How to Investigate a Disease Outbreak

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Investigating a disease outbreak requires examination of both affected and unaffected animals with the goal of identifying factors associated with the occurrence of disease. By following a series of systematic steps, an unbiased, organized assessment of the problem can be made, and the likelihood of understanding a disease outbreak is increased. Authors' address: Dept. of Clinical Sciences, College of Veterinary Medicine and Biomedical Sciences, Colorado State University, Fort Collins, CO 80523.

1. Introduction

While individual sick or injured horses can be challenging cases, problems affecting a large number of animals at the same time can be unsettling and even more difficult to solve. Typically, it is cases of respiratory disease, diarrhea, or abortion that make a practitioner wonder if they might be seeing the beginning of a disease outbreak. It is possible, however, to encounter cases of neurologic disease, sudden death, even colic or lameness that may be part of a larger problem affecting a number of animals.

The basic premise of epidemiology, and specifically outbreak investigation, is that disease does not occur randomly. In general, a group of cases might be considered an outbreak whenever a larger proportion of the animals at risk are affected than one would normally expect. The number of affected animals required to be classified as an outbreak varies according to the characteristics of the disease and population affected. Also, there may be a pattern to the disease occurrence that is unusual and therefore warrants investigation. Disease patterns may be temporal, spatial, or related to certain characteristics of the animals involved. It is understanding these disease patterns and relating them to the patterns of potential risk factors that allows identification of measures to prevent new cases of disease and future outbreaks.

Different combinations of infectious or toxic agents, individual and herd immunity, population age and movement, nutrition and environmental factors may contribute to an outbreak of disease. Sometimes it is possible to identify the cause or causes of an outbreak simply using keen observation and intuition gained through experience. Unfortunately, this approach can be biased easily by an individual's interests, expertise, or past experiences, as well as the emotions of the practitioner or the client. This presentation outlines a systematic, unbiased approach to identify the contributing cause(s) or source of an outbreak with the ultimate goal of recommending control measures to stop the current outbreak and to prevent future outbreaks.

2. Methods

When faced with a number of sick or injured animals, the clinician should begin with triage and treatment of the cases at hand. Symptomatic therapy of affected animals can usually be initiated

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immediately, before the cause of the outbreak is fully understood. The next 10 steps outlined here offer a systematic approach to the investigation of disease outbreaks. They are not exclusive of other measures one may take when investigating an outbreak and may not all apply to every situation. Although they are presented here in numbered sequence, it is not absolutely necessary to follow them in order and several steps may be taken simultaneously. Treatment of affected individuals may be modified and preventive measures taken at any time during the course of the investigation.

A. Step 1: Verify the diagnosis

Often the purpose of an outbreak investigation is not to diagnose the problem affecting the individuals, but to identify the source of the problem. If a working diagnosis has already been established, it should be reconfirmed by the investigator. Reviewing physical findings and laboratory test results from each case can be used to confirm the clinical diagnosis and rule-in or rule-out alternative differential diagnoses. When a diagnosis has not been reached, a tentative diagnosis can often be based on common clinical signs. It is helpful to record each case that has occurred and list the signs and symptoms exhibited by each as well as the laboratory findings.

B. Step 2: Define a Case

Even if the diagnosis is tentative, a case definition is needed to focus the investigation on a specific problem. The case definition should distinguish the disease under investigation from other conditions that are more common and may be occurring simultaneously at the normal, expected frequency in the population. It is not a good idea to try to investigate secondary, minor problems known to affect the population during an outbreak investigation. A good case definition includes the animals that have the primary disease under investigation and excludes those that are healthy or may be sick but affected by an unrelated disease. If no diagnosis has been reached, the list of signs or symptoms made earlier may suggest a typical description that qualifies as the case definition for the investigation.

For example, in an investigation of respiratory disease in foals, the primary interest may be foals which develop pneumonia at 3 to 4 months of age. With this scenario it would be important to distinguish these foals from those that developed sepsis and pneumonia at less than one month of age. The case definition for this investigation might need to include the premise of a normal birth and age greater than 1 month.

C. Step 3: Determine the Magnitude of the Problem

Before continuing with a complete investigation, it is a good idea to stop and consider whether there really is an outbreak occurring. This is done by comparing the current frequency of disease with what would be expected in a similar group of animals under similar conditions. First, a count of the affected animals and the total number of animals at risk (affected and unaffected) is needed. Then an overall attack rate (AR) can be calculated (Fig. 1).

The attack rate for the population under investigation is then compared to the attack rate in other similar populations. How large the increased frequency of new cases needs to be to constitute an outbreak is a judgement call. A racing stable predominately made up of two-year-olds might expect a respiratory disease attack rate of 20% over a few months time, but this would seem excessive for a barn of pleasure horses over a few weeks time.

D. Step 4: Describe the Temporal Pattern of New Cases

The temporal pattern of the outbreak is described by creating a chronological time line or graph (Figs. 2 and 3) that counts the number of *new* cases relative to the passage of time. Days, weeks, and even months may be an appropriate unit of time, depending on the duration of the problem. This graph, called an epidemic curve or histogram, can also record events that may have affected the population and may be linked to the disease, such as when new shipments of feed, bedding, or horses arrived.

The epidemic curve can reveal a distinct temporal pattern to the outbreak. A rapid increase in the number of cases over a very short period of time (Fig. 2) suggests a point-source epidemic where a large number of animals are exposed to a common source of the disease-causing agent at the same time. Such a pattern is often seen with food- or water-borne disease or a highly virulent infectious agent. A case or two followed by a gradual increase in the frequency of disease (Fig. 3) suggests a propagated epidemic where there is an animal-to-animal transmission of an infectious agent either directly, through fomites, or insect vectors. Multiple exposures to a common point source can produce irregular or repeating patterns in the epidemic curve.

E. Step 5: Describe the Spatial Pattern of New Cases

A topographical map of the premise is the simplest way to understand the spatial distribution of new cases of disease. The scale of the map should be appropriate for the outbreak under investigation. It may be limited to a particular barn or set of pens, or it may include an entire farm, county, etc., depending on the scale of the outbreak. Generally, such a map should include the location of stalls, pens, and pastures as well as traffic patterns, gates, natural boundaries, and storage areas for feed, water, chemi-

$$\text{Attack Rate} = \frac{\text{Number of new cases since onset of outbreak}}{\text{Total number of animals at risk at onset of outbreak}} \times 100$$

Fig. 1. Formula for the calculation of an attack rate (AR).

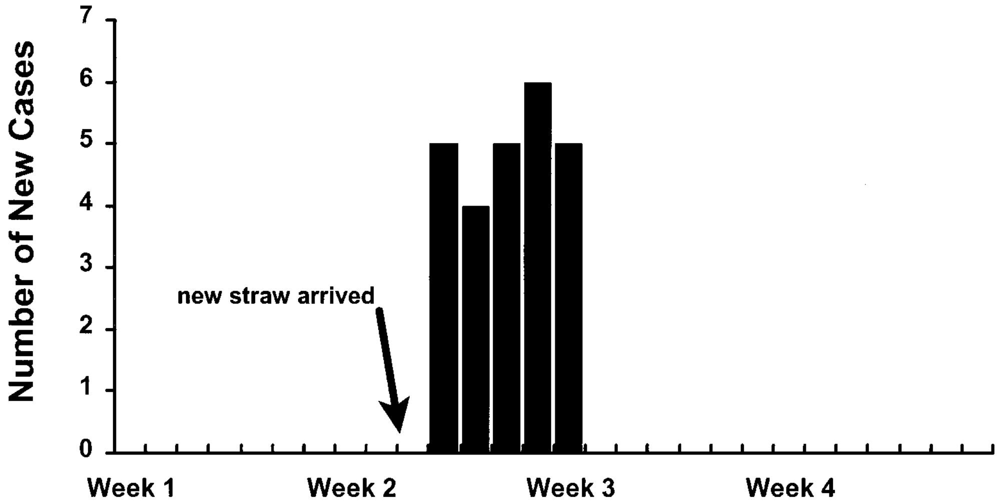

Fig. 2. Epidemic curve for a hypothetical botulism outbreak caused by a new shipment of contaminated straw bedding. This curve is typical of a point-source outbreak with a large number of cases occurring suddenly over a short period of time.

cals, and equipment. Information on plants in each area as well as fertilizers or insecticides used and farm personnel working in each area could be recorded on the map.

F. Step 6: Describe the Animal Pattern of New Cases

Comparing the rate of disease among different groups of animals can be very helpful in identifying other disease patterns. Descriptive information such as age, breed, and sex, as well as the feed that each horses receives, what their water source is, where they train, and any other factor that may be related to the disease under investigation, is used to categorize animals as exposed or nonexposed. This information is recorded for the affected and unaffected animals. Then the number of affected and unaffected animals in each group is counted. For example, the number of affected and unaffected animals eating each type of feed and using each type of bedding may be relevant to a suspected botulism outbreak. During an abortion investigation, the number of affected and unaffected mares might be counted for each brood mare band, age group, or for each stallion used.

G. Step 7: Analysis of the Data

While statistical testing is usually not possible unless large numbers of animals are involved, simple proportions can be used to identify suspicious factors that may be related to the outbreak. Factor-specific attack rates can be calculated using the formula given for the overall attack rate. However, affected and unaffected animals exposed to the factor of interest are counted separately from those that are nonexposed. These attack rates are examined by constructing an attack rate table (Table 1) that summarizes the information collected when describing the animal patterns of the outbreak.

Comparing the attack rates between exposed and nonexposed groups identifies factors associated with the outbreak. If the attack rate is high in the exposed group and low in the nonexposed group, this factor is more likely to be the cause of the outbreak. It is particularly helpful to calculate the difference between the attack rates for exposed and nonexposed groups. For example, in Table 1, straw bedding is identified as the likely source of the cause of a hypothetical outbreak of botulism because the differ-

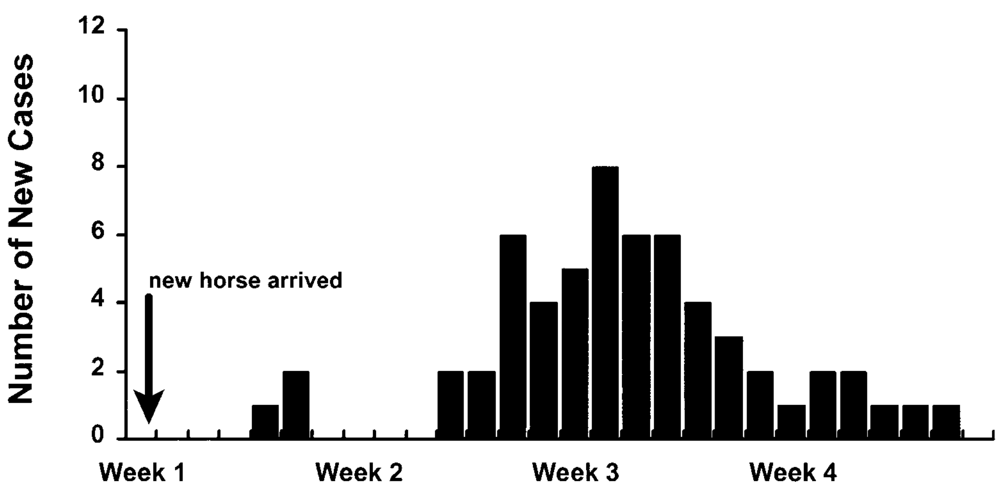

Fig. 3. Epidemic curve for a hypothetical outbreak of respiratory disease in a susceptible population. The first 3 cases occur 4 days after the arrival of a new horse and are followed 4 days later by a gradual increase in the number of cases. This pattern suggests a propagated outbreak of an infectious disease.

Table 1. Comparison of Attack Rates (AR) for Different Feeds and Bedding in a Hypothetical Outbreak of Botulism. The Large AR Difference for Straw Suggests It Is the Source of the Outbreak

	Exposed			Nonexposed			
Suspicious Factor	Number Affected	Number Not Affected	AR (%)	Number Affected	Number Not Affected	AR* (%)	AR† Difference
Feed							
Alfalfa hay	13	34	(28)	3	10	(23)	5%
Grass hay	23	42	(35)	15	32	(32)	3%
Sweet feed	18	42	(30)	0	0	—	—
Oats	2	5	(29)	1	3	(25)	4%
Bedding							
Straw	21	6	(78)	5	45	(10)	68%
Shavings	3	10	(23)	3	12	(20)	3%
Sawdust	6	42	(13)	5	35	(13)	0

*AR = number affected/(number affected + number not affected) × 100.
†AR difference = AR exposed—AR non-exposed.

ence between the exposed and nonexposed attack rates is very large.

H. Step 8: Formulate a Working Hypothesis

Based on the information collected so far in the investigation, it is usually possible to formulate one or more hypotheses about the cause or source of the outbreak. If the outbreak seems to be propagated from individual to individual, this suggests an infectious cause. If it appears to be from a point-source, contaminated feed, water, or bedding may be suspected.

Factors identified with the attack rate table as associated with the occurrence of disease should fit the hypotheses. Also, at this stage of the investigation it should be possible to make recommendations to prevent new cases and refine the treatment protocol if necessary.

I. Step 9: Intensive Clinical and Epidemiologic Follow-up

The objective of this step is to test the hypotheses developed up to this point. The case definition may be revised to include a specific diagnosis. Laboratory testing that may not have seemed relevant or had been cost prohibitive at the initial stages can now be focused on specific infectious or toxic agents. The population truly at risk may be more clearly defined and data analyses may need to be repeated to get a better estimate of the association between a purported cause and the occurrence of disease. Also at this time, surrounding farms may need to be investigated and the results of those investigations compared with the primary investigation.

J. Step 10: Reporting the Findings

A detailed written report describing the history of the outbreak and the steps taken to investigate should be prepared. The process of putting together the report helps the investigator clearly and logically examine the evidence collected, state the reasoning during the investigation, and describe the conclusions. It should include the results of laboratory testing, data analysis, and any maps, charts or tables used for the investigation. The report should also include detailed recommendations for treating new cases should they occur, as well as recommendations for preventing new cases and future outbreaks. The report is a key part of the medical record and may be a useful educational tool for owners, practitioners, or students. It should be prepared as a potential resource should future litigation be involved.

3. Discussion

Solving a disease outbreak can be a difficult challenge. With serious illnesses or widespread disease, emotions run high because of the personal and financial commitments most owners have to their horses. The systematic approach described here brings order to a potentially chaotic situation, decreasing the stress of the outbreak on the practitioner and the owner, and increasing the likelihood of a successful investigation.

We often feel tremendous pressure to solve the problem ourselves if we are the primary clinician responsible for providing veterinary services to the farm. As with any professional service, discretion and confidentiality is required. Absolute secrecy, however, is often overplayed; and this is an excellent opportunity to use a team approach. Specialists from a nearby referral center or diagnostic laboratory each can contribute their own expertise to the investigation. When faced with a large or complicated outbreak, it may be helpful to seek the advice of a toxicologist, pathologist, or epidemiologist. Additional expertise in nutrition, internal medicine, theriogenology, or other specialized field may be needed depending on the disease under investigation. Field veterinarians with local, state, or federal agencies can also be a valuable resource. If there is reason to suspect a reportable or foreign animal disease, the State Veterinarian must be contacted. They can provide special laboratory testing that may not be available privately and may need to impose quarantine restrictions to prevent the spread of the outbreak. Outbreaks of a potentially zoonotic disease should be reported to the local health department.

The steps described above can be expensive and time-consuming. It is helpful to schedule one or two site visits solely for the purpose of conducting the investigation. With a busy practice it may be tempting to schedule the visit in the evening, but it is better to be on the farm during the normal course of operations, when key personnel are present. Unless it is an emergency, one should not try to treat individual cases or provide routine services during a site visit for the investigation. Bringing 2 or 3 consultants along helps keep the focus on the outbreak. After an initial introduction to the client, the consultants may even be able to lead the investigation to prevent it from disrupting practice schedules to the detriment of other client's needs. After the investigation is completed, it is a good idea to schedule a follow-up visit to report the results to the owner, answer any remaining questions, and to make sure that your recommended preventive measures have been implemented.

During a site visit it is imperative to keep an open mind and not limit questions to one particular area of suspicion. It is a good idea to avoid leading questions, listen, and keep interpretations to oneself until the end of the investigation. Conditions on the farm should be observed personally in addition to interviewing the owner and staff. For example, questions about feeding should be followed with, "Please show me." Questions need to be phrased carefully so that no one feels threatened, and it may be helpful to interview farm staff separately from owners and managers. The objective is to solve the problem, not to place blame. Personnel who do not read or speak English fluently may work the most closely with the animals, so you should be prepared to address language and reading barriers.

Conducting a disease outbreak investigation in an equine population is often more challenging than with other types of farm animals. The high emotional and monetary value placed on the individual creates a critical situation even if a relatively small number of animals are involved. Most of the steps outlined above can always be applied, but it is difficult to perform the analytic step when faced with only a dozen or so cases.

Whether an outbreak is large and has a potential international impact, like the epidemic of acute fatal pneumonia due to Hendra virus (equine *Morbillivirus*) in Australia, or small and localized like the 1999 botulism outbreak in the Southwestern United States, the steps outlined here are useful for identifying the cause and source of the problem. Both affected and unaffected animals need to be examined, and a systematic, unbiased assessment increases the likelihood of identifying factors associated with the occurrence of disease so that recommendations can be made to break the cycle and prevent future outbreaks from occurring.

Further Reading

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