**Guide to the canine parvovirus outbreak simulator (and answers)**

Have you ever wanted to try your hand at managing a canine parvovirus (CPV) outbreak, without all the mess and trauma of the real thing? Well, now you can! Not a horrible amusement park ride as you might surmise from the name, the Canine parvovirus outbreak simulator allows you to work through a real life outbreak scenario as many times as you like until you are confident of your risk assessment skills. It also lets you get a sense for the fallibility of risk analysis – every once in a while, in the simulator as in life, you will do everything right and an infected animal will slip past your radar. However, you can also clearly see how many more lives are saved through careful risk assessment than either depopulation or failure to respond at all.

**How does it work?**

The CPV outbreak simulator generates a typical shelter population exposed to a case of parvovirus. The program is set to generate a random set of animals that reflects the age range, clinical status, length of stay, vaccine and antibody titer status of a typical dog population in many open admission shelters in the United States. The goal of the simulator, as with the goal of managing an outbreak in real life is to:

1. Avoid euthanasia of behaviorally sound animals (in this case, assume all the animals are behaviorally sound and could be adopted if they do not succumb to CPV)
2. Stay within the allotted space for quarantine and rescue
3. Stay within the allotted budget. As is commonly the case in real life, the budget is sufficient to perform all needed testing and provide at least low-cost treatment for truly infected animals, but not much more than that. Some budget is recovered for each animal that is placed up for adoption, on the assumption that adoption fees will be collected to offset the cost of care already provided.
4. Avoid putting up for adoption or sending to rescue an animal that is incubating or infected with parvovirus. Because tests are fallible and you cannot avoid all risk, occasionally this will happen in spite of playing by all the rules. However, you can take steps to systematically evaluate risk and perform necessary tests to minimize the chance of this occurrence.

Accomplish these four goals by sorting the animals into the risk categories described below, and choosing an outcome based on the assessed risk. You can hit “refresh” and receive a new population to work on as many times as you like.

Below are some basics of risk assessment for outbreak management. Remember risk assessment is just one component of outbreak management. In a real outbreak, you would also need to consider communication (within the shelter and with the media/surrounding community), protection of animals that have not yet been exposed but may be incoming to the shelter, environmental decontamination, and follow-through. You can learn much more about the ins and outs of outbreak management through the resources recommended at the end of this document. In the meantime, however, we hope this simulator gives you the confidence that you CAN manage an outbreak, at reasonable cost and with minimal loss of life.

**Outbreak management basics: risk assessment**

Halting an outbreak in a shelter population requires creating a clean break between naïve (not-yet-exposed, incoming animals) and exposed animals that may be incubating or shedding the virus. In most shelters, just shutting the doors until the infection has burnt itself out is not an option, and funds, space and opportunity for quarantine, rescue and treatment are limited. If the entire population required these options, it would often be more than the shelter could provide.

However, many shelters have at least a limited number of opportunities for each of these outcomes. The key to managing an outbreak is accurately identifying which animals really need the additional investment of quarantine, rescue, or treatment, and which can be moved on through the system as usual with relative safety.

To identify which outcome is appropriate for each animal, they should be divided into the following risk categories:

* **Not yet exposed**
  + Animals that have not been admitted to the facility
    - Avoid admitting these animals if at all possible
    - Do not admit animals that are not sick, injured or dangerous unless absolutely necessary
    - Designate clean housing for animals that must be admitted
      * Decontaminate with disinfectant active against un-enveloped viruses if these are a concern (e.g. Rescue®)
      * Separate air space or at least 25 – 40 feet separation from possibly sick dogs
      * Clear visual separation for both cats and dogs
      * Ideally house in a separate building or ward (consider offsite as well as onsite options), but if necessary “snaking clean break” with separate equipment and staff for un-exposed versus exposed animals
* **Not meaningfully exposed**
  + E.g. Animals housed in an area of the shelter unaffected by the outbreak
  + Can be moved on through the shelter as usual, e.g. to adoption or rescue (if rescue opportunities are limited these should be reserved for medium risk animals if willing; if rescue is unlimited, then rescue is a fine alternative to adoption for unexposed/low risk animals)
* **Exposed/low risk**
  + E.g. Adult animals with a vaccination history or clinically healthy animals with antibody levels indicative of protection
    - To determine which animals are protected by vaccination, the date of exposure needs to be determined.
      * If the [index case](http://en.wikipedia.org/wiki/Index_case) was sick at or very soon after intake, then that is the date of exposure
      * However, if the first case was in the shelter for some time before development of clinical signs, you will need to count backwards from the date of diagnosis to the earliest likely date of pre-clinical shedding. For example, dogs can shed parvovirus for at least 3 days prior to development of clinical signs. We know that the vaccine generally provides protection within 3-5 days of administration (barring maternal antibody interference), so we combine these to estimate dogs exposed to an index case in the shelter *at least eight days* after vaccination are likely protected.
    - Titer testing is required to determine antibody status in juveniles (under the age at which maternal antibody interference with vaccination is possible) as well as adults with insufficient vaccine history.
    - Antibody levels can be determined via [in house testing](http://www.youtube.com/watch?v=wQ4o6gFzqiw) or via a diagnostic laboratory. Titers correlate well with protection against parvovirus, canine distemper and feline panleukopenia.
    - Titer testing can only be performed in clinically healthy animals (free of all signs of the disease in question). Clinically ill animals (of any age) should be tested for the disease if possible, treated if necessary, or quarantined if testing indicates they are not currently infected.
  + Exposed low risk animals can be moved on through the shelter as usual, e.g. to adoption (if rescue opportunities are limited these should be reserved for medium risk animals if willing; if rescue is unlimited, then rescue is a fine alternative to adoption for unexposed/low risk animals)
* **Exposed/medium risk**
  + Puppies or kittens with evidence of protective antibody titers which can rapidly decrease
  + Ideally move medium risk animals out of the shelter to rescue/transfer/foster or other clean environment free of possibly infectious animals
* **Exposed/high risk**
  + E.g. Animals with clinical signs but testing negative for the infection; healthy animals without a history of adequate vaccination and/or with negative antibody titers
  + Ideally quarantine for the possible incubation period of the illness
* **Exposed/Infected**
  + Animals testing positive for the infection in question
  + Ideally isolate and treat
    - Do not assume that treatment has to cost a fortune. Veterinarians report good success in many cases with treatment limited to antibiotics; anti-emetics/GI protectants; pain control; oral, subcutaneous or intra-peritoneal hydration; and nutritional support. As long as adequate isolation facilities exist (at the shelter or elsewhere) and adequate monitoring can be assured so that animals failing to respond to treatment do not suffer, lower cost treatment is preferable to euthanasia when the “gold standard” is beyond the shelter’s budget. To read more about less intensive treatment, see <https://onlinelibrary.wiley.com/doi/full/10.1111/vec.12561> and <http://csu-cvmbs.colostate.edu/documents/parvo-outpatient-protocol-faq-companion-animal-studies.pdf>

Performing a risk analysis to divide animals into the categories above can often render the number of animals requiring the more costly options of quarantine or treatment manageable. Even if some investment is made in diagnostic testing, costs can often be recovered in adoption fees for animals which would otherwise be euthanized.

In the simulator, five outcomes are available: “adopt”, “quarantine”, “rescue”, “treat” and “euthanize”. For the simulator’s purpose, “treat” means treat for a diagnosed CPV infection. Although in a real life scenario, dogs with diarrhea or other symptoms of illness would also be isolated and treated for those symptoms in a separate ward from the CPV cases, in the simulator these animals should be assigned to one of the above outcomes based on their CPV risk assessment. For example, a dog with diarrhea would be housed in quarantine if they are exposed/at risk but not diagnosed with CPV. Assume these dogs will be treated as needed during quarantine for their other clinical signs☺.

**Optional quiz time! Answering the questions below will help you prepare to manage this or any outbreak. Although the outbreak simulator is a parvo outbreak, the same principles could apply to canine distemper or feline panleukopenia, but the details may differ.**

1. If continued intake can’t be avoided, one of the first things to do in an outbreak is create a clean, safe space to house newly admitted animals. This requires clear visual and adequate physical separation from the exposed population and careful cleaning with a disinfectant proven effective against the infectious agent involved. List three disinfectants that reliably inactivate un-enveloped viruses such as canine parvovirus or feline panleukopenia.

**1. Bleach (sodium hypochlorite) at 1:32 dilution and related products (calcium hypochlorite, e.g Wysiwash®; sodium dychlorisocynarute e.g. Bruclean®). Remember – surfaces must be pre-cleaned of all organic material before using bleach and the related products**

**2. Potassium peroxymonosulfate (e.g. Trifectant®)**

**3. Accelerated hydrogen peroxide (e.g. Rescue®)**

1. At what age can vaccination in general be assumed to be protective against parvo, distemper and panleukopenia? **16-20 weeks of age – after maternal antibodies have waned**
2. Specifically, how many days after vaccination can an adult animal be assumed to have reasonable protection against infection?
   1. Parvo: **3-5 days**
   2. Canine distemper: **protection within hours + full immunity reached within 3-5 days**
   3. Panleukopenia: **protection within 24 hours + full immunity reached within 3-5 days**
3. How long *before* development of clinical signs can the following diseases be shed?
   1. Parvo: **up to** **3 days before**
   2. Canine distemper: **1-2 weeks before but potentially longer**
   3. Panleukopenia:  **up to 3 days before**
   4. Just for the heck of it, canine influenza: **2-4 days before**
4. Putting these facts together, how many days before exposure to a clinical case would an animal have to be vaccinated for protection to be assumed (assuming the clinical case has been continuously present in the population; if the clinical case entered the shelter just prior to breaking with illness, then only the time to onset of vaccine protection need be considered):
   1. Parvo: **8 days**
   2. Canine distemper: **3-5 days prior to the clinical case entering the environment (since the pre-clinical period for distemper can be so variable)**
   3. Panleukopenia: **8 days**
5. Testing is not perfect. To understand how much faith to put in a positive or negative test result, you need to know the sensitivity and specificity of the test, as well as have some idea of the prevalence of the condition in the population you are testing. Unfortunately, finding this information is not always super straightforward. Ideas are to check with the test manufacturer (contact them directly or check their website), check the scientific literature (through sites such as <http://www.sciencedirect.com/> or <http://www.ncbi.nlm.nih.gov/pubmed>), find this information in textbooks, and/or ask experts in the field. Consider the source when deciding how much faith to put in a particular estimate of test accuracy. In the outbreak scenario, you are using two tests: an in-house ELISA antigen test for parvovirus and an in-house ELISA antibody test to check for antibodies to parvovirus. Although various brands and different diagnostic test types are available, consider for now the commonly used IDEXX SNAP**®** parvo test. What information can you find about the sensitivity and specificity of this test? If a 95% confidence interval is given, note that too. What could cause a difference in estimates from different studies? How does the estimated sensitivity and specificity compare to another test type, such as RT-PCR?

|  |  |  |  |
| --- | --- | --- | --- |
| **Test characteristic** | **Manufacturer estimate** | **Scientific literature estimate 1** | **Scientific literature estimate 2** |
| **IDEXX SNAP® test sensitivity** | **100% w/ 95% CL** | **82%** | **77-80%** |
| **IDEXX SNAP® test specificity** | **100% w/ 95% CL** | **100%** | **N/A** |

Paste in the references for where you found each estimate in the scientific literature:

**Markovich, J. E., K. M. Stucker, et al. (2012). "Effects of canine parvovirus strain variations on diagnostic test results and clinical management of enteritis in dogs." J Am Vet Med Assoc 241(1): 66-72.**

**Decaro, N., C. Desario, et al. (2009). "Detection of canine parvovirus type 2c by a commercially available in-house rapid test." Vet J**. **2010 Jun;184(3):373-5. doi: 10.1016/j.tvjl.2009.04.006.**

Was it a big hassle to find either the manufacturer’s estimate or scientific studies? How long did it take? Do you think this is something you could realistically do in practice?

**It was not difficult to find the manufacturer’s estimate – I googled it and was sent straight to Idexx’s FAQs link. The abstracts for the scientific studies were on pubmed and contained enough information to calculate sensitivity and specificity, so even though in private practice it might not be possible to get the full article, this would be enough to get an idea of the most important information.**

1. Synbiotics TiterCHEK™ and Biogal VacciCheck™ are two readily available in-house titer test kits. Can you find what each manufacturer estimates as the sensitivity and specificity of these tests for detection of canine parvovirus antibodies? In the “where found” column, note where you were able to hunt down this information.

|  |  |  |  |
| --- | --- | --- | --- |
| **Test** | **Sensitivity** | **Specificity** | **Where found (e.g. paste URL)** |
| Synbiotics TiterCHEK™ | **91%** | **98%** | [**http://www.synbiotics.com/Products/CompanionAnimals/Canine/TiterCHEK-CDV-CPV-Parvo/96-0460-DET.pdf**](http://www.synbiotics.com/Products/CompanionAnimals/Canine/TiterCHEK-CDV-CPV-Parvo/96-0460-DET.pdf) |
| Biogal VacciCheck™ | **97%** | **100%** | [**https://www.biogal.co.il/50cvv201-50cvv110**](https://www.biogal.co.il/50cvv201-50cvv110) |

1. Synbiotics TiterCHEK™ has been in use in shelters in the United States a little longer than VacciCheck™, which may explain why there’s a little more in the scientific literature about the Synbiotics test in a shelter context. Two studies came to different conclusions about the sensitivity and specificity of this test. Can you find these two studies and figure out at least one reason why they came to different conclusions?
   1. Litster, A. L., B. Pressler, et al. (2012). "Accuracy of a point-of-care ELISA test kit for predicting the presence of protective canine parvovirus and canine distemper virus antibody concentrations in dogs." Vet J 193(2): 363-366. **Results: CPV: sensitivity 92.3%, specificity 93.5%**
   2. Gray, L. K., P. C. Crawford, et al. (2012). "Comparison of two assays for detection of antibodies against canine parvovirus and canine distemper virus in dogs admitted to a Florida animal shelter." J Am Vet Med Assoc 240(9): 1084-1087. **Results: CPV: sensitivity 98%, specificity 98%**
   3. Why do you think they came to different conclusions? **In the Gray/ Crawford et al study there was only one person performing/interpreting the ELISA results, whereas in the Lister/Pressler study there were 2 people processing the ELISA results. The use of only one person to interpret the ELISA readings in the Gray/Crawford study may have resulted in more consistent and accurate readings.**
2. Prevalence of the condition of interest strongly influences the positive and negative predictive value of a test (that is, the likelihood that a positive or negative result is true, respectively). To see how this plays out, consider the case of testing for antibodies in puppies versus adults. A study of dogs entering Florida shelters found that 36% of puppies (less than 1 year) had antibody titers to canine parvovirus, versus 87% of adults (>2 years). Using the estimates of sensitivity and specificity given in example 8a above (92.3% and 93.5%), what would the positive predictive value of a positive CPV titer result be:
   1. In a puppy? **88.9%**
   2. In an adult (> 2 years)? **99%**

You can use the handy dandy UC Davis KSMP [predictive value calculator](https://www.sheltermedicine.com/library/resources/?utf8=%E2%9C%93&site=sheltermedicine&search%5Bslug%5D=positive-and-negative-predictive-value-calculator-for-diagnostic-testing) to help figure this out.

1. Using the handy dandy calculator, if you tested 40 puppies, given the sensitivity, specificity and prevalence of positive titers estimated above, how many times would you wrongly call:
   1. A truly titer positive puppy, titer test negative?  **1 time**
   2. A truly titer negative puppy, titer test positive?  **2 times**
2. What’s the worst thing that could happen with each of these wrong test results?
   1. A truly titer positive puppy, titer test negative? **This puppy may be assumed to be unprotected from parvo, so worst-case scenario could be that it is euthanized for lack of quarantine space.**
   2. A truly titer negative puppy, titer test positive? **This puppy may be assumed to have been protected from parvo at the time of exposure and may be treated as low risk when in fact it is incubating parvo and should have been quarantined. Worst-case scenario it will break with parvo and spread disease to others.**
3. Increasing specificity increases the positive predictive value of a test. Examining the pair of studies in question 8 above, perhaps you could figure out a way to run the titer check test in such a way that you could come closer to the 98% sensitivity and specificity estimate. How would that effect the positive predictive value of the test in puppies (36% prevalence):
   1. PPV with 93.5% specificity: **88.9%**
   2. PPV with 98% specificity: **96.3%**

How would this affect the number of truly titer negative puppies testing positive? **You get fewer puppies who are truly titer negative that will test positive.**

Nifty, huh? Just by achieving higher specificity, you can substantially change the accuracy of the results. Keep this in mind whenever you are interpreting test results. If a false positive test result would be a fiasco (for instance, the animal would be euthanized), you want a very high positive predictive value (PPV). This is achieved by either using the test only in a population where the disease is likely, or using a very specific test. If you don’t have a very specific test, considering using two tests and only calling the animal “positive” if both tests are positive.

An example of this would be testing for parvo in puppies with or without clinical signs. Puppies with GI signs, in a shelter experiencing an outbreak of parvo, are reasonably likely to be infected. Let’s say 50% are truly infected, with a sensitivity and specificity for this test of 95% (for the sake of the exercise). Run this scenario through the test accuracy calculator and you will find that if you test 100 puppies, half of which have parvo, you will only get 3 false positive results and 48 true positive results.

Now what if you decided, as a precaution, to test all puppies at intake, even those that appear healthy? This is *not* generally recommended but some shelters do this, especially when admitting puppies from high-risk neighborhoods. Healthy appearing pups, even from a high risk area, are not very likely to be in the short pre-clinical shedding period for parvo.

Let’s say 2% (1 in 50) of healthy-appearing puppies are shedding parvo at the time of intake. With the very same sensitivity and specificity, now 5 out of 7 positive test results would be *incorrect* – so the cost of catching two puppies shedding parvo on intake would be 100 tests and 5 inaccurate diagnoses. If the result of the positive test is euthanasia, that would be 5 puppies needlessly euthanized. You could remedy this by adding another layer of testing, say a blood smear or CBC, and only calling a healthy appearing puppy parvo-positive if it is both SNAP test positive and has evidence of a low white blood cell count. Or, if space is available, you could strictly isolate SNAP test positive healthy puppies to see if they go on to develop clinical signs – if the consequences are less dire, then the risk of accepting a false result are decreased.

**In summary**

Many practitioners, even those that do not specialize in shelter work, will be faced with the opportunity to help manage an outbreak in a shelter, kennel, or rescue home at some point. A systematic approach to risk analysis, coupled with a solid understanding of test application and interpretation, can help manage even a serious outbreak with minimal disease spread and loss of life.



**Resources:**

Chapters 3 (Outbreak management), 5 (Vaccination), 10 (Canine distemper), 12 (Feline Panleukopenia) and 13 (Canine Parvovirus) in [Infectious Disease Management in Animal Shelters](http://www.amazon.com/Infectious-Disease-Management-Animal-Shelters/dp/0813813794)

AAHA Canine Vaccination Guidelines: <https://www.aaha.org/guidelines/canine_vaccination_guidelines/faq_practice_and_shelter.aspx>

AAFP Feline Vaccination Guidelines<http://jfm.sagepub.com/content/15/9/785.full.pdf+html>