

Key points:

- Insufficient human and financial resources are available for spay / neuter programs to be effective on reservations and in the Third World
- Vaccination of large numbers of animals reduces population turnover and preventable deaths
- Rabies is a human health concern, not a domestic animal concern except where human health applies

A decade ago, the worldwide dog population was estimated to be 700 million. (61). Given that the size of dog populations is dependent on human provided food (either directly, or indirectly via garbage dumps) (67), and that the human population has significantly increased worldwide since 2013, the number of dogs likely exceeds 1 billion. If, despite high spay rates, dog overpopulation exists in the USA with its vast resources, relative large number of veterinarian per capita, and culture that encourages pet ownership, how is the remainder of the globe going to ever approach even a 10% spay rate, let alone the >70% needed to actually achieve overpopulation.

Think about the Navajo Nation, just one of many reservations in Arizona let alone the entire USA. There are an estimated 250,000 free-roaming dogs on the Navajo Nation (68), very few of which are spayed or neutered currently. This number may even be conservative, with others estimating up to 500,000. The average spay / neuter vet does 30 surgeries a day, which is highly dependent on the ratio of males to females, the age and heat or pregnancy status of the females, how obese a female is, etc. One full time, 5 day a week vet willing to do nothing but spays and neuters year round, would perform

150 surgeries a week, or 3600 every 6 months (allowing 2 weeks vacation twice a year for the rare individual willing to do nothing but spay neuter every day). Assuming heat cycles every 6 months in a dog, to get a 70% surgery rate in one heat cycle would require 70% of 250,000, or 175,000 surgeries in 6 months. This would require a full time staff of 49 vets on the Navajo Nation doing nothing but spay / neuter, and the process would have to be continued long term for several years at high rates to actually start to see population reduction. If the more liberal number of 500,00 dogs is used, then it would require 98 full time vets doing exclusively spay and neuter.

These numbers are likely even artificially low, given the assumption of an effective 70% spay rate, which is lower than many studies have demonstrated. Not only is the possibility of even 49 full time vets on the Navajo Nation a pipedream, this does not include all of the free-roaming cats, which could easily double the number of surgeries required. Further, these vets are strictly performing spay / neuter, and does not include the massive amount of labor and money for vaccine wellness programs, sick patient care, emergency surgeries, and the huge number of livestock that also need veterinary care. And this is just one reservation, and does not include all of the other reservations in the USA that deal with the same issues. Finally, and most importantly, consider that geographically, the USA is very small compared to the rest of the world, where feasibly over 1 billion dogs live, 75% of which are stray (60), and most in association with human poverty.

Thinking of a free-roaming population in terms of a static number (carrying capacity), most efforts have been focused on decreasing the numbers of new animals entering the population (births), rather than decreasing the numbers of animals leaving the population (deaths). Unfortunately, the proactive approach to decreasing the number of sexually intact dogs and cats in free-roaming settings has not worked. If it has not worked, then reducing the numbers of deaths is the alternate approach. Limiting the number of deaths from vehicle accidents, poisonings (intentional or unintentional in the search for food), and other non-disease causes is difficult. Limiting the number of deaths from infectious disease that is not readily preventable with a

vaccine is also a difficult task (e.g. heartworm disease is easy to prevent in a household setting, but virtually impossible in a feral setting unless caretakers can recognize every animal in their respective area and can give ivermectin based (not moxidectin based) preventatives monthly (see heartworm section of text for difference between the classes of preventatives). TVT is reducible with spay and neuter but serious reduction in feral animals requires spay/neuter programs far beyond that done anywhere.

The largest numbers of deaths occur from infectious diseases such as parvovirus and distemper, which fortunately are also the most amenable to programs for street animals. Unlike spay/neuter, surgery is not required, and unlike heartworm disease, knowledge of previous exposure is not required for preventative measures. Vaccines exist for the most common causes of death and illness ("mortality" and "morbidity"), are easy to give in large numbers, can be given without concern as to whether an animal already had a vaccine (vaccine reactions are extremely rare and usually easy to treat), and it is also likely that an initial series of vaccines conveys years if not lifelong immunity. No special training is needed to administer vaccines, and virtually anybody can give any dog or cat a vaccine without knowing much veterinary medicine. Any chance of the vaccine causing problems is far outweighed by the statistical likelihood of preventing terminal disease. As long as the vaccines are kept refrigerated and the person giving the vaccine has help restraining an animal correctly, no harm is likely to occur. Knowledge of previous vaccination is not required, and in feral settings it should always be assumed that the animal has no previous vaccine history.

The only exception to wanting to know previous vaccination status would be an owned animal whose owner is willing to return for sequential vaccination, as would occur in routine general veterinary practice. In these cases, standard protocol would apply (3 combination vaccines for puppies and kittens with the last at 16 weeks of age or later; 2 combination vaccines for adults with no known vaccine history; one year booster for all). Given that many studies suggest that immunity following this protocol conveys for life, the timing for later boosters is of much less importance than the initial

series. After all, when was the last time you had your childhood vaccines boosted?

The importance of vaccination can be easily understood with our imaginary population (at carrying capacity) of 1000 dogs or cats at the start of a 10 year span. Given that the average feral cat lives 2 years and the average feral dog 4.8 years, let's say for the sake of easy math that the average domestic animal on the street lives 3.3 years (which is probably accurate considering that there are more cats than dogs worldwide, skewing our cat/dog average towards the cat side of things). In year 0 (the start of our 10 year span), our imaginary population is 1000. By year 3.3, these 1000 have died and been replaced by a different group of 1000 (our carrying capacity). Most have died from infectious disease. Now the same occurs for years 6.6 and 9.9. Adding the total number during the 10 year span is 4000 animals that have lived during this decade.

Now, imagine a population that is fully vaccinated, minimizing the number of deaths from infectious disease. Animals will still die from being hit by cars, hurt in fights while searching for food, etc., so it becomes extremely unlikely that any will live to their theoretical lifespan. By vaccinating we have raised the lifespan from 3.3 to 5 years, a modest increase. Now, we have our original 1000, and by year 5 this 1000 has been replaced, and again a replacement in year 10. The total number of animals that have lived at any point in this decade is now 3000.

By raising the lifespan from 3 years to 5 years by simple vaccination, we have reduced the total number of animals that lived and died from 4000 to 3000, a reduction of 1000 animals that had to ultimately die poorly in the street. This is a reduction of the entire number of animals that lived at the start. We may not have reduced the total active population whatsoever, but we made a significant reduction in animal deaths, especially those from preventable infectious disease.

Vaccines thus play a more important role in actually improving the quality and quantity of life for feral animals, for whom spay / neuter (TNR) efforts have no effect. Spay / neuter advocates may contend that TVT is an infectious disease for which no vaccine exists and thus

the key to long term prevention requires surgical alteration. In a world with unlimited funds, surgical alteration might indeed be the answer to TVT, but exponentially far more deaths occur from parvo and distemper than TVT. Further, TVT can be transmitted by oral contact even in neutered individuals, so fencing and reduction of free-roaming would be a more realistic long term approach.

Vaccine programs have secondary benefits in that animals can be treated with flea and tick medication as well as deworming agents. Tick borne diseases, rare in urban and suburban areas, are very common amongst dogs on tribal lands, and the morbidity (illness) and mortality they cause is severely underreported. On at least one reservation, a random sample of adult dogs yielded virtually every individual testing positive for Ehrlichia, and it is likely that there are common tick borne diseases beyond those on available tableside tests (eg. 4DX). Acute tick borne disease can usually be successfully treated with doxycycline, but chronic Ehrlichiosis can cause severe illness and is typically resistant to treatment. Flea and tick medications or collars need to be given or last for many months or even year round depending on the local climate, and can be expensive, but are a worthwhile addition to vaccine clinics if finances permit.

Intestinal parasites typically cause less severe illness than viral and rickettsial (tick borne) diseases, but when combined with other infections, injuries, and a state of semi starvation and the endless search for food, can be part of the many factors leading to general poor health and disease. Fortunately, broad spectrum dewormers are relatively cheap and easy to administer, and can be included at any vaccine clinic.

What about rabies prophylaxis efforts on reservations in the United States?

Consider rabies prevention efforts on the reservation. Each year, veterinarians from the federal, state, and local level organize rabies vaccine clinics, teaming up with a dozen or more individuals and

epidemiologists from the CDC, IHS (Indian Health Services), the US Public Health Corps, the state veterinarian's office, local tribal health officials and local volunteers. 3 day events are held, with hundreds of thousands of dollars spent in terms of salary and payroll for the governmental parties involved, vehicle expenses, hotels, meals, and finally rabies vaccines. Locals bring their pets out by the hundreds, and when asked why they came out, will invariably give an answer supporting their dog or cat's health. Yet, how many of these locals know that in a 25 year span (1978-2002 inclusive, the most recent years listed on the Arizona Department of Health Services website), only 5 total cases of rabies in dogs were reported in the entire state of Arizona, and that these were primarily along the Mexican border (69). The odds of a dog acquiring rabies is probably less than being hit by lightning. Further, consider the scope of the government's rabies efforts. A typical 3 day clinic that vaccinates 600 animals is considered a huge success. Yet, on the Navajo Nation, 600 animals is a drop in the bucket compared to the estimated 250,000 dogs alone.

It is highly likely on many of these reservations that there has never been a reported case of rabies in a dog, and yet there have likely been hundreds of thousands or even millions of deaths from parvo or distemper in that same 25 year span. On a reservation with 250,000 dogs that live a short lifespan of a handful of years, it is possible that 5+ million dogs have lived and died in that 25 years, so a million deaths from infectious disease other than rabies is entirely possible.

Yet, at the rabies clinics, no core parvo/distemper canine vaccines or core panleukopenia feline vaccines are provided. Adding one additional vaccine to every rabies vaccine given would add no extra time and the overall increased cost would be a few thousand dollars (a rabies vaccine costs the same as a core parvo / distemper or FVRCP vaccine). Adding one vaccine for the true causes of death would be a drop in the bucket compared to the overall clinic cost, but this is not done.

The entire premise is based on human health, of course, and the trade-off is animal mortality in order to prevent the possibility of even 1

human death. Rabies is endemic in wildlife throughout the southwest US, and while certainly fatal to humans, animal welfare groups should not be misled into thinking that the veterinarians that work for IHS, the CDC, or the state government are being proactive in animal health.

Further, the sole reliance on injectable rabies vaccines is a severely limiting factor since it requires significant labor, as well as owner compliance in order to get individuals to bring their pets to rabies clinics. The decision to use injectable only vaccines is not practical on a large scale, and is being replaced by oral rabies vaccines in areas such as Thailand where rabies in domestic dogs is much more common (70). In these areas where rabies is a significant problem, government run agencies administer much larger numbers of vaccines quickly. This is the only practical way to approach the minimum of 70% of all dogs vaccinated for rabies that the World Health Organization recommends to prevent outbreaks (71).

Another example is the Rocky Mountain Spotted Fever (RMSF) project amongst the reservations. RMSF, like rabies, is exceedingly rare, and only discovered in Arizona two decades ago. Originally reported on the San Carlos Apache reservation, 5 tribal members died from RMSF between 2005 and 2012 (72), from an estimated population of 10,313 (of which 82.6% will die prematurely from other preventable causes of mortality) (73). Despite these statistics, the CDC has spent millions of dollars trying to address RMSF, and since dogs carry the ticks that can transmit the disease, the CDC recommended that dogs be permanently chained near their houses. This might be effective from a tick borne disease perspective, but few would agree with this from an animal welfare perspective.

As part of current federal and state rabies clinics, animals are also fitted with tick collars, with the understanding that ticks on infected dogs can transmit Rocky Mountain Spotted Fever to humans. These collars only reduce tick infestation for 6-8 months, with each collar costing the American taxpayer 14 times more than would a core (parvo/distemper) vaccine that will likely provide lifelong immunity from diseases that have statistically guaranteed exposure and result in terrible, agonizing deaths. Instead, the government freely provides

the collars for an ultra rare tick borne zoonotic (transmissible from animal to human) disease, as well as a rabies vaccine for a disease the dog will statistically never encounter. Put simply, human health is the priority for CDC veterinarians, as with IHS and state veterinarians, and animal welfare issues are ancillary and only considered if no human health is compromised. There are cultural differences regarding what is acceptable animal welfare for various tribal members, but there should not be any misleading of disease statistical frequency presented to tribal members for whom their pet's well being is also important.

This all might seem benign, and certainly the tick collars also reduce Ehrlichiosis and other tick borne disease in dogs. But, having the community bring their pets to one central location, typically in summer, has two major problems. First, congregating dogs and cats that have not received any other vaccine virtually guarantees that there will be some parvo or distemper exposure. Second, many of these clinics occur in shadeless areas in temperatures approaching 100F, also virtually guaranteeing heat stroke for some of the dogs. In other words, death is virtually guaranteed for some animals in order to prevent a disease that has never occurred in any dog or cat on most of these reservations, nor has occurred in humans in these same locales.

In our 25 year old proverbial boat with a million small leaks in the form of preventable canine deaths from infectious disease, the government spends millions of dollars on 5 random rabies leaks that have occurred, and nothing on the other million parvo and distemper leaks that remain. It will not change funding nor tribal response, but locals should at least understand rabies is a fatal but ultra rare human problem, and that from a statistical perspective, rabies is a non issue for their pets when looking at the larger picture.

One could argue that rabies eradication programs are required to keep rabies as a truly rare disease, but inherent in this argument is that human health is the priority. At no time before the advent of vaccines was canine rabies on the same level as parvo and distemper remain today despite effective vaccines. Further, wildlife remain the

endemic hosts for rabies, and any canine rabies prevention program does not address the reservoirs for rabies. In order to address the root of the problem, states such as Texas have used oral rabies vaccine baits distributed from small airplanes in order to reduce rabies amongst wildlife vectors.

This is not to say that for an individual owner, rabies vaccination of their pet is not important. In order to be compliant with the law (which varies from state to state and country to country), rabies vaccination may be a legal requirement. If the situation exists where impoundment and/or euthanasia might occur without proof of rabies vaccination, then an individual would want this vaccine. Further, in the very rare event of an actual exposure to a rabid wild animal, in most cases an owned dog or cat would be held in quarantine at the owner's expense. In the exceedingly rare event that the dog or cat demonstrates neurologic signs during that quarantine, in most jurisdictions the animal will be euthanized and tested for rabies. So, there are practical and legal reasons for an informed owner wanting a rabies vaccine, and thus there may be reason for a field clinic to administer them, but this the statistical odds of being euthanized due to neurologic signs is exponentially lower than dying from parvo, distemper, or panleukopenia. Tribal or public members should be given appropriate info in order to make an informed decision, and not be misled into thinking rabies is a significant risk to their pets.

A "successful" government run tribal rabies vaccine clinic will vaccinate 500 animals and end up costing the taxpayer well over \$100,000 for a disease no dog or cat will statistically ever see. By way of comparison, a small animal rescue funded clinic vaccinating for the core diseases of parvo and distemper could add a rabies vaccine for the same number of animals in 3 or 4 days, for a total cost of under \$1750 for the extra vaccine. If the tribes still want rabies vaccination, it would thus be more efficient by a factor of 57 or more for the government to simply provide rabies vaccines to that same animal rescue clinic if a licensed veterinarian is present. But, since tribes and tribal members are not footing the bill and paying for the federally run rabies clinics, this scenario is not likely to happen, however ideal it might be.

Given US based government health agencies that have seemingly unlimited funding available for the pursuit of ultra rare human diseases (and that novel and rare infectious disease is a very academically appealing area to public health agencies), a small rescue or vet providing low cost or free services may wish to avoid this vaccine since administering this vaccine effectively cuts in half the total number of animals that can be vaccinated with core vaccines. I.e. If a typical clinic budget is \$1750 for 500 total vaccines that can be purchased at \$3.50 per vaccine, the clinic can either vaccinate 500 dogs and cats for diseases that are common and lethal, or only 250 animals if rabies vaccination is included. Further, in many jurisdictions, an owner interested in this vaccine can go to an animal control office directly and get this vaccine, usually for free.

Outside of the United States, where rabies remains endemic, rabies prophylaxis is more important in terms of preventing mass euthanasia, either by public officials or by the general populace (74). In many cultures, street animals are considered a nuisance, and in the face of rabies outbreaks, fear of being bitten may lead to the killing of any and all street animals by members of the public. In these cases, and even without a known rabies issue, the extremely rare possibility of actually having rabies may be offset by their desire to avoid street dogs being killed, harmed, etc.

Rabies outbreaks

Outside the Western world, and for truly feral animals, rabies vaccination becomes more complicated. There is no way to provide proof of vaccination in an animal caught, vaccinated, then released, since collars and tags will be torn off in short order. In some locations in Latin America, animal rescue groups specifically want to avoid collaring since there is some concern (valid or otherwise) that these street animals can be grabbed by the collar then taken for dog fighting purposes in areas where organized fighting still occurs. In parts of Asia where eating dog meat is not only common but part of organized market displays where animals are restrained and slowly burned alive

for spectacle, collaring that may allow easy capture of street animals also may wish to be avoided.

It is important to note that in the United States, many government run rabies clinics are in response to reports of a rabid animals locally. However, considering that rabies is still endemic in wildlife populations, the numbers of dogs and cats vaccinated must be considered in comparison to the estimated total population. In true rabies outbreaks as have occurred in Peru, Bali, India, etc., it is not simply a matter of vaccinating animals that come to a voluntary clinic. Similar to the garden plot analogy and the time for a plant to seed, the rabies virus has an incubation period from the time of exposure to the development of clinical signs. This means that for a rabies outbreak, a large percentage of the total population of domestic animals must be vaccinated within a short time span (71). Like spaying a feral population, there is a major temporal component if it is to work. A rabies clinic that occurs in a community once a year and gets an unknown percentage of the population is not the same as dealing with a true outbreak scenario.

Finally, spay / neuter and specifically TNR is often presented by advocacy groups as an ancillary method of helping reduce rabies. However, even culling (euthanasia) efforts overseas that reduce domestic animal overpopulations quickly and more readily than TNR have failed to reduce canine rabies (75). Presenting spay / neuter as a means to help with human rabies exposure will not be effective and will further call into question other purported population benefits when viewed through the eyes of animal control agencies in other countries that have actual human rabies problems as opposed to the 2-3 human cases in the USA each year. No amount of spay / neuter will reduce endemic disease on reservations nor will it reduce the core problems of parvo and distemper. Vaccination is the core of disease prevention programs, and can be done at high levels quickly and at high numbers far beyond any surgical numbers.

The pragmatic real world approach? Stick to core vaccines

Considering that rabies is virtually non-existent in domestic animal populations in the richer Western world including the reservation system,, if our goal is animal welfare and quality of life, focus should be on the core vaccines (parvo/distemper for dogs, panleukopenia combo for cats). In an ideal world with unlimited funds, we can give both, and in some cases might have to give rabies vaccines in order to get tribal permission for vaccine clinics (it is likely however, that local animal control officials do not understand how rare rabies actually is). In the Third World at large, total rabies deaths in domestic animals pales in comparison to that from other diseases, but remains a human health risk and thus rabies prevention should be included in order to reduce collateral euthanasia of even healthy animals in the face of rabies outbreaks. I.e. if dogs are seen as a reservoir for rabies, public members and government officials will kill free-roaming populations in the interest of protecting human health, and mass oral vaccination programs can alleviate this problem.

The other significant advantage in the core vaccines is that no veterinarian is required to be present for administration. Outside the reservation system, this is actually a problem when breeders and non-veterinary staff buy over-the-counter vaccines that are frequently stored improperly and thus inactivated, and emergency veterinary clinics see OTC "fully vaccinated" animals with parvo every day. For mass vaccine clinics on the reservation, this problem can be avoided if vaccines are purchased through reputable veterinary supply companies or pharmaceutical companies directly, are kept refrigerated at all times until administered, and if all personnel handling the vaccines understand how to reconstitute vaccines immediately before use (i.e. not hours before) and keep them cool and out of the sun until given. With this approach, vaccine clinics can be done if a licensed veterinarian is unavailable, and the immunity provided en masse will accomplish more for community animal health than any spay / neuter clinic simply given the larger numbers of animals vaccinated.

Although it is not fully established what percentage of vaccinated individuals is required for distemper and other respiratory infectious diseases to achieve herd immunity (the level at which enough of the population has immunity to make insignificant the exposure of non-immune individuals to a given pathogen) (76), mass vaccination can at least reduce exposure, and likely achieve herd immunity as has effectively occurred in the majority of the US and Europe. For canine parvovirus, it is estimated that 70%+ of owned dogs must have immunity in order to achieve any form of herd immunity, with unknown but higher percentages required for animals that are more likely to be exposed (eg. shelter and free-roaming dogs) (77).

For canine distemper specifically, there are other far-reaching benefits to vaccinating domestic dog populations en masse, since wildlife since canine distemper kills many other species, including coyotes, foxes, and endangered species worldwide. Unlike the permanent mosquito transmitted heartworm introduction to wildlife reservoirs in the western US (courtesy of animal welfare groups following Hurricane Katrina), canine distemper is only transmitted via airborne exposure and therefore can be eliminated from a domestic dog community if enough individuals are vaccinated. As such, domestic dog vaccination programs can thereby reduce wildlife exposure as a side benefit. Complete elimination in wildlife species will require the use of oral distemper vaccines, which have been used with mixed results (78, 79).

Unfortunately, the situation is different for parvovirus, which affects both domestic dogs and wildlife but can survive in the environment for months to years despite freezing temperatures (80), and thus can never be fully eliminated on a practical level. Parvo requires vaccination of all new pups indefinitely, but as in the majority of the US, this can be done easily on Native reservations. For feline panleukopenia (a parvovirus), the same applies for cats.

As discussed above for rabies outbreaks, large percentages of animals must be vaccinated in order to achieve herd immunity, a state in which enough individuals carry immunity and thereby stop the spread of a virulent pathogen. For rabies, a minimum of 70% of dogs

in any given population must be immune (71), and for parvo the number is likely higher (76). Due to environmental persistence, continued annual vaccination is required. In owned but free-roaming populations, it might be practical using conventional injectable vaccines to achieve these high percentages in a short enough time period to have at least 70% of the population covered, but it is a different situation for truly feral animals.

In order to vaccinate feral animals with an injectable medication, they must be trapped, netted, or confined in some manner. This poses risks to both the animal and the personnel administering the vaccines, and is a slow process. Achieving a >70% injectable vaccine rate within a few months is not practical with larger feral populations, whereas oral vaccines would be infinitely easier to administer. For rabies, oral vaccines have been used on wildlife for decades, and are being used in domestic dog populations in places such as Thailand with excellent success in the reduction of rabies outbreaks (70). Unfortunately, there are no commercially available oral canine parvovirus/distemper nor feline panleukopenia vaccines, and as previously noted, mixed results have been noted in attempts to generate immunity using oral distemper vaccines in wildlife species that are at risk from dying from canine distemper (78, 79). Recent promise has been shown using modified live parvovirus vaccines orally to generate immunity in domestic dogs (81), but an easily administered oral vaccine remains commercially unavailable.

There are obvious limitations to using oral vaccines, ranging from storage stability to ensuring that animals actually eat the oral baits used. For proof of vaccination purposes for owned animals receiving an oral vaccine, it may be unreliable to provide written proof of vaccination since the possibility always exists that an animal vomits up the bait after administration, whereas an injection done correctly does not carry a similar risk of failure. However, the much larger numbers that could be vaccinated in the total population would offset the minor limitations. For the large free-roaming and feral populations on the reservation and in the Third World, the prospect of oral vaccines for the common killers would save billions of lives of domestic animals in the long run.