Disease Outbreak Investigation in the Beef Herd: Defining the Problem

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Introduction

Disease outbreak investigations can be an important, challenging part of beef practice. They require one to develop, by planning and experience, a thorough investigative approach which can be used to identify patterns and distinguish between the normal and the abnormal. Epidemiology is a key tool, but careful observation and logical deduction are also important. If handled correctly, even the most complicated disease outbreak situations can become excellent practice builders for the bovine practitioner.

We present the basic steps that we have found necessary to ensure success in an investigation of disease problems in the beef herd. We place emphasis in this particular presentation, though, on one of the main tasks of the investigation, which is to clearly define the problem as early as possible. This is because, to paraphrase some well-placed advice, *a problem well-defined is three-quarters of the solution.*

What is an Outbreak?

A disease outbreak is often brought to your attention by the farmer or herd manager. What gets classified as an outbreak, therefore, often depends upon the herd owner's threshold of concern. A worrisome increase in disease or drop in production for one farmer may be insignificant to another. Some farmers ring the alarm bells and call in a veterinarian to investigate a mild scours problem seen in three well hydrated calves. Other farmers may wait until one-third of their calf crop has died before picking up the phone. Thus, the herd owner's threshold of concern will frequently dictate when a veterinarian becomes involved during the progression of a disease outbreak.

Disease outbreaks can be difficult to recognize, particularly if you work in a multi-person practice. A farmer may be struggling with a calf diarrhea problem and never actually think of asking you to visit the farm. The only evidence the veterinary clinic has of the problem is that the farmer has come into the clinic several times to purchase oral electrolytes and antibiotics. Outbreaks may also be difficult to identify where a number of different veterinarians attend to a series of sick individual animals on a farm without noticing or worrying that there might be a connecting link between the cases. The farmer may fail to notice or suggest a connection, figuring that he or she is simply going through a period of "bad luck."

The Approach

Several protocols for investigating an outbreak of disease in a herd or herds have been suggested.[1,2,3,4,5] Most are very similar, differing only in the order and perhaps number of steps that should be followed. In our experience, we have found that there are six main tasks that need to be tackled in order to properly work through a disease outbreak (Table 1). These tasks or

Table 1. The six main tasks of a disease investigation.

Define the Problem
Define Groups
Collect Samples
Establish a Working Diagnosis
Take Action
Do the Follow-Up

steps follow most logically in the order that they are listed, but often an outbreak investigation team can be working on a number of steps concurrently. Also, environmental or other conditions often intervene in such a way that reordering the approach makes better sense for that particular investigation.

You need first and foremost to carefully define the problem. This is accomplished by questioning the farmer, doing clinical examinations and necropsies, defining groups and evaluating their risk, and collecting blood, feed, and other samples. This should lead to a working diagnosis which allows you to take action before leaving the farm. The investigation does not end, however, until you have collected all the clinical and laboratory data and re-evaluated the working diagnosis, recording all findings on a final report which is delivered in a timely manner to the farmer.[6]

Each investigative task should be approached with the investigative objective of using the techniques of descriptive epidemiology to answer the five "W" questions: What, Where, Who, When, and Why.[4,7] In this way, one can develop a comprehensive understanding of the epidemiology of the disease outbreak so that a plan for its control and prevention can be put into place.

The Visit

"If the art of the detective began and ended in reasoning from an armchair, my brother would be the greatest criminal agent that ever lived." Memoirs of Sherlock Holmes: The Greek Interpreter.[8]

All outbreaks require, in terms Sherlock Holmes would understand, a visit to the "scene of the crime". You cannot confidently and effectively investigate a disease outbreak without visiting the site of the event. Farmers often phone or come into the veterinary clinic and carefully describe their experience with an ongoing disease problem that is affecting their herd. Some will conclude by asking when you can come out to the farm, but many will instead ask, "What should I do?", or "What treatment should I use?" Unfortunately, veterinarians are often faced with these questions in the midst of a busy day when they feel least able to cope with yet another complex problem. It might seem best at the time, therefore, to try to deal with situation from the clinic and provide immediate answers to the farmer's questions. After all, many herd owners are excellent observers and they can communicate a clear story that leads to an obvious diagnosis. However, we have documented many cases where this approach led to much more serious problems for both the veterinarian and the farmer several days or weeks later.

These situations develop most often as a result of the way in which the farmer describes the problem and asks for advice. A common example of this is feedlot owners who complain to a veterinarian that the antibiotic they have been using is no longer effective against respiratory disease. They then frequently drive the discussion towards assessing the relative merits of newer antibiotics which should be substituted for the ineffective one. But advice on switching antibiotics is not warranted here. The farmer might have identified the problem correctly but he or she may have come to the wrong conclusion. Conditions at the feedlot may have changed so that sick animals are no longer being treated early enough for an antibiotic to be effective. Or the primary cause of disease may have switched for a time to being viral. Switching antibiotics will do nothing to correct either of these situations, except to delay a proper disease investigation and possibly elevate death losses.

Herd owners may also focus on the wrong problem. One had a long conversation on the phone in the spring with us describing a congenital problem in his calves. A good proportion of his calf crop was on the ground and not one of them could walk on their hind legs. His main questions were what to do with his calves and whether the remaining unborn calves would also be affected. We suggested that the insult to the fetuses in the herd had probably occurred some time ago and it was very likely the remainder of his calves would also be affected. However, we recommended a visit to the farm to investigate what might have happened so this could be avoided in the future.

Upon arriving at the farm, we observed a large pile of dead animals. The pile consisted of many dead calves, but there were also many dead cows. When asked about the dead pile, the producer noted that *he had lost 20% of his cow herd over winter and they were still dying!* He had been consumed by his calf problem; he had never mentioned anything about dying cows on the telephone. We shifted the emphasis of the investigation to the cows because cows were still dying. If their mortality rate could not be reduced, the man would lose his cow herd as well as his calf crop. This was an obvious example of how important it is for the veterinarian to visit the farm and observe the situation.

Preparation for the Visit

The visit should be scheduled at a time when all those who work with the animals can be present. In

many cases, this means the whole family and the hired hands. This ensures that there will be extra help available for working with the animals. More importantly, however, the presence of everyone increases the likelihood that you will be able to piece together the details of the history. Also ask the farmer to gather together all of the appropriate records and encourage him or her to have the affected animals or groups available for examination.

The visit should be scheduled at a time when you will have several hours of uninterrupted time to devote to the investigation. Most initial visits require a minimum of two to four hours. You should be prepared to examine as many animals as necessary. To increase efficiency, bring along an animal health technician from the veterinary clinic. The technician can take notes during your questioning, help move and confine animals for examination, take samples, assist with necropsies, and ensure that all samples and information are properly labelled and prepared for the laboratory.

Defining the Problem

As stated earlier, a problem well-defined is three-quarters of the solution. Carefully defining the problem is the starting point for any disease investigation. This amounts to answering the WHAT question of the W5. There are five steps one should work through for proper problem definition (Table 2).

Table 2. The five steps one should work through for proper problem definition.

Listen to the Story
SHOW ME
Clinical Examinations
Necropsies
Decide if there IS a Problem

Listen to the Story

"Just let us hear it all in your own way as it occurred." A Study in Scarlet.[8]

To be an effective disease investigator one must become a good interviewer. We have found the best approach is to let the farmer tell the story of the outbreak from his perspective, typically in chronological order. This usually is not difficult, because the first thing most producers want to do is describe their problem. The difficult part is allowing them to do so without interrupting unnecessarily or jumping to a conclusion and asking questions that focus on that conclusion.

This approach goes against the advice of others who suggest that prepared questionnaires be used during the interview process.[2,9] We have found that prepared questionnaires interfere with both the flow of the interview and the rapport that you are trying to develop with the producers. In many outbreaks, you will not know the real nature of the problem until well into the investigation; however, in order to use a questionnaire "which is applicable to the particular disease which is being investigated",[9] you have to know in advance the nature of the problem. Furthermore, many of the "standard" questions on a prepared questionnaire are not relevant to the particular case. Finally, asking questions in the order they appear on a prepared questionnaire hinders a chronological presentation and understanding of the events. Better to be a good listener and carry on an intense interactive conversation with the farmer than allow a "structured" document to come between you.

When all members of the family or operation are present, you may find that the story is told by the whole group, the narration being passed from person to person as they remember different facts. Encourage them to use all of the records at their disposal in order to be sure of dates, numbers, and places. This means referring to shirt pocket record books, all manner of database managers or spreadsheet programs on the family computer, the calendar hanging on the kitchen wall, receipt books, scraps of paper hidden away in "junk drawers", and daily diaries. When disagreements occur, carefully explore them to see if a consensus can be reached. If not, you can pursue these later while you examine animals and the farm.

Try not to ask leading questions, loaded questions, or questions that suggest some answers are more "acceptable" than others.[10] For example, don't ask questions like "Why don't you own a scale?", or "Do you ever clean out this pen?", or "Why didn't you call me in earlier?", or "Which vaccine products do you use on your cattle herd?" The last question demonstrates that you assume producers will vaccinate their herd. The farmer is placed on the defensive if he/she does not use any vaccines. This can damage the rapport you are trying to develop during the interview, and it can even lead to misleading answers being given to certain questions. Better to make it more acceptable for the farmer to respond that they use no vaccines by asking the question in a more neutral fashion. For example, you might ask instead, "Do you happen to use any vaccines in the herd, or have you not found that necessary?" This question is more likely to produce a factual answer, and you can come back to the issue later in the investigation if you think it is important to change their vaccination approach.

Once the story has been presented, do not be afraid to ask the family what they think is going on. In the words of Schwabe, "observations about disease made by laymen are not to be dismissed lightly".[11] Many farmers are astute observers. You should know what

hypotheses they have developed as a result of their observations because they could very well be correct; if they are not, you are going to have to show them, with evidence, why they are not so that they come to accept and act upon another hypothesis that proves more likely to be the cause of the outbreak.

The interview is a good time to search for any indications that the family members or hired workers have been ill,[2] especially if there are early indications that you may be dealing with a zoonosis or a general "exposure" to some intoxicant. This has to be done carefully and with tact because you don't want to alarm the family, nor do you want to "put ideas in their heads" that may slant their interpretation and presentation of events as they latch on to a new hypothesis. Nevertheless, it is important to get this information and interpret it in light of your investigation findings.

SHOW ME

"It was invisible, buried in the mud. I only saw it because I was looking for it." Memoirs of Sherlock Holmes: Silver Blaze.[8]

There is no substitute for walking around the farm and examining the situation first-hand. "Show me the sick animals, the healthy animals, the dead animals. Show me the environment, the pen, the pasture, the feed, the water, the equipment. Show me how you actually do things."

Show me is critically important because what they say might not be what you see. For example, when dealing with a diarrhea problem in newborn calves, the farmer might report that the calving and "kick-out" grounds are amply spacious for the number of cows he/she is running. A walk through these grounds, though, often shows that, because of tree-cover or snow-fall or the presence of old equipment, the cows are using only a small portion of the total ground available to them. As a result, their calves are being exposed to a limited and highly contaminated area. The problem becomes not one of available space, but usable space.

Show me is also important because what they say may not be what you hear. During the interview, the producer may be using descriptive terms which mean one thing to him, and a very different thing to you. This can lead to a gross misunderstanding of the situation. In one investigation of an outbreak of colics on a brood mare farm, the rotund nature of the horses and the thick perirenal and subcutaneous fat observed during a necropsy suggested that the horses were being overfed. Yet, during the interview process the producers stated they "fed one small bucket of grain per day per three head."

"One small bucket" in the mind of the investigating veterinarian was a one litre ice cream bucket. Why, then, were the horses getting so fat? A walk through the farm led to some suspicions. The horse owners were loggers and their perception of the words small and large functioned on a much different scale than most people. To them, a garage could hold three logging trucks and a winch was required to lift a "small" chain. When asked to "show me" how they fed grain to the horses in the morning, the horse owners produced a large plastic garbage bucket which they filled and then distributed to three horses. Weighing this "small bucket" of barley and whole oats showed that the 2 year old horses were being fed 18 lb grain/head/day and yearlings were getting 24 lb grain/head/day! This was a far cry from the couple of pounds of grain in a little plastic ice cream container envisioned by the investigator. The observation led to a working hypothesis that the horses were receiving too much grain, and overfeeding was likely contributing to the gastrointestinal incidents that had been occurring on the farm during the previous two months.

Clinical Exams and Necropsies

"The completeness of the evidence collected 'in the field' almost always depends solely upon the investigator's powers of observation".[11]

You should do at least a cursory clinical examination on all of the livestock present so that they can be divided into groups. Count the sick. Don't forget to also count the well so you can calculate attack rate tables where necessary. Look specifically for the index case or cases because they may help you identify the source of the outbreak.[12] This group also tells you about the prognosis of the disease. Many may in fact be dead. Also examine any recent additions to the herd.

Define the *severity of morbidity*. This represents an opportunity to "triage" the animals and decide which are in most need of immediate treatment. In outbreaks of calf diarrhea, for example, determine the number of calves with soft feces versus diarrhea. Of those calves with diarrhea, separate those who are still sucking from those who have "crashed" or are recumbent and showing signs of severe dehydration, acidosis and hypothermia.

Perform necropsies on as many cadavers as are available. We are sometimes surprised to encounter disease outbreak situations where the attending veterinarian necropsied one or two animals, and then ignored the remaining cadavers. If you happen to choose the wrong animals in these situations, and you necropsy animals that are not truly representative of the dead pile, you run the risk of coming to the wrong conclusion. *In an outbreak situation, necropsy diagnosis is a herd diagnosis.* Make sure also, if you are sending pathology samples to a laboratory, that one pathologist is involved with the processing of all the samples so that a diagnosis based upon "quantitative pathology" is offered. This

requires a quick phone call to the laboratory with a warning about what is coming.

Many farmers in northern climates who have death losses occurring during early spring calving create a makeshift "morgue" by burying the cadavers under straw and snow. During outbreak investigations at this time of year we have learned to ask if there are any dead animals that have been stored in such a snow and straw "body farm". These frozen cadavers, after thawing, provide an excellent opportunity for making a "quantitative pathological diagnosis".

Even when all dead animals are not available for examination at necropsy, they should be listed by pen of origin, date of death, or in the case of a calf, by identity or age of the dam.[6]

Decide if there IS a problem.

It is important to decide, after evaluating the situation, if there really is a problem. Farmers really do have drastically different thresholds of concern, and some become overly concerned about what amounts to "no problem". We have been called into situations where, for example, a farmer is frustrated because "none of the treatments work against calf scours on my farm". Careful examination of calves on the farm showed that none were really scouring, despite the owner's claims to the contrary. One of the main complaints of one such owner was that the sick calves were "so darn hard to catch to treat".

Clearly, there is no sense spending a lot of time and money trying to diagnose a non-existent problem. Unfortunately, identifying such a situation can lead to the "no problem problem", where convincing the farmer that he or she doesn't really have a problem is a tough task. This takes a good deal of patience and follow-up effort. Sometimes the farmer never does become convinced there is no problem, and in the process of calling in "experts" from far and wide, and administering all manner of bizarre home-made remedies, an iatrogenic problem results.

Step 2 (Defining Groups) and 3 (Collect Samples) in Table 1 are really extensions of defining the problem and, as such, also deserve some exploration here.

Define Groups

Defining groups is started during the clinical examination and necropsy stages of the investigation and finished by carefully examining the herd records. Animals are identified by name or number (who), place (where), and time (when). Attack rate tables can then be drawn up to look for important patterns and clues as to why the outbreak may have occurred.

Greg describes the same process as it is used by Epidemic Intelligence Service Officers when investigating outbreaks of human disease:

> *"Virtually all epidemiologic analyses require comparisons, usually of groups of persons—ill and well, exposed and not exposed. In epidemic situations, one usually compares ill and well people—both believed to have been at risk of disease—to determine what exposures ill people had that well people did not have. These comparisons are made by using appropriate statistical techniques. If the differences between ill and well persons are greater than one would expect by chance, one can draw certain references about why the epidemic occurred".*[1]

MacMahon and Pugh have called this using the "method of difference" to explore the cause of a disease outbreak.[13] They noted that "If the frequency of disease differs appreciably under two sets of circumstances and some factor can be identified in one circumstance but is absent in another, this factor (or its absence) may have caused the disease".[13] John Snow used this technique to identify the importance of water supply in the occurrence of cholera even though the precise nature of the disease agent had not yet been established.[14] Wilesmith identified and used differences in the occurence if BSE among different parts of Great Britain to develop hypotheses concerning the cause of the emerging syndrome.[15]

We have found the process of defining groups to be useful in many situations, especially when dealing with diseases or situations which are not well described in the veterinary literature. In investigating outbreaks of congenital joint laxity and dwarfism (CJLD) affecting calves in two beef herds in central British Columbia, we created the attack rate table seen in Table 3.[16] Two different farmers had purchased a group of bred heifers during the month of November and brought them into their own herds at that time. The following spring, approximately 50% of the home-bred cows on both farms had calves that were affected with CJLD. This was also the case for calves born to the purchased heifers at one of the farms, but there was a striking difference at the other farm. This attack rate table motivated us to carefully explore differences in how the two groups were managed, and led to the hypothesis that silage feeding

Table 3. An attack rate table for congenital joint laxity and dwarfism (CJLD) affecting calves born to dams at two ranches in central British Columbia.

Heifer Group	% CJLD Calves at the:	
	GF Ranch	PM Ranch
Home-bred	53	47
Purchased	0	50

was somehow involved in the pathogenesis of CJLD.[17] The same technique was used to identify feed as a cause of another congenital anomaly in beef cows known as Congenital Spinal Stenosis.[18] Defining groups, then, can be a key step towards defining the full nature of the problem in a disease investigation and can help significantly in identifying the cause of the problem.

Collect Samples

"We used to have a saying in medical school. If you hear hoofbeats, look for horses. But in a case like this I know we're looking for zebras." Kay Scarpetta in *Cruel & Unusual.*[19]

We tell our students that in order to verify your answers to the W5 questions of the investigation, you need to collect samples and satisfy the "Seven S's for Sampling" (Table 4). It is more efficient to ensure that you collect all the samples you might need for the investigation during your primary investigative visit, and a quick mental check of the seven S's should reduce the incidence of missing or forgotten samples. The seventh S, SPECIFY, is a reminder to properly identify all samples.

Table 4. Outbreak investigation sampling procedures required to verify the answers to the "W5" questions.

THE 7 S's FOR SAMPLING	
SUCK	blood
SCOOP	poop
SWAB	orifices
SLICE	necropsies
SPOON	feed
SIPHON	water
SPECIFY	identity

It is important to be thorough at this stage of the investigation. Thorough sampling enables you to rule-out differential diagnoses, and it allows for subsequent searches for "zebra" solutions that might be impossible with less thorough approaches. In a recent investigation of mortality due to calf scours in a beef herd much of our investigation, with a few unexplained anomalies, pointed to coronavirus as the cause. We had 32 frozen dead calves to take back to the veterinary college, and lots of clinical epidemiological information from which we could build a plausible "story". So much, in fact, that it seemed like we were overdoing things by catching acute scour cases in order to collect fresh diarrhea samples. However, it was only these latter samples that identified *Salmonella* as a serious problem in this herd. Thoroughness at the sample collection stage helped explain the "anomalies" that we may have overlooked in our investigation.

Take samples from your defined groups. For example, ensure that samples are taken from acute cases as well as chronic cases, from diseased and healthy animals, and from animals coming from different corrals or pastures. You are often looking for pattern differences among groups, so you need to take enough samples per group to enable you to discern a pattern. We find that 5-10 samples per group is usually adequate for this. It is difficult to discern a pattern in antibody titres in anything less than a group of five. If in doubt take extra samples and store them. You can always discard them later if you find they are not needed.

Wobeser makes a crucial point when it comes to collecting samples: "Because of the specialized nature of medical science, most specimens collected during a disease investigation will be analyzed by someone other than the collector. The single most important guideline for specimen collection is to consult, in advance, with the person(s) who will do the analysis".[20]

All of the above steps should enable you to define the problem either prior to, or shortly after, leaving the farm. The remaining steps in the disease investigation procedure follow naturally, once the problem has been properly identified.

Establish a Working Diagnosis and Take Action

With all the information, a "best fit" or working diagnosis will be possible. Your recommendations should be based upon this "best fit" diagnosis.[6] The farmer should be presented with an action list so he or she has a clear understanding of the steps you feel are necessary to stop the outbreak and prevent a recurrence. In feedlot and cow-calf situations, it has often been necessary to clearly state that animals should be moved from one location (where mortality occurred) to another, or to recommend the removal or replacement of a supplement in a feed.[6]

For thinking about the possible range of actions that can be taken in the beef herd to "remove the pump handle", we have found it useful to keep Schwabe's "Directed Actions Against Disease" in mind.[4] These possibilities include selective slaughter, quarantine, depopulation, mass treatment, mass immunization, environmental control, and education. This is also the stage at which you must clearly consider the following questions in establishing your plan of action: Is the disease contagious? Is it a reportable disease? What are the producer's plans? Can the producer survive economically?

Do the Follow-Up

Finally, after all the laboratory results are collected, one has to analyze and interpret the final findings to attempt to definitively answer the "WHY". Important unknowns should be pursued.[6] Laboratory results

may indicate that additional specimens should be submitted for ruling out other potential causes of the disease outbreak. It may also become necessary to examine or test neighbouring pens or farms as a comparison to check on the accuracy of the laboratory examinations.

The outbreak investigation is not completed until a written report is supplied to the farmer. All your findings and calculations should be documented in the report. All the unknowns or questions you have not been able to answer should also be noted. A discussion of the logic you used to reach your diagnosis of "best fit" should be part of the report which should conclude with a list of your recommendations (Table 5).[6]

Table 5. List of headings which should appear in the final report of findings from a disease outbreak investigation.

Location of the herd
The complaint
History of the herd
Description of the Facility
Production Procedures
Observations
Laboratory Results
Data Analysis
Discussion
Diagnosis of "best fit"
Recommendations or Action List

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Abstract

Investigation of osteochondrosis in grazing beef cattle

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Severe lameness attributed to osteochondrosis is described in an extensively managed Brahman herd grazing on improved native pasture. Clinical signs were observed in five animals, three of which were necropsied. The most prominent lesions were in the elbow and stifle joints. There was multiple fissuring and ulceration of thickened articular cartilage with numerous osteochondral bodies present in the joint spaces. All affected animals were entire males sharing a common ancestral sire. Inheritance and gender were suspected to be contributing factors in the development of the disease.