Chapter 1

Introduction to animal disease surveillance

“To know that you do not know is the best.
To pretend to know when you do not know is a disease.”
Lao-tzu (604 BC–531 BC)

INTRODUCTION
The aim of this manual is to assist those working in animal health to design and analyse appropriate disease surveillance systems, particularly for early warning, detection of disease, or demonstration of freedom from disease. In order to design an effective surveillance system, two things are required:

• an understanding of available surveillance options, and
• an ability to compare and evaluate the different options, so that you can decide on the best combination.

This chapter discusses the characteristics of animal disease surveillance systems that allow us to compare and evaluate their use for a variety of purposes; it also introduces a range of different possible approaches to surveillance. Some of the material in this chapter and in Chapter 3 is based on information contained in another book by Angus Cameron.1

TERMINOLOGY
A range of different terms with specific meanings are used in this manual. The appendix lists the main abbreviations used, but the key terms and meanings are set out in Table 1.

CHARACTERISTICS OF A SURVEILLANCE SYSTEM
In order to design, evaluate and compare surveillance options, it is important to understand the different characteristics of a surveillance system. This section discusses a number of characteristics that can be used to describe surveillance.

Origin of surveillance information
Active surveillance
Active surveillance describes an activity that is designed and initiated by the prime users of the data. The main purpose of the activity is disease surveillance, and examples include:

• a serological survey to assess the prevalence of antibodies to brucellosis;
• a farmer questionnaire to identify the level of mortality in their animals.

The term ‘active’ is employed here because the users of the surveillance data (e.g. the veterinary authorities) are actively involved in generating the data.

1 Cameron, A.R. (in press) Surveillance in the Animal Health Management Essentials series. Under publication by the OIE Regional Coordination Unit, Bangkok.
One of the significant advantages of active surveillance is that the activity is designed by the users of the information. Therefore, it is possible to ensure that both the nature and the quality of the data collected are adequate to meet the users’ surveillance requirements.

**Passive surveillance**

Passive may be thought of in two ways. First, passive surveillance describes surveillance systems where information on disease events is brought to the attention of the veterinary authorities without them actively seeking it. Another way of thinking about passive surveillance is that it uses data that have already been collected for some other purpose; in such circumstances, veterinary services do not initiate the data collection.

Examples of passive surveillance include:

- **A farmer disease reporting system.** In the process of seeking advice, diagnosis or treatment for sick animals, farmers ‘report’ disease. The reason the farmers make the report is not to help the surveillance system, but to seek veterinary assistance for the problem with their animals. The use of the data for surveillance is secondary.
• **Abattoir meat inspection.** The reason for meat inspection is to ensure the safety and quality of meat sold to consumers. If the data were not used for surveillance, meat inspection would still be required.

The main advantage of passive surveillance systems is that they are inexpensive. As a result, they often can ensure much greater coverage of the animal population. However, the data may not fully meet the veterinary services’ needs and there is little control over data quality. Data quality may be improved if farmers and veterinarians are provided with education or rewards to improve reporting for specific conditions.

**Disease focus**

**Targeted surveillance**

Targeted surveillance describes surveillance that is focused on a specific disease or pathogen. For example, a serological survey for brucellosis may use the Rose Bengal test (RBT). Blood from each sampled animal is tested, and the result of the test is classified as RBT positive or RBT negative. An animal that has tuberculosis or foot-and-mouth disease (FMD), but not brucellosis, would be simply classified as RBT negative, as these other diseases are not of interest in the surveillance activity.

The term targeted surveillance can be used in two different senses. In this case, it is referring to surveillance targeted at a specific disease. Later in this manual we will use the term in a different sense – surveillance targeted at a high-risk portion of the population. To differentiate between the two, it is preferable to refer to the second situation as risk-based surveillance rather than targeted surveillance.

**General surveillance**

General surveillance is not focused on a particular disease, but can be used to detect any disease or pathogen. For example, the farmer disease reporting system is a general surveillance system, as any disease may be reported. However, not all diseases will be reported with the same reliability. Farmers are more likely to report diseases that show clear signs and have a significant impact (for example, many animals are infected, or the disease results in death, such as haemorrhagic septicaemia) than they are to report diseases that display few signs or do not result in an immediate economic impact (such as that caused by intestinal parasitic infections).

Some laboratory tests, such as histopathology, allow detection of many different diseases, rather than just a single disease.

An important feature of general surveillance is that it is not only able to detect known diseases of interest, but it may also be able to detect new, emerging, exotic or unknown endemic diseases. In other words, it is not necessary to be looking for a specific disease in order to find it.

The distinction between general and targeted surveillance depends on the disease detection system used. Targeted surveillance is based on the use of tests that are able to provide a yes/no answer for a specific disease. Examples include:

- polymerase chain reaction (PCR)
- enzyme-linked immunosorbent assay (ELISA)
- agar gel immunodiffusion (AGID).
General surveillance is based on tests that are able to identify multiple diseases (in some cases, all diseases). These tests include:

- clinical examination
- disease investigation
- post-mortem investigation
- meat inspection
- histopathology
- various syndromic surveillance activities.

**Purpose of the surveillance, and nature of the disease**

Although there may be some special cases, the purpose of most animal health surveillance can be divided into the following four categories:

- surveillance for diseases that are present
  - describing the level or distribution of disease (or a pathogen or risk factors for disease)
  - detecting cases of disease (at the animal or group/herd level), in order to take action at that same level.
- surveillance for diseases that are absent
  - detecting the incursion of new, emerging or exotic diseases (or pathogens or their risk factors)
  - demonstrating freedom from disease or pathogens.

**Surveillance stakeholders**

The general purpose of animal disease surveillance is to collect information to support decision-making to improve or maintain animal health or welfare. Surveillance stakeholders are those who are either involved in the generation and collection of surveillance data, or who make decisions that could be assisted by access to surveillance data.

The range of people responsible for making decisions about animal health is very wide. Obviously, it encompasses those involved in setting national disease control policy, but it also encompasses regional and local veterinary staff, including field staff involved in individual animal care; livestock owners; livestock traders, and those supporting the livestock industries. It also includes international organizations such as the World Organisation for Animal Health (OIE) and the Food and Agriculture Organization of the United Nations (FAO), as well as neighbouring countries and trading partners. All of these groups need reliable surveillance information in order to make decisions.

**Population coverage**

Population coverage refers to the proportion of the population that is actually examined as part of the surveillance system. Two approaches can be used.

**Sampling**

When sampling, only some animals in the population are examined. For example, a sentinel herd system involves a relatively small number of herds; a small number of animals from these herds are tested or examined at regular intervals – animals that are not in the sentinel herds are not examined at all, and therefore these herds are used as a sample of the population.
A structured survey may involve randomly selecting a number of villages or farms, and then randomly selecting some animals from these villages or farms to test.

**Comprehensive coverage (census)**
In a census, all animals in the population are examined. For example, if the population of interest is ‘all farmed pigs in the country’, a passive disease reporting system covers the entire population, as every single pig in the country is examined (even if only superficially) at more or less regular intervals. If a particular animal becomes diseased, there is a chance that that disease event will be captured by the surveillance system – the probability depends on many factors (for example, severity of the disease, relationships between farmers and veterinarians, whether a report is made). But each pig, if it becomes sick, has a chance of being recorded in the system.

**Representativeness**
The representativeness of a surveillance system describes how well the information that is gathered describes the population of interest.

If the level of a characteristic of the animals in our surveillance system (for example, the percentage of animals with protective antibody titres) is approximately the same as the level in the source population, the system is representative of the population with respect to that characteristic. If there is a difference between the animals in the surveillance system and the animals in the source population – for instance, 90 percent of animals with protective antibodies, compared with 60 percent in the source population – the surveillance system is not representative, but is biased.

Bias is the difference between the real value in the population and the value we measure through our surveillance. In many cases, bias due to a non-representative surveillance system can cause significant problems.
Example

Consider abattoir surveillance to assess the level of contagious bovine pleuropneumonia (CBPP) in a population: the system uses a sample of the population; the population of interest is 'all farmed cattle', but the surveillance examines only cattle that are sent to the abattoir. Animals infected with CBPP are likely to get sick or die on the farm, so an animal with the disease is much less likely to be sent to the abattoir than a healthy animal. As a result, the proportion of cattle with CBPP in the abattoir is likely to be much lower than the proportion on farms. Therefore, abattoir surveillance is biased.

As the surveillance system is likely to detect a lower proportion of animals than the proportion that is truly infected, this type of system is negatively biased.

The meat inspection system in some developing countries may be less developed than in other countries. This means that it is more common in developing countries for sick animals to be sent to an abattoir than it is in countries where more stringent controls are in place. As a result, abattoir surveillance is more useful for detecting clinical disease in some less developed countries than in more developed countries.

Making animal health management policy decisions on the basis of biased information can be very hazardous. If this information were being used to monitor the progress of a control programme, or to prioritize spending on future disease control programmes, the wrong decisions could be made, which, in turn, might have a negative effect on the health of the population. Such a situation could occur where, for example, the level of disease may seem low, and therefore no action is taken, but the true level of disease is high.

Surveillance systems that provide comprehensive coverage of a population are more likely to be representative. For example, in a passive reporting system, theoretically, virtually all animals are seen by their owners on a regular basis. Such a system is comprehensive, as it represents a census of the population. However, if some farmers are more likely to report disease than others, such a system may not be representative.

Example

A surveillance system for brucellosis may be based on farmer reporting of abortions or arthritis. If a control programme is in place – specifically one that involves modifying the management systems around calving, in order to limit the spread of the disease – then farms that adopt good management practices are less likely to have the disease. Farms that do not use good management practices may have higher levels of disease. However, farmers with poor management may also be less likely to report disease than farmers with good management.

The disease rates may be higher, but the reporting rates may be lower from farms with poor management than from farms with good management. The outcome is that, even with a system where every infected animal has a chance of being reported, differences in disease and reporting probabilities can result in a bias – in this case, making the total level of disease appear lower than it actually is.
Surveillance systems that aim to provide an accurate assessment of the level of disease typically produce results in terms of proportions, for example, the percentage of animals with CBPP, or the percentage of animals with protective antibody titres against FMD.

If you are making decisions (for example, evaluating the progress of a disease control programme) based on data expressed in the form of a proportion or percentage, it is important that the surveillance system is set up to avoid bias.

**Type of data collected**

**Diagnoses**

Diagnoses refer specifically to disease, usually clinical disease. At the level of an individual animal, a diagnosis tells us what disease an animal has. In surveillance, a diagnosis is used to classify some animals as having a particular disease and other animals as not having that disease.

In order to make a diagnosis, the animal should be examined by a veterinarian. If necessary, specimens should be submitted for laboratory testing.

**Classifications**

Often, we are not solely interested in clinical disease, but in some characteristic of the animal that is related to disease, such as the characteristics described in the following examples:

- A serological survey to demonstrate freedom from FMD will classify animals as seropositive or seronegative. In this case, seropositive animals (due to vaccination or previous exposure at some time in the past) are unlikely to have the disease – we are simply using the serological status as an indicator of whether the animal has been exposed to the virus (or possibly to a vaccine) at some time in the past.
- Surveillance to evaluate the progress of a vaccination programme for FMD can be carried out by estimating the proportion of animals that have protective antibodies. This is based on the antibody status of the animals rather than a diagnosis of disease. Any measurable characteristic may be used to classify animals for the purposes of surveillance.

**Analysis of specimens**

Both the diagnosis of disease and the classification of animals according to some characteristic (for example, antibody status) are usually achieved using some type of test. Certain tests are laboratory based, such as:

- enzyme-linked immunosorbent assay (ELISA) to measure antibody levels;
- virus isolation;
- PCR to detect a pathogenic agent.

Other tests can be performed in the field; such tests may include clinical diagnosis by a veterinarian, or meat inspection in an abattoir.

In cases where laboratory testing is being used, what is collected for surveillance is normally not just information alone; rather it may include a specimen from the animal (blood, milk, a tissue sample, etc.). This specimen is subjected to one or more tests, in order to produce test results – the data required.
**Signs and syndromes**

In circumstances where disease is shown to be present, the most commonly collected information is the diagnosis. As a definitive diagnosis is not always possible, some surveillance systems are designed to collect uninterpreted data, rather than the diagnosis that would result from its interpretation.

To make a diagnosis, a veterinarian will observe the signs exhibited by a sick animal (for example, lameness, coughing, increased heart rate) and will interpret these signs in order to determine what disease is causing the problem.

Many signs are easily observed by people without veterinary training. Although non-veterinarians may be unable to make a definitive diagnosis, people who work with livestock are often very good at identifying clinical signs in their animals. Village animal health workers are not usually veterinarians, but they have been trained to recognize disease signs. However, there may be legal restrictions on who can officially confirm a diagnosis (for example, qualified veterinarians only).

Therefore, a surveillance system may collect data on the signs of disease observed. Changes in the patterns of signs observed in a population may indicate changes in the diseases that cause those signs. For instance, even if the diagnosis is not known, a sudden increase in the number of cases of coughing indicates the potential introduction and spread of a respiratory disease. This information can be used to initiate a detailed disease investigation to determine the cause of the coughing.

In order to make interpretation and reporting of this type of surveillance simpler, cases are often classified into syndromes according to the key sign or group of signs.

A syndrome is simply a defined collection of signs. In the examples on page 6, the syndrome may be ‘respiratory disease’ and may include any case of disease that manifests as coughing, difficulty in breathing and so on. Other syndromes include:

- acute febrile illness
- diarrhoea
- skin lesions
- sudden death
- lameness.

Both reporting of signs and reporting of syndromes are referred to as syndromic surveillance.

Syndromic surveillance is usually designed to help with the detection of changes in disease patterns or the early detection of new diseases. When a change is detected, it must be followed up by more detailed investigations to diagnose the disease causing the change.

Surveillance may collect data on the signs or the general syndrome associated with a disease. The use of syndromes in data collection and reporting is more common than the use of signs because, with syndromes, there is only one data item per case (for example, respiratory disease). With signs, a single animal may exhibit many different symptoms (for example, coughing, difficulty in breathing, standing with neck extended, increased heart rate) – and this makes reporting, collation and analysis of the data more complicated.
Negative reporting
Negative reporting is a special form of disease reporting. The data item in this type of surveillance is the fact that an animal does not have a specified disease.

Negative reporting data may be used in two ways:
- To rule out a disease in a laboratory-based reporting system.
  - For instance, in a country seeking to demonstrate freedom from bovine spongiform encephalopathy (BSE), laboratory results may be collected from BSE tests on neurological cases. The results may all be negative. This does not provide any information on what neurological diseases are present, but it does provide evidence that BSE is not present.
- To rule out a disease in a clinical reporting system.
  - This is common for diseases, such as FMD, which show clearly evident clinical signs, and spread quickly in a naive, susceptible population.

For example, a system may be established in which veterinarians complete a report after every farm or village visit, indicating that FMD was not present at the time of the visit. No special examination is necessary because, if FMD were present, it would normally be very easy to identify just by looking at the animals. The fact that the veterinarian visited the farm and did not see any evidence of disease provides information that the disease was absent. (While there is a small chance that the veterinarian was mistaken, such errors can occur in any type of testing or surveillance.) A surveillance system that collates large numbers of negative reports from across a wide area can provide objective evidence that there are unlikely to be any animals with clinical signs of FMD.

Documentation of a clinical negative reporting system can provide valuable reassurance to trading partners about continued freedom from disease in a particular zone, compartment or country.

Indirect indicators
Some surveillance systems do not collect data on the disease or health status of animals directly; rather, they adopt a more indirect approach.

For instance, information provided by drug companies, distributors and feed supply stores on sales of particular types of veterinary drugs and/or feeds can be used for indirect surveillance. Changes in the patterns of drug sales and commercial feed sales are likely to be good indicators that there is a change in the pattern of disease. However, this does not confirm what the disease is or that any observed changes must be followed up by a detailed investigation to assess if there is really a change in disease incidence and, if so, what the disease is.

Surveillance for indirect indicators of disease is often described as an aspect of syndromic surveillance, and is commonly used to assist with the early detection of disease. The ideal indicators are, therefore, those that change early in the disease process, as the following examples demonstrate.

The most common surveillance system used to detect disease is based on farmers reporting to veterinarians when they have a disease problem. However, before the farmer calls the veterinarian, they may try to treat the problem themselves. If a new, widespread problem affects a livestock population, it may be possible to detect the problem through
the use of drug sales and/or commercial feed sales, rather than having to wait for veterinary reports, which may come sometime later.

In human disease surveillance, thermometer sales and workplace sick leave records can serve as useful early indicators of disease patterns in the population.

Indirect indicator surveillance normally refers to active surveillance. The veterinary authorities establish a relationship with the holders of the data (for example, drug suppliers), and ask that updates on sales be provided for analysis at regular intervals (e.g. daily or weekly).

**Risk factors**

Most surveillance, including indirect surveillance, entails collecting information about disease or a disease-related state. Another approach to surveillance is to measure the risk factors that may be involved in causing the disease. This type of surveillance seeks to provide alerts before an outbreak of disease, so that preventive measures can be put in place.

Examples of risk factor surveillance are:

- Vector surveillance for vector-borne diseases. The vector for bluetongue is the *Culicoides* biting midge. Insect trapping sites provide surveillance information on the presence or absence of the disease vector.
- Surveillance for risk factors for the development of algal blooms, which may produce toxins that kill farmed aquatic animals or contaminate aquatic products, thus making them unsafe for human consumption.
  - Surveillance systems can be established to monitor sunlight and water temperature, in order to assess the risk of the development of blooms. This is risk factor surveillance for the development of algal blooms.
  - Surveillance may directly measure the amount of algae present, and whether they are toxic or not. This is risk factor surveillance for aquaculture or food safety.

External risk factors, or factors not having a direct biological effect on the occurrence of disease in animals, may be considered for surveillance activity. For example, in some regions, movement of animals from one area to another during religious festivals has resulted in an increase or resurgence of FMD outbreaks and other transboundary animal diseases. Data on prices and livestock movements may be used to predict times of increased risk and the location of potential new disease outbreaks.

**Quality**

The way the quality of surveillance is measured depends on the type of surveillance carried out.

**Surveillance to demonstrate disease freedom or detect disease**

When surveillance is undertaken to demonstrate freedom from disease, or for early detection of disease, the conclusion is either that disease has been detected and is therefore known to be present, or that disease has not been detected, and is therefore believed not to be present.

With this ‘yes/no’ result, two types of errors may be made. First, it is possible to falsely conclude that disease is present when, in fact, it is not (a false alarm). False alarms may cause concern and expense, but do not ultimately endanger the disease status of the population (because no disease is present). A good surveillance system would be expected to generate a false alarm from time to time.
The second error is to falsely conclude that disease is not present when, in fact, it is (surveillance failure). Missing a genuine case of disease can be a serious error, as the disease may spread undetected.

A surveillance system can be thought of as a type of diagnostic test on the entire population: the population has or does not have a disease and the surveillance data are used to make a decision. The ability of a surveillance system to correctly identify a diseased population is analogous to the ability of a diagnostic test to identify a diseased animal. It is measured quantitatively by the sensitivity of the surveillance system.

Sensitivity is the key measure of the quality of a surveillance system that aims to detect disease or demonstrate freedom from disease. Sensitivity is discussed further in Chapter 3. The evaluation of the quality of the surveillance system therefore depends on an estimation of the sensitivity of the surveillance system.

While the sensitivity of the surveillance system is the key measure of system performance, the sensitivity of the system is based primarily on the number of animals (or herds) sampled and the sensitivity of the test(s) applied to them. The other important consideration when evaluating a surveillance system designed for demonstrating freedom or detecting disease is some assessment of the representativeness or otherwise of the sample, and whether or not any biases in the sample have been accounted for in calculating sensitivity.

**Example**

Let us assume that we are undertaking a survey to demonstrate freedom of the cattle population from bovine brucellosis. We know that only 5 percent of cattle herds in the region are dairy herds and the other 95 percent are beef herds. However, because we can use a bulk milk test for dairy cattle, it is easier to test dairy cattle than it is to test beef herds, should we find ourselves in a situation where we are obliged to do serological testing.

Let us also assume that we decide to test 320 herds, and we have calculated that this will give us the level of system sensitivity we need. For this calculation, we are assuming that our sample is representative of the population. However, if the likelihood of infection differs between beef herds and dairy herds and we test mostly dairy herds (because testing these herds is easier and cheaper), then our sample is unlikely to be representative of the population. In this case, our estimate of the sensitivity of the surveillance will be incorrect and we may either overestimate or underestimate the true value. To overcome this, we need to either ensure that the sample is representative of the population, or make adjustments to our calculations to take account of the difference in risk between herd types.

**Surveillance to measure the level or distribution of disease**

In order to determine the level of disease, a surveillance system most often measures prevalence (the proportion of infected animals in a population). Various other measures, such as incidence, may be used, but for the purpose of this discussion, prevalence will serve as an example.

Assessing the quality of a measure of prevalence involves assessing the two types of error that can occur: systematic error and random error.
Systematic error

Systematic error is the error produced by some systematic problem in the surveillance system. If the same surveillance is conducted repeatedly on the same population, the error will always be present, and the result will be the same.

Systematic error is measured by bias, which is defined as the difference between the true result and the expected result of the surveillance system (the expected result is the average of all results you would get if you repeated the same surveillance many times).

Example

Abattoir surveillance might be used to assess the prevalence of clinical paratuberculosis (Johne’s disease) in cattle. This disease causes chronic diarrhoea and weight loss. Therefore, in some countries, infected animals may be less likely to be sent to an abattoir than healthy animals.

As a result, the prevalence of clinical cases of Johne’s disease in an abattoir will always be lower than the prevalence in the general population. Abattoir surveillance for Johne’s disease is therefore biased.

Random error

Random error is due to the fact that the result of our surveillance can vary according to the chance of selecting one animal or the next animal. With small sample sizes, the random error can be large.

Example

Consider a population of 1 000 animals with a true prevalence of 10 percent. If only three animals are chosen at random, it is quite likely that all three would be healthy animals. This means that our estimate of the prevalence from our sample would be 0 percent. The random error is 10 percent.

Consider the same population, but a sample of 300 animals instead of three animals. It would be much less likely to select all healthy animals for the entire sample of 300. It is more likely that the sample would have 10 percent of 300 (30) infected animals, but due to random sampling, the actual number of infected animals in the sample might be a little higher or a little lower. It is quite likely that we would select one or two infected animals more or less than the expected number. It is much less likely that we would select a number of infected animals that is very different from the expected number (e.g. selecting as few as 4 or as many as 60 infected animals by chance).

The precision of an estimate describes how much random error there is. When calculating the results, the size of the random error is described by the confidence intervals around an estimate.
Cost and practicality
An important characteristic of surveillance systems is their cost. The precision (when measuring disease) or sensitivity (when detecting disease) of a surveillance system increases as the number of animals examined increases, but so also does the cost. A good surveillance system should be cost-effective.

In addition to cost, the resources to undertake surveillance must be available. Practicality should always be considered.

SURVEILLANCE OPTIONS
Surveillance can be carried out in a range of different ways. This section describes a number of different approaches.

Passive disease reporting systems
The term passive disease reporting systems describes the surveillance that is achieved when farmers identify that they have some sick animals, and they contact a veterinarian seeking help.

Passive disease reporting systems are the most common and probably the most important form of surveillance in any country. They are a form of passive surveillance, as the reason farmers contact a veterinarian is not because they are seeking surveillance, but because they are seeking help with the treatment of their sick animals.

These systems are also classified as general surveillance, as they can be used to identify a wide range of diseases.

Passive disease reporting systems have a number of key advantages:

• The coverage of the animal population is usually very good because the person responsible for identifying the disease is the farmer. Most animals in the population are closely observed by their owners relatively frequently. This is in contrast to surveys, where only a very small proportion of the animal population is examined.
• The system is relatively inexpensive – farmers need to contact the veterinarian anyway, and so therefore the main additional cost incurred is related to collecting the information for surveillance purposes.

Passive disease reporting systems are often the means by which new diseases – either incursions of exotic diseases or emerging diseases – are first discovered; this is because these systems achieve high coverage of the population, and are capable of detecting any disease (unlike the situation that applies where targeted surveillance is used).

Therefore, passive disease reporting systems play a very important role in any national surveillance system. These systems are far from perfect, however, due to the possibility of:

• farmers not observing their animals;
• farmers not recognizing signs of disease;
• farmers being afraid to report disease, due to the fear of negative consequences;
• farmers being unable to report disease because they live in a remote area;
• failure of the reporting system within the veterinary services to correctly register or diagnose the disease.

Efforts to address these limitations can significantly improve early detection of disease.
While there are many variations in the detailed operation of farmers’ disease reporting systems, a typical system may operate as described below:

- An animal gets sick, and this fact is noticed by the farmer. The chances of a farmer noticing a sick animal depends on the signs it manifests with (more spectacular signs, such as sudden death, unusual neurological signs, or large, visible lesions are easier for a farmer to notice) and the number of animals affected (if more than one animal is affected, a sick animal will be easier to notice). Sometimes a farmer may experience problems that are not associated with clinical signs; for example, subclinical disease, nutritional deficiencies or mastitis at a herd level may cause production losses that are noticed by the farmer, thus prompting a call to the veterinarian.

- The farmer contacts somebody about a sick animal or animals. The simplest case is when the farmer contacts the local government veterinary officer directly. Alternatively, the farmer may contact a private veterinarian, who then contacts a government veterinarian. The process may also involve a number of other steps, such as contacting neighbours, the village head or the local animal health worker for assistance. Ultimately, if the official veterinary service knows about the case, the information can be used for surveillance purposes.

- Information about the case is recorded. Normally, this is done by the local government veterinarian, but it can happen at other stages. Information may be recorded in a number of ways, but most often, a standard paper form is used.

- The written disease report is passed through a reporting hierarchy. If a report is compiled by the local village animal health worker, it will be passed to the district veterinary office. The information may then be passed from the district office to the provincial office, and from there perhaps to a regional office, before eventually arriving at the national office. At each stage, the information in the disease report may be analysed, summarized, or transformed into a different format. One common approach is for reports to be collated at the district level, with a summary report indicating the number of cases of different diseases sent to the provincial office each month. The provincial office combines all district reports into a single provincial summary of the number of cases, which is then sent to the national office. The national office then collates all the provincial reports.

Once surveillance data have been collected at the national level, they are available for use. Routine use of farmer reporting data often includes annual reports of the number of cases of different diseases reported each year, as well as information necessary to meet international reporting obligations.

Diagnostic laboratories are often seen as alternative sources of surveillance data. However, the process by which samples arrive at the laboratory is basically the same as for the passive disease reporting system. For example:

- The farmer notices that an animal is sick and seeks veterinary help.
- A diagnostic specimen may be collected and sent to the laboratory.
- Data from the laboratories are summarized and sent to the provincial or national offices for reporting, either linked to field reports or independent of them.
Abattoir
Abattoir surveillance is commonly used as a form of passive surveillance. The main advantages of this type of surveillance are:

- It is inexpensive – animals are processed and inspected for other purposes, and therefore the abattoir surveillance costs are primarily related to data capture and any laboratory tests performed.
- It can cover a very large number of animals.
- It allows collection of diagnostic specimens, such as blood or tissue samples, for laboratory testing.
- It provides a relatively constant supply of surveillance data.
- It enables data to be collected from a relatively small number of abattoirs that slaughter animals from a large number of farms or villages (thereby decreasing the data collection costs).

Active, targeted surveillance can also be carried out at abattoirs, in order to take advantage of some of these benefits.

Abattoirs vary significantly from country to country and from area to area. Highly industrialized commercial abattoirs are sophisticated factories with large workforces and tightly controlled food hygiene and safety requirements. Village abattoirs may operate outdoors and slaughter only a very small number of animals under poor hygiene conditions.

The types of surveillance information that can be collected from an abattoir include:
- routine meat inspection findings
- targeted specimens for laboratory analysis
- enhanced inspection findings.

Routine meat inspection findings
In all but the smallest abattoirs, there is some form of meat inspection. Normally, a limited number of parts of the carcass and viscera are examined.

The aims of meat inspection are to ensure that the meat is fit for human consumption, or to detect or exclude a limited number of specified conditions. For instance, specific lymph nodes may be examined to detect granulomas, in order to be sure that the animal is not infected with tuberculosis.

If the findings of routine meat inspection are recorded and captured by the surveillance system, they may provide a useful source of surveillance data about diseases that can be detected.

In many abattoirs, animals are also examined before slaughter, and this information may be used to supplement the meat inspection findings. These examinations, which are rarely detailed, aim to detect obvious injuries or lesions, as well as signs (such as depression or fever) which may indicate that an animal is clinically ill.

Targeted specimens for laboratory analysis
Abattoirs offer a valuable opportunity to collect specimens that cannot be collected easily from live animals. The simplest method is the collection of blood, but tissue specimens may also be collected. Large numbers of samples can be collected very rapidly at a busy abattoir, thus making this task simpler and cheaper than collecting similar specimens in the field.
The ability to collect specimens depends on the nature of the abattoir and the type of specimen required.

**Blood**

Blood is best collected as soon as possible after the animal has been slaughtered, and while it is being bled. In a busy commercial abattoir, this is one of the most dangerous, and therefore one of the most strictly controlled areas of the plant, because it is the only place inside the abattoir where there are live animals, and this may place workers at serious risk of injury.

Even if there is plenty of blood available to be collected, it is necessary to consider carefully how it can be collected without endangering or disrupting normal abattoir operations. Collecting blood at smaller, less busy abattoirs may be easier.

**Tissue samples**

Tissue samples can often be collected during or after removal of the viscera from the carcass. The ability to take tissue samples depends on the way in which tissues are used by the abattoir. If whole organs (such as livers) are going to be sold into the market, the abattoir may be reluctant to allow samples to be taken, and may require them to be purchased.

**Enhanced inspection findings**

Routine inspection may detect only a limited number of animal health problems. It may be possible to carry out special inspections at the abattoir for a specific disease that can be detected during post-mortem examination. This may be done by:

- external research
- surveillance staff
- existing meat inspectors, who have been trained to carry out more detailed examinations in order to detect disease.

These more detailed examinations may be further improved by the collection of specimens by the meat inspectors for laboratory confirmation.

**Sentinel herds**

A sentinel herd usually consists of a relatively small number of animals, which are kept together and are visited on a regular basis and tested. Testing usually involves blood tests to check for antibodies to specific diseases. It may also involve clinical examination or tests for a specific disease agent.

The typical operation of a sentinel surveillance system is as follows:

- A relatively small number of sentinel herds are established in areas considered to be at high risk of disease incursion.
- Where possible, animals are individually identified.
- When animals are first introduced into the sentinel group, they are tested to ensure that they are susceptible to the target disease (i.e. they do not already have antibodies).
- At each subsequent test, the antibody status of the animals is assessed.
- If an animal is antibody positive, this indicates that the animal has been exposed to the disease in the time between the current test and the previous (negative) test.
Sentinel herds or flocks are therefore distinguished from other systems by being a relatively small group of identified animals, placed in a fixed strategic location, and monitored over time.

**Surveys**

Surveys are often seen as the best way to carry out surveillance, but they can be costly and logistically challenging. They are a form of active surveillance, and therefore the veterinary services have full control over the design of the survey and the data collected.

The key advantage of surveys is that the sampling strategy can be developed to exactly meet the needs of the veterinary services and decision-makers. Many other forms of surveillance involve a compromise between the data needed to support decision-making and the data that are available.

Surveys may be representative or risk-based (targeted at a subpopulation with a higher risk of having the disease).

Representative surveys are the most common form. With this approach, it is possible to confidently calculate measures of the level of disease, or probabilities of disease freedom, without the fear of error due to bias.

*Survey Toolbox* (Cameron 1999), Parts I and II (Chapters 2 to 9) deals with most aspects of livestock disease surveys; Chapter 3 concentrates on techniques to ensure a representative sample.

Risk-based sampling is used to detect disease or to demonstrate freedom from disease. Animals are chosen from high-risk groups, so that if the disease is present, there is a better chance of detecting it than would be the case if purely representative sampling were used.

**Syndromic and indirect surveillance**

Various forms of syndromic surveillance have been used for many years. However, recent interest from the field of human surveillance has led to a great deal of research in the area.

A syndrome is defined as a collection of signs that indicate the presence of a disease. Syndromic surveillance is therefore concerned with the signs and groups of signs that are associated with disease. These may be clinical signs, such as fever, lameness and diarrhoea, or indirect signs, such as a decrease in the feed consumption at the pen level in a piggery, or an increase in antibiotic feed additive sales from a supplier. When the signs do not relate to clinical signs, this type of surveillance is known as indirect surveillance.

Syndromic surveillance involves the identification of specific signs or groups of signs, and analysis of the patterns of these signs in space and time.

The purpose is not to diagnose a specific disease, but to detect abnormal patterns of signs that may be due to one of a large number of diseases. When an abnormal pattern is detected, a disease investigation follows, in order to diagnose the actual cause of the disease.

Patterns of signs and syndromes are often much less clear than direct diagnoses of disease.
Risk-based disease surveillance

Example

If diarrhoea is used as an indicator of the presence of classical swine fever (CSF), a syndromic surveillance system might collect farmer reports of diarrhoea in their pigs, or sales of treatments for diarrhoea.

Diarrhoea can have many causes, so there would be a constant stream of reports coming into the surveillance system. A single case of CSF would just be one more report among many others. However, CSF usually occurs as major outbreaks, and can spread from farm to farm. When it enters the population as a new cause of diarrhoea, the normal pattern of reports of diarrhoea may change.

In order to detect these changes, large amounts of data are required to establish the normal patterns of the sign or syndrome being analysed. These patterns describe how much illness there is, seasonal variations, and normal random variations (in the absence of the target disease). An understanding of the normal patterns makes it possible to detect a change in these patterns when the new disease appears.

The source of data for syndromic surveillance systems should normally be fast, simple and inexpensive, and should allow the routine collection of large amounts of data.

Example

Commercial poultry farms expect a certain level of mortality each day, and they routinely record the levels of daily mortality in their sheds. Since death is a syndrome that can be used to detect disease, the data on mortality (if collected centrally for analysis) could easily be used to detect unusual patterns of mortality in the population and trigger a rapid investigation.

The above examples illustrate the three types of data that can be collected by a syndromic surveillance system:

• individual clinical signs (diarrhoea, fever, lameness, agitation, etc.) – farmers or veterinarians record the clinical signs they observe, without making a diagnosis on the basis of these signs; patterns and combinations of the signs are analysed to determine what is normal, and to detect what is abnormal.
• syndromes (respiratory, gastrointestinal, neurological, death, etc.) – cases are classified according to the dominant organ system involved; these classifications can be analysed, in order to ascertain unusual patterns.
• indirect indicators of disease (feed consumption, drug usage, etc.) – indicators that are not observed directly in sick animals, but are observed indirectly.
Negative reporting (zero reporting)
A veterinary negative reporting system is a specialized surveillance system designed to provide evidence of freedom from disease. This system is a type of passive surveillance which aims to document information that is being generated for other purposes.

Veterinary staff routinely visit farms, villages and other places where animals are kept for a range of reasons, such as examining and providing treatment of clinical cases, vaccination as well as other control activities or inspections and certifications. During the course of these visits, there is normally an opportunity to meet with the livestock owners and to observe the other animals.

If the veterinary services are aiming to demonstrate that a country or zone is free from a disease that normally shows clear and obvious clinical signs, each visit by veterinary staff provides the requisite evidence. Even if specific examination of animals is not undertaken, it is very unlikely that a disease such as FMD exhibiting its normal manifestations in cattle or pigs could be present without the farmer asking the veterinarian about it, or the veterinarian noticing the disease in the animals. The fact that disease is not noticed during a routine visit can therefore be seen as evidence that the disease is not present.

After each visit, the veterinarian completes a brief report, which includes the location, the date, and confirmation that the target disease was not seen or reported during the visit.

The ‘test’ in this case (talking to the owner, and inspecting the animals from a distance) is not very sensitive and has very low sensitivity in early cases of disease. However, it is very inexpensive.

Information from the veterinary negative reporting system can be used in response to Carl Sagan’s often quoted phrase: “Absence of evidence is not evidence of absence.” In other words, to provide evidence that the disease is absent, a simple absence of reports is not adequate. The veterinary negative reporting system generates documented evidence that the disease is not present. Over time, the number and coverage of these reports can provide significant evidence that the country or zone is free from the disease in question.

Participatory disease surveillance
Participatory disease surveillance (or participatory disease searching, (PDS)) is a relatively new term used to describe an approach to surveillance involving the engagement of farmers.

The method arose out of earlier work on participatory epidemiology and participatory rural appraisal. The common features of all these approaches are the use of trained teams to conduct semi-structured or unstructured interviews with farmers, and the use of a variety of tools to get an overall assessment of the problems and needs of the farmers. Typical tools include:

- participatory disease or risk mapping
- brainstorming
- participatory piling
- development of calendars
- prioritization or ranking exercises
- open discussions.
The prime objective of participatory approaches remains surveillance, and a key output is quantitative data on the occurrence of disease. The participatory approaches from which PDS evolved are specifically designed to give investigators a general understanding of issues and problems from the point of view of the farmers; they are also designed to help address these problems without any preconceptions of what the most important issues might be.

PDS may be used in two ways:

- targeted surveillance, investigating the occurrence of a single disease (for example, highly pathogenic avian influenza (HPAI) in Indonesia, or rinderpest in Pakistan or Somalia). This application is at odds with the participatory philosophy, as the prime concern of investigators is finding out about the disease of interest – although they may be happy to learn about disease in general (or indeed other problems) from the farmers’ point of view, they are not in a position to do anything about these more general problems.

- general surveillance, in which information about all diseases of importance to farmers can be collected and prioritized. The investigators are limited by their preconception that animal disease is a key problem.

Because PDS is a surveillance activity, rather than a component of a rural development activity, and because its main purpose is to collect data, it is better to separate it from the associated methods from which it evolved, and to assess its value in terms of surveillance.

PDS is active surveillance (general or targeted). Trained teams visit villages and talk to farmers, and the reason they do this is to generate surveillance data. Farmers are the source of the information, and the way data are collected is through discussion with farmers.

PDS may be thought of as an alternative approach to the passive disease reporting system, which overcomes some (but not all) of the problems of low farmer reporting rates.

The participatory tools used in PDS are not something special for this activity; rather, they are simply a documented approach to collecting good information from farmers. Aspects of this approach can and should be used (to the extent appropriate) whenever veterinary staff are discussing disease-related issues with farmers.