Time** (when?)
- **Production systems** (which farms/herds/flocks?)
- **Individual animals** (which animals within a herd?)
- **Biological specimens** (which samples?)

Sampling terminology



Ex: Fish farms around the coast of an island country

→ All the fish farms in the island country

→ Farms in three bays around the island

→ 500 fish from five farms in each bay

→ Individual fish, or pooled sampling units such as sediment collected from the bottom of the ponds



Source: Open University module- sampling (animal health) for AMR surveillance)

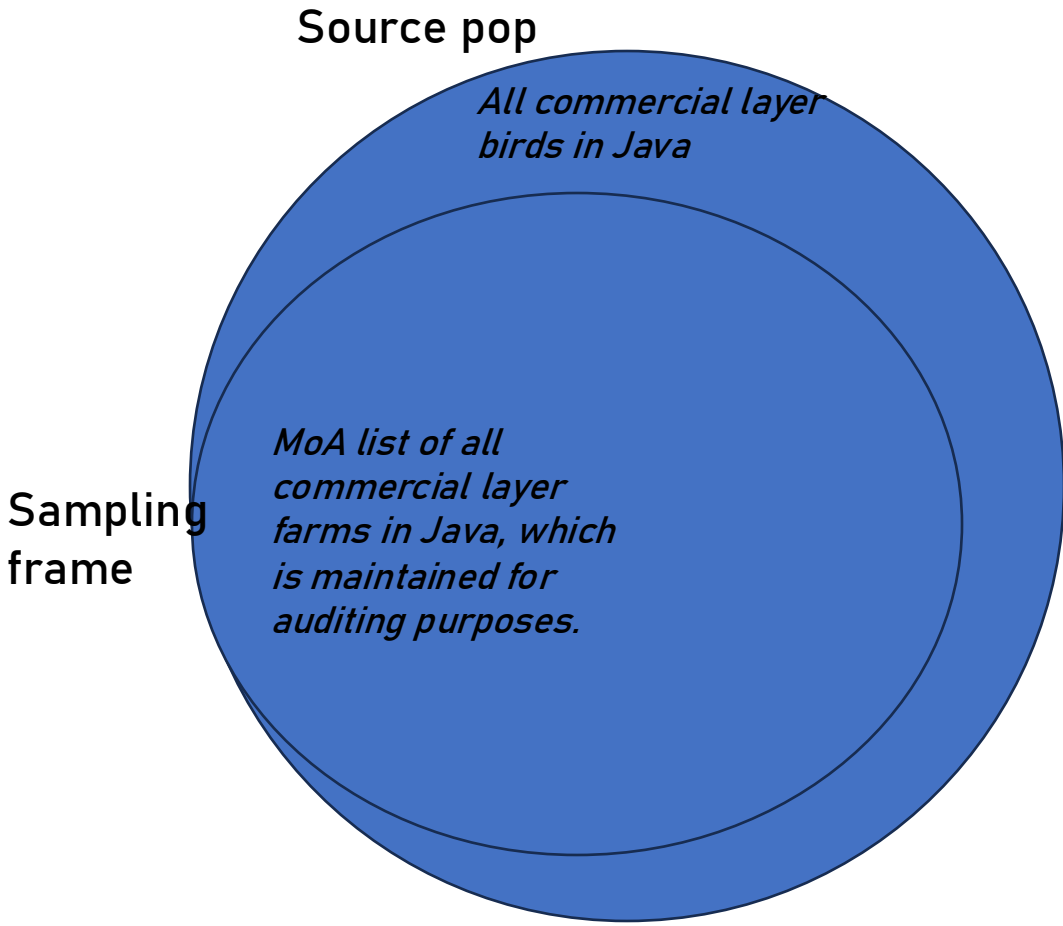
Sampling frame (1/2)

A list of all sampling units in the source population

- Sampling frame might be
  - A list of all poultry farms in the province(s) selected as the source population
  - A list of registered poultry slaughterhouses

- Because sampling frame consitute a data collection process, they are subject to the risks of errors and bias

- The sampling frame should be constructed such that the source population represented by the frame covers at least 80% of the target population (EFSA, 2020).



Sampling frame (2/2)

Any sampling frame is likely to be imperfect,

- Incomplete list
- Duplicates in the list

The ideal sampling frame is therefore a list which:

- contains every unit of interest in the population (no omissions),
- contains every unit of interest only once (no duplications), and
- uniquely identifies every unit of interest.

Just because a sampling frame isn't perfect, it doesn't mean it can't be used. It is a matter of judgement to assess how good the sampling frame is, and whether the problems with it are likely to affect the results of the survey.

Why good sampling frame matters?

Ensures **representativeness and prevents bias**

- Accurate prevalence
- Avoids selection bias

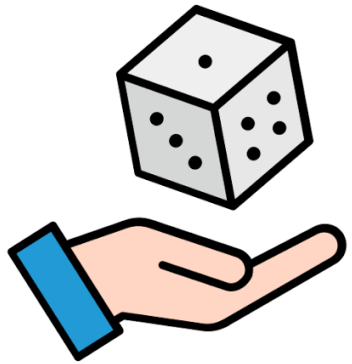
Enables statistical inferences

- provides the **denonimator** needed for quantification of precision and confidence
- Early detection and demonstration of freedom

Supports risk-based surveillance and targeted surveillance

- **Stratification of risk**
- Resource optimization

Sampling taxonomy – methods





PROBABILITY

Simple random
Systematic random
Stratified random
Cluster

RISK-BASED

NON-PROBABILITY or BIASED

Convenience
Purposive

Probability method

Every sampling unit within the population has the same (or known) probability of being selected.

They allow for representative sampling (such that results can be generalised to the target population) and limit selection bias

- **Simple random sampling:** Where a sampling frame is available and is used to randomly generate a list of units to be sampled. This can be done manually (such as 'pulling numbers out of a hat') or using a random number generator to compile a list of sampling units.
- **Systematic random sampling:** Where every n^{th} unit is selected as each unit presents (or appears). For example, this could involve selecting every tenth fish that swims through a race. In public health, this could involve selecting every fifth patient presenting at a primary healthcare facility included in the sampling frame. Both the sampling interval (what value n takes) and starting point (whether systematic sampling starts from the first, second, third or nth unit) should be selected randomly
- There are important extensions to simple or systematic random sampling
    - **Multistage sampling:** A random sample of primary units is selected, followed by a random sample of secondary units (and then tertiary, and so forth). For example, randomly selecting regions and then randomly selecting farms and then randomly selecting animals from each farm.
    - **Cluster sampling:** This is similar to multistage sampling, except that all sampling units are sampled in the final stage. That is, the farms are randomly selected, and then all animals on those farms are sampled
    - **Stratified random sampling:** The source population is divided into mutually exclusive strata based on factors that may affect the outcome, such as geographic region. A known number of units are then randomly selected from each stratum.
- These different sampling methods can be combined. For example, stratified sampling can be included within a multistage sampling design

Source: Open University module- sampling (animal health) for AMR surveillance)

Biased – Non-probability method

Sampling is done **without** determining a sampling unit's probability of being sampled.

Non-probability sampling methods **should be avoided**, as they introduce substantial bias, and greatly limit the applicability of the findings to the target population.

- **Convenience sampling** is the collection of easily accessible sampling units, such as animals that present to a veterinary clinic, or farms located close to a laboratory with the appropriate testing capacity.
  - common in animal health surveillance programmes, but
  - highly prone to **selection bias,** and thus poorly representative
  - Results cannot be generalised to the target population
    - Efforts to identify and select from sampling frames should be promoted over convenience sampling
  - E.g. Based on hunter-shot sampling, road-kill sampling for wildlife surveillance

Source: Open University module- sampling (animal health) for AMR surveillance)

Risk based sampling

- High risk items are deliberately chosen, using risk factor information
- Non representative (non random)
- More efficient for rare disease events

- The probability of a unit being selected between strata differs; however, the probability within a stratum is equal (random selection within a stratum).

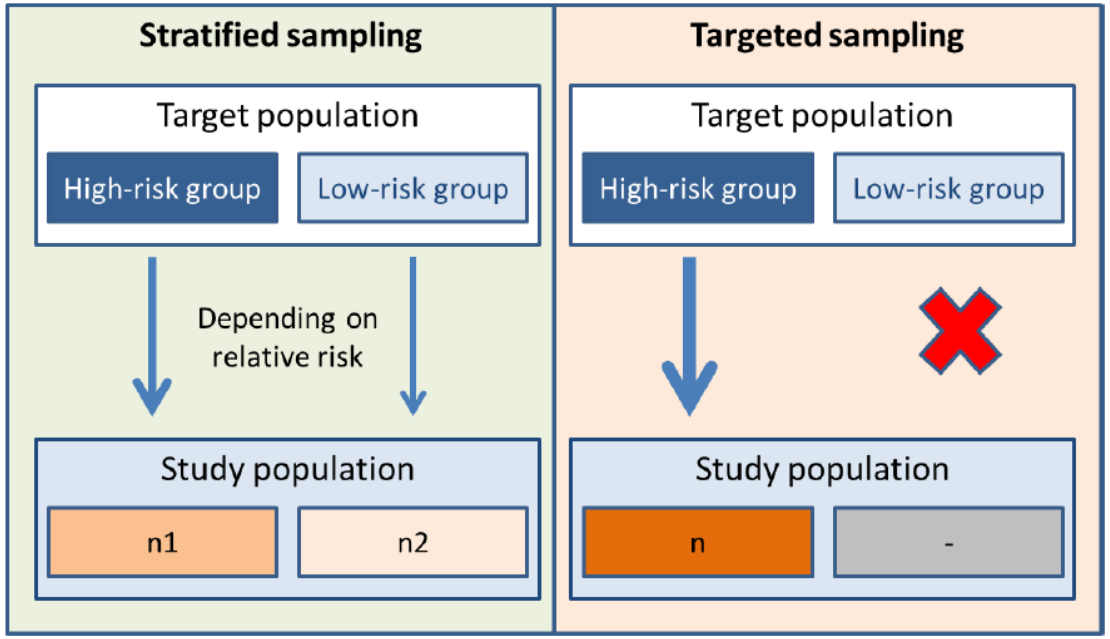


Figure 10. Risk-based sampling distinguishes between high- and low-risk strata of the population. Subsequently, two approaches may be chosen: A) Stratified sampling: all animals have a nonzero probability of being selected but sampling intensity varies between risk-groups resulting in two sample sizes (n1 and n2); or B) Targeted sampling: sampling is concentrated on a defined sub-population that is expected to have a higher prevalence of the disease which results in a single sample size (n).

Source: **Risk Sur**, 2014. *Best practices for risk-based and cost-effective animal health surveillance in the European Union.*

How sampling design influences Surveillance Sensitivity

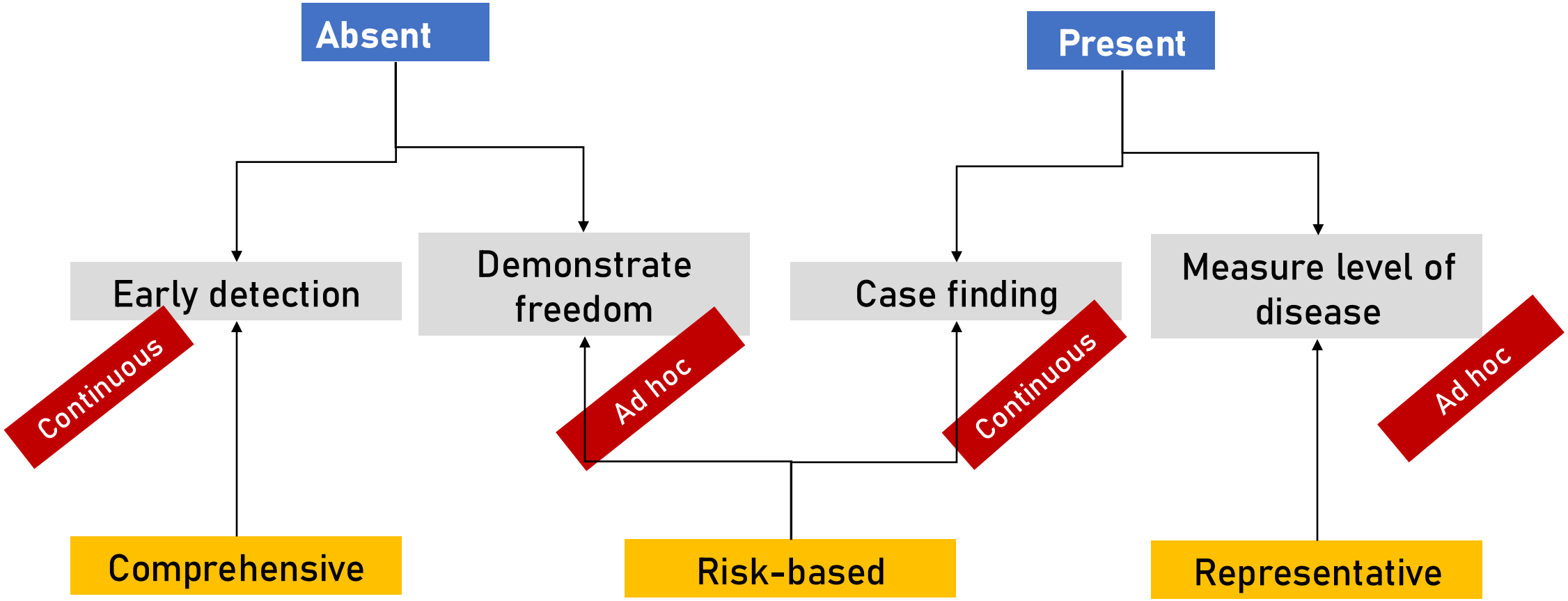
Surveillance sensitivity = the **probability** that the surveillance system **detects** disease/infection **if** disease/infection is **present**

Sampling considerations	Example
Larger sample size	↗ More likely to detect infection
Sampling high-risk populations	↗ More likely to detect infection
More frequent sampling	↗ More likely to detect infection early
Sampling during high-risk periods	↗ More likely to detect infection
Selecting appropriate species	↗ More likely to detect infection
Poorly representative or biased samples	↘ May miss infection
Incomplete sampling frame	↘ Some infected populations may never be sampled

Designing surveillance: A sequence of decisions

1. What is the objective?
2. What disease are we targeting?
3. Which populations are at risk?
4. Which production systems matter?
5. Which sampling method should we use?
6. How many units should we sample?

Choosing the right sampling approach



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

How Disease Characteristics Influence Sampling

Disease characteristics	Example	Possible sampling implications
Low prevalence disease	PPR in a disease-free country; HPAI during inter-epidemic periods	Larger sample sizes and/or risk-based sampling to increase the likelihood of detection
Species-specific disease	HPAI surveillance often prioritizes ducks; PPR affects small ruminants	Determine which species to sample
Seasonal disease	HPAI risk may increase during migratory bird seasons and festive periods associated with poultry trade	Determine when to sample
Vector-borne disease	LSD transmission associated with biting insects	Focus sampling in areas and seasons favorable to vector activity
Clustered disease	HPAI often associated with live bird markets, duck production systems, wetlands, and migratory bird interfaces	Target high-risk populations and locations
Movement-driven disease	FMD and HPAI spread through livestock and poultry movements	Sample markets, border areas, transport routes, and aggregation points
Rapidly spreading disease	FMD can spread quickly through animal movements	Increase sampling frequency for earlier detection
Subclinical or silent infection	FMD may circulate before recognition; HPAI can be silent in ducks	Rely more on active surveillance and laboratory testing
Disease with obvious clinical signs	LSD typically produces visible skin lesions in cattle	Greater reliance on clinical surveillance and investigation of suspect cases

How Production Systems Influence Sampling

Production system features	Example	Possible sampling implications
Smallholder / backyard production	Village poultry, backyard pig farms	Sample a larger number of holdings, often with fewer animals per holding
Commercial intensive	Integrated broiler operations, commercial layer farms	Fewer holdings may need to be sampled, but each holding represents a larger proportion of the population
High animal movement	Trader networks, contract farming systems, feeder-calf operations	Prioritize markets, traders, collection points, and movement corridors
Multi species / integrated systems	Mixed cattle-goat or duck-rice farming systems	Include multiple species in the sampling design
Free-ranging or scavenging systems	Free-grazing ducks, village poultry	Focus on interface areas and periods of animal mixing
Nomadic or transhumant systems	Seasonal movement of small ruminants	Sample along migration routes, grazing areas, and aggregation points
Highly clustered production	Pig-dense regions, poultry production belts	Target production hotspots and high-density areas
Vertically integrated systems	Commercial poultry companies with centralized management	Use stratified sampling across production stages (breeder, hatchery, grow-out, market)
Production peaks	Increased poultry production before festivals	Increase sampling during high-production and high-trade periods (e.g. more sample types, more frequently)
Production at wildlife interfaces	Duck farms near wetlands; pigs near wild boar habitat	Include interface locations as surveillance priorities

Take-home messages

- Sampling starts with the surveillance objective
- It is important to consider strenghts and limitation of the sampling frame
- Different diseases & production systems require different sampling approaches
- Risk-based and probability-based sampling are complementary
- Good sampling design improves surveillance sensitivity

Credits, further readings

- **Open University**, 2025. Sampling (animal health) https://www.open.edu/openlearncreate/course/view.php?id=12544

- **Cameron, A**, 2012, *Manual of Basic Animal Disease Surveillance*, AU-IBAR https://epimundi.com/development/publications/basic-surveillance/

- **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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