Good afternoon. I'm Kondra Williams, and I'm representing the Clinician Outreach and Communication Activity, COCA, with the Office of Emergency Risk Communication at the Centers for Disease Control and Prevention. I'd like to welcome you to today's COCA Call. Rabies is Still Here: Epidemiology, Outbreaks, and Costs of Prevention in the United States. All participants joining us today are in listen-only mode.

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At the conclusion of today's session, participants will be able to accomplish the following. Describe the four key components of a rabies exposure risk assessment when evaluating a bite victim and the unique considerations of rabies epizootiology to the United States. Explain the occupational risk that rabies in livestock can present to farmers and veterinarians in how to mitigate that risk. Describe the importance of a thorough rabies exposure assessment prior to recommending the patient for post- exposure prophylaxis vaccination.

After the presentations, there will be a Q&A session. You may submit questions at anytime during today's presentation via the Microsoft Teams platform. Please note that the ability to ask a question during the live webinar is limited to the first 1,000 attendees who will join the webinar. If you're unable to ask a question during the webinar, you may submit your question after the live session by emailing COCA@CDC.gov.

Kindly note, that we receive many more questions than we can answer during our webinars. If you're a patient, please refer your question to your healthcare provider. If you're a member of the media, please contact CDC Media Relations at 404-639-3286, or send an e-mail to media@cdc.gov.

I would now like to welcome our presenters for today's call. We are very pleased to have with us Dr. Ryan Wallace, a veterinary medical officer in the National Center for Emerging and Zoonotic Infectious Diseases at the Centers for Disease Control and Prevention. Ms. Carrie Klumb, a senior epidemiologist and the rabies surveillance coordinator at the Minnesota Department of Health. Dr. Katy Donovan, the deputy state epidemiologist stationed at the Rhode Island Department of Health from the Office of Readiness and Response at the Centers for Disease Control and Prevention. And Ms. Alexia Goodman, a public health epidemiologist at the Rhode Island Department of Health.

It is my pleasure to now turn it over to Dr. Ryan Wallace. Dr. Wallace, please proceed.

Thank you, Kondra, and thank you everybody for joining us today to learn about rabies in the United States.

As many of you know, in large part due to readily available, although often costly, access to human rabies vaccines, we have very few human rabies deaths in the U. S., but thousands of animals are diagnosed with rabies and tens of thousands of Americans are treated for rabies exposures every single year.

Today, we're going to talk about the current landscape of rabies in the United States. And our guest presenters will touch on the impact of rabies and livestock and how important rabies risk assessments are to make sure people who need PEP receive it. Next slide.

I'll start today by talking about the landscape of rabies in the United States. Next slide.

I had thought about how to describe a rabid animal, but realize it's the digital age and there's plenty of videos of rabid animal human conflict on the internet. So what you're seeing here is a rabid bobcat that's entered a suburban family's morning routine. It had come out of the left side of that video and bitten the woman who was trying to get into the car. The gentleman then runs over and grabs it. And if you ever find this video online, it's worth listening to yells, "It's a bobcat!" and throws it across the yard. So, what we see here

is a really typical interaction that plays out every single day across the United States of rabid wildlife coming into human spaces and exposing U. S. citizens to rabies virus. Next slide.

So rabies virus causes behavioral changes in any animal or human that is infected. Well, we just watched there was that bobcat wandering into the yard, obviously acting abnormal, and then attacking two people. Rabies virus causes this behavioral change. It causes that increased aggression. It makes those infected more likely to bite and scratch, just like we saw this rabid bobcat do in the video.

For those two people who are bitten by the rabid bobcat, the virus would have been inoculated from that bobcat saliva into their wounds. This virus is neurotropic, and it almost immediately starts migrating towards peripheral nerves--where it'll enter the peripheral nervous system, hijack that intraneural transport mechanism, and start flowing towards the central nervous system, where it's going to replicate much more, much more quickly. The virus moves at only about 1 centimeter per day.

So rabies viruses is known to have a very highly variable incubation period as early as 3 weeks, as long as 3 months to multiple years. And that's really a factor of this nervous system movement. The location of inoculation and distance from the central nervous system drives that incubation period. Once the virus reaches the central nervous system, it replicates at a relatively fast pace within the neurons. However, the virus does not cause neuronal death itself. It causes those neurons to dysfunction, and that translates into the neurologic abnormalities we see in animals or people that are infected.

To complete this transmission cycle, the virus then migrates back out through peripheral nerves, first going through the cranial nerves and into the salivary gland where viruses shed and moves on to the next victim. All mammals are susceptible to rabies virus and all mammals will die within days to weeks after symptom onset. Next slide.

As I said, an incubation period is highly variable, but this is our time to administer rabies post-exposure prophylaxis, which when given under U.S. protocols, has been almost universally protective at preventing clinical signs of rabies. However, if post-exposure prophylaxis is not administered in time, the disease starts as prodrome. This is a really benign early stage of the virus of the infection. It has very vague symptoms such as fever, malaise, flu-like illness, and confusion. For a rabies victim, they're often gonna seek medical care on day 4 of this prodrome period. Can you please click? Next? Yep.

They'll progress on within about 7 days to the early clinical phase. This is where more of the hallmarks of rabies clinical signs appear to just hypersalivation, hydrophobia, paresthesia,

and paralysis. Day 9 after symptom onset is typically when a clinician will suspect rabies, and Day 11 is when the first rabies test will come back positive.

I highlighted here the therapeutic window. There are no proven, effective, treatments for rabies once clinical signs develop. However, there are several experimental therapies that are out there. They all have one commonality in that they need to be administered as early in the clinical phase as possible--within 10 days--and I think hopefully you can appreciate the problem we are in with rabies therapy is that rabies is typically not diagnosed until after this therapeutic window is passed. Click. Or next slide. Sorry. Yep.

So rabies death typically occurs by day This is in the later clinical phase, when the neurologic abnormalities become much more pronounced. We see respiratory failure, severe autonomic instability, cerebral edema, and then death. Next slide.

Rabies vaccines have been available for over 100 years. The original vaccine was a rather crude formulation of an attenuated rabies virus obtained from the rabid brains of rabbits. That vaccine had to be administered over a dozen times over a period of 10 days.

Thankfully, today, the rabies post-exposure prophylaxis series is much easier and safer. It consists of wound care, rabies immunoglobulin administered at the site of the wound to neutralize any virus that has not yet entered the peripheral nervous system, and then 4 doses of vaccine administered over 14 days.

Today, approximately 29 million people each year globally are vaccinated against rabies, saving an estimated 2 million lives every year. Next slide.

In order to understand the epidemiology of rabies globally and in the United States and to understand the basics of a rabies risk assessment, it's important to understand how rabies moves through a population.

So rabies has specific reservoir species. These are mammals that are capable of transmitting the virus to just one or two other of their like species before they die. And it's this can this is how the virus stays propagated within an animal population. Click.

However, like I said, any mammal can get rabies, develop rabies, and die. And a rabid animal does not really care what it's biting.

And so every day, across the United States, our reservoir species are exposing other wildlife and even our domestic animals, and they go on to develop rabies. They're unlikely to spread it much farther than one or two transmission chains, and then it dies out. Click.

But occasionally, if the ecology changes, if the biology of an animal changes, or if the virus mutates, we can see the virus start to spread within a new species, and this is called a

host-shift event. These are incredibly concerning and can have very large impact on public and animal health, as it represents a new source of exposure for people and pets. Next slide.

Globally, this dynamic of reservoir species, spillover, and host-shift events has been playing out for thousands of years. It has led to a really complex diversity of rabies virus variants and reservoir species across the globe, with over 88 known rabies virus variants globally. Next slide.

Rabies is the deadliest of all zoonotic diseases.

If you look in the lower left corner of this graph, you see a lot of our pandemic prone pathogens. These are ones that are relatively geographically confined. When there are outbreaks, they're incredibly concerning, but they are not globally enzootic. In the upper right, we tend to see our globally enzootic viruses. And rabies is the deadliest of all, causing an estimated 74, 000 human rabies deaths every year and over 4 million disability-adjusted life years. Next slide.

So rabies is obviously a really big problem globally. Wherever there is canine rabies, largely in Africa and Asia, there are large numbers of human rabies deaths. But I think we all tend to hear that rabies is relatively rare here in the United States. Next slide.

But that's wrong! Rabies is present in every single U. S. state except Hawaii. If you're a news-a-phile like I am, and you really like reading these headlines, just do a Google News alert, and every single day there is a concerning, scary, or sometimes interesting, you know, rabies story that has been published from our county, county and state health departments. Next slide.

The United States has one of the--has the strongest rabies surveillance system in the world, and because of that we have excellent data that has been able to characterize the changing landscape of rabies here in the U. S. If we went back to the 1930s, 40s, and 50s, rabies in the U. S. looked exactly like it does in Africa and Asia today-- with a virus spreading from dog to dog and spilling over into human populations and causing significant human death very frequently.

Luckily, we've invested a significant amount of effort into eliminating the virus that spreads between dogs, and you can see that decline in the dog curve on this graph. As dog cases went down, so did human cases. Unfortunately, through that spillover in host-shift dynamic, as we started controlling rabies viruses in dogs, we realized that there were emerging rabies viruses in U. S. wildlife. Next slide.

Our ability to track how rabies changes in the United States is a cornerstone of our ability to rely on risk assessments to safely recommend post-exposure prophylaxis to people who are bitten. So if we went back to 1996 here in the United States, the epidemiology of rabies would have looked like this. And I want to draw your attention to a fox variant in the northeast, and a coyote variant in the south of Texas, and two different places where raccoon virus was spreading. Next slide.

If we go forward just 10 years, the fox variant and the coyote variant have disappeared. But now the raccoon variant has spread across the entirety of the east coast, and we have two new fox variants in the southwest. Next slide.

We go forward just 10 more years. The fox outbreak in the southwest has expanded, as has the skunk outbreaks in the midwest. Go forward. Sorry, next slide.

And again, 10 years later to our most recent map, things still change. We have a new variant in Arizona, the Sonora Durango Skunk variant, and we continue to see changes and growing an expansion of our skunk and raccoon reservoirs.

So rabies virus is constantly moving, whether naturally in animals or moving with people as they move their animals. And with that, the risks of rabies for our populations change, and understanding where rabies is and is not, and what animals it's likely present in or is low risk to be present in, again are the cornerstone of our rabies risk assessment process here in the U. S. Next slide.

Rabies deaths in the United States are rare; however, there have been 89 human rabies deaths since 1990. Two-thirds of these deaths are due to the result of untreated contact with rabid bats. And a quarter of these are due to the dog rabies virus, which while it's been eliminated here in the U. S. is still a big risk for travelers who are being exposed abroad and coming back to the United States, where they display signs and are diagnosed. Next slide.

But what I really want to emphasize is that rabies is a daily threat here in the United States 1.3 million people every single year seek medical care for an animal bite. And whether it's their medical care provider, the ER doctor, the health department, somebody is having some version of a rabies risk assessment with these individuals. If you look across all of our 3,000 or so health departments across the United States, they average about 2 rabies consultations every single day. Here at CDC, my program receives 7 rabies clinical consultations every day. If we look at the CDC website, it's one of the most-- the rabies page is one of the most viewed pages for all of our content with 4,600 visits a day. And if we look at our rabies diagnostics, 14 rabid animals are diagnosed with rabies in the U. S. every day. This is a daily threat and a daily challenge for our public and our health departments. Next slide.

So a rabies risk assessment is critical to decide whether or not PEP is indicated. Again, 1.3 million people are seeking medical care for a bite, yet only 100,000 are going to be recommended post- exposure prophylaxis. Our ability to tell over a million people, you don't need this vaccine, is because we have confidence in our surveillance system, and we have a really structured risk assessment process.

So the first step of that process is to determine if an exposure has even occurred. And exposure is defined as infectious materials from a suspect rabid animal making direct contact with fresh broken skin or mucous membranes. So typically, a bite or scratch. If we think an exposure has occurred, we then move on with the bio-geo- behavioral risk assessment.

The biology of the animal is assessed. Is this a reservoir or otherwise high risk species? If so, we're going to be very concerned.

We look at the geography where the exposure occurred. Is this a place where rabies is commonly found? Or maybe rarely found, or, if you're in Hawaii, never found?

And then lastly, we look at the behavior of the animal. Was the animal showing signs of illness? Was this a provoked bite or an unprovoked bite?

And if we put all of this together, we can get a very accurate recommendation for whether post-exposure prophylaxis is necessary. Next slide.

So obviously, if a real exposure has occurred, it's critical to get that person life-saving medication: post-exposure prophylaxis.

But there are consequences of recommending PEP when it's not indicated, and the biggest one is the patient financial burden. Post-exposure prophylaxis in the U. S. costs on average about $12,000 per course. And often times exposures impact multiple family members, which can have an incredible financial impact on a family, especially if they're uninsured or underinsured.

But there's other issues. We only have two vaccine manufacturers that rabies vaccine manufacturers in the U. S. Every year, there are regional supply shortages and restrictions that health departments or CDC need to get involved in to try to make sure people who need it get it. It's also a complex vaccine regimen where people need to take off work or school up to 4 to 5 different days.

And there are mild adverse events that do occur with this vaccine series, which obviously we don't want to put people through if they don't need it. Next slide.

So all this infrastructure I've described that allows or enables the United States to only have one to three human rabies deaths a year it costs about $7 billion a year to operate, but through our ability to rule out the need for this expensive post-exposure prophylaxis series for a million people and through our insurance that we're getting the vaccine to those people that are truly exposed, this system saves over $100 billion every single year—most of that through societal and health care sector benefits. Those activities are thought to prevent up to 3,000 human rabies deaths in the U.S. every year. Next slide.

But this takes all of us working together on a daily basis to make the system work. Our state and county health departments are out there every day responding to these exposure events. And they share that data with CDC. Next slide.

At CDC, we collate all that information, and we try to disseminate it as soon as possible. Typically, once a year. Next slide.

And as this data accumulates, it informs thousands of national, state, local healthcare, and legal codes, next slide, that are then implemented in our healthcare and veterinary clinics that are directly impact patient medical decisions. Next slide.

I want to point to two resources that CDC has developed to help try to help this risk assessment process. The one on the left is actually our shiny app that takes that bio-geo-behavioral risk assessment process and quantifies it. And so you can put in your animal, and your location, and the circumstances of the bite, and it will tell you, based on our national rabies surveillance data, the probability that animal has rabies.

On the right we have a rabies post-exposure prophylaxis schedule generator. This is because the schedule is rather complex, over 14 to 28 days, and one of the most common issues we see is that people get the vaccine on the wrong days. And so you can put in your schedule and see if you've adhered to the ACIP recommended schedule. Next slide.

Alright, so here's our self-check.

You have a 5-year-old in Washington state that has a deep bite wound from his neighbor's new puppy. The child and puppy were running around with a dog toy when the puppy playfully jumped and bit the child. The puppy is too young to be vaccinated against rabies. Which of the following are the correct bio-geo-behavioral considerations for this event? We'll wait just a few seconds for everybody to see those options. Next slide.

So the correct answer is D. This exposure was from a dog, which while they can get rabies, it's relatively rare with only 30 to 50 rabid dogs reported in the United States every year now. The exposure occurred in Washington state, which only has bat rabies virus variance as their enzootic variant. And so while a dog again can get rabies, it's very rare in this part of

the country. And this was a normal interaction. You could call it a provoked bite, a normal behavior for a puppy, and so again low risk. And so what we see here is low risk, low risk, low risk. In this situation, it'd be very safe to advise that that puppy be monitored for 10 days before administering post-exposure prophylaxis to that child. Next slide.

Alright. Thank you. And I'm going to now pass it off to Carrie Klumb, rabies epidemiologist with Minnesota. Thank you, Dr. Wallace.

Good afternoon, everyone. Today I will be talking about occupational exposures to rabies from a cluster of rabid steers on a dairy farm in Minnesota. Next slide.

This is a familiar looking map for everyone at this point, but I just wanted to start off with a little bit of background, orient you to where I am located. So in Minnesota, has a circle around it, and within the United States, there's seven distinct antigenic rabies virus variants associated with terrestrial carnivores in the U.S. And in our part in my part of the country that wildlife reservoir is the striped skunk. Next slide.

So the rabies virus is primarily transmitted between members of the reservoir species in each region, and in Minnesota, a rabid skunk bites another skunk, which develop rabies, and bites another skunk. And so on. But periodically, a rabid skunk bites a domestic animal or a person, and these are called spillover events. Next slide.

In the spring of 2024, we saw more of these spillover events from skunks to cattle than we had in the previous 9 years. This was the result of an epizootic or outbreak of rabies in the skunk population. Many cattle farms in Minnesota overlap with skunk habitat, increasing the rabies occupational health risks for farmers, their families, and veterinarians. Although there is an approved vaccine rabies vaccine for cattle, it is not considered a routine vaccination. Next slide.

The Animal Rabies Surveillance System in Minnesota was built using a one-health approach, and for that reason, we have both animal and human health working together to monitor rabies. So this includes the University of Minnesota Veterinary Diagnostic Lab, the Minnesota Department of Health, or MDH, Public Health Laboratory, the MDH Zoonotic Diseases Unit, and the Minnesota Board of Animal Health, or BAH. Next slide.

In Minnesota, all animals must be brought to the VDL where necropsy is performed to remove the brain. The brain is then sent to our public health lab, where the drug fluorescent antibody test is run, and those results are reported to the ZDU and BAH. All rabies positive results receive additional follow up from MDH first and then the Board of Animal Health after. Next slide.

Domestic animals exposed to a rabid animal are placed under an official board quarantine, which can range in length from 45 to 180 days. And people exposed to a rabid animal receive rabies post-exposure prophylaxis or PEP, which Dr. Wallace had gone over consists of human rabies immune globulin and a series of 4 vaccinations over 2 weeks. Next slide.

OK, now that you've had a little bit of background about how things operate in Minnesota, I'm going to move on to the cluster of rabid steers on the dairy farm and the ensuing public health investigation. Next slide.

On May 11th of 2024, a steer on a dairy farm died after exhibiting neurologic signs. No necropsy was performed. Next slide.

On May 13, a second steer exhibited neurologic signs. The farmers called their veterinarian out, and the steer was euthanized, and then submitted for rabies testing. The steer tested positive for rabies on May 16. Next slide.

The same day MDH and the Board of Animal Health began a joint investigation. MDH interviewed six potentially exposed people and assessed their need for PEP. The Board of Animal Health conducted a site visit to assess animal exposures and to establish official quarantines. Next slide.

After the initial human and animal health investigations were completed, the remaining 33 steers on the affected farm were placed on a 45 day quarantine by the Board of Animal Health. Rabies vaccination was recommended for the steers and a booster for the dog. Twelve unvaccinated cats were recommended for euthanasia. The farm owners reported smelling a skunk in the weeks prior to the first steer showing signs of illness but never saw a skunk. No family members were found to have an exposure warranting PEP. Next slide.

However, the herd veterinarian did have an occupational exposure to rabies. His glove and skin were punctured by a skull fragment in the process of removing the steer's brain for rabies testing. All veterinarians in the United States are required to be pre-exposure vaccinated for rabies, so he was recommended to receive two booster shots instead of the full PEP series. Next slide.

On May 18, the herd veterinarian administered the first of 2 rabies vaccines to the remaining 33 steers. Next slide.

Four days later, on May 22, a third steer had onset of neurologic signs, was euthanized, and tested positive for rabies. Then five days later, on May 27, a fourth steer had onset of neurologic signs, was euthanized and also tested positive for rabies. Next slide.

These new cases prompted additional follow up with the veterinarian and farm owners. The Board of Animal Health conducted another site visit at the farm and extended the

quarantine from 45 to 120 days. The dog remained alive and well, and the cats have been euthanized. The veterinarian and family members were interviewed again to assess for new exposures. Next slide.

The two farm owners had extensive contact with these infected steers, including possible saliva contact. Their young children had unmonitored access to the steer and were too young to be reliable historians. As a result, all four family members were recommended to receive PEP. The veterinarian did not have any new exposures. Next slide.

On June 1, the second rabies vaccine dose was administered to the remaining 31 steers. Next slide.

Thirteen days after the fourth steer became symptomatic, a fifth steer began exhibiting neurologic signs and died, but was not submitted for rabies testing. The farm owners were concerned about the quarantine of the herd being extended again and did not divulge the steers illness until much later on. Fortunately, no further deaths were reported after this fifth steer. Next slide.

Temporal clustering of rabid animals on a farm has been previously reported, but it's a rare occurrence. The dairy steers were housed in a small pen, making it feasible for a single rabid skunk to bite multiple steers. The viruses were closely related to each other, supporting the idea of a single rabid skunk biting multiple cattle. However, having a cluster of five rabid or suspect rabid steers over four weeks is highly unusual and steer-to-steer transmission could not be ruled out. Next slide.

OK. Now is time for the self-knowledge check. Which of the following steps should be taken by farmers when their cattle appeared ill? A) Call their veterinarian to schedule a farm visit B) Attempt to treat the animal on their own by administering a variety of medicines C) Wearing appropriate PPE when handling ill animals D) Restrict the number of people caring for the animals to limit potential exposures E) Isolate the sick animals away from the healthy animals or F) Which is A, C, D, and E?

Just give you a couple seconds here. And we'll move to the next slide.

So the answer is F, and the rationale behind that is that we do not want farmers to treat ill animals on their own, even though this often occurs. Treatment for cattle can involve significant contact with saliva, increasing the risk of exposure. Next slide.

Both MDH and the Board of Animal Health completed their investigations, but where did it leave the farmers? There were both financial and mental health costs to having multiple rabid steers on the this dairy farm. Next slide.

The cost of routine or pre-exposure vaccination of this herd would have cost $310 approximately and the medium yearly income on a dairy farm, according to the 2024 Minnesota Farm Finances Annual report, was approximately $127,000. Next slide.

The financial costs of rabid livestock were summarized in the Rabies and Livestock in the United States, 2012-2021 Paper, and that paper noted that for every rabid livestock four or more people are often exposed to rabies and require PEP. Because rabies often presents in similar ways to other common livestock illnesses like choking, bloat, and milk fever, farmers often treat livestock first, and only call their veterinarian when the treatments don't work. Typically, rabies is not considered up until that point, which means that farmers are not wearing appropriate PPE, resulting in exposures. Next slide.

This table is from the paper I just mentioned on the previous slide and illustrates the economic burden of rabid livestock in the United States. And I've highlighted the rabid cattle costs where you can see the majority of costs come from rabies PEP for people who are exposed to rabid cattle. Next slide.

So now going back to the cluster that occurred in Minnesota, you can see the same cost breakdown occurred there, with rabies PEP making up the majority of the costs. The total cost of the farmers and the medical sector was approximately $47, 500 or 153 times the amount of routine vaccination of the herd. These costs included 9 veterinary visits, 65 rabies vaccinations, rabies testing and shipping of 3 animals, the loss of 5 steers ready for market, PEP for 4 family members, and 2 booster shots for the veterinarian. Next slide.

Rabid livestock can be a major financial burden to individual farmers. These rabid steers and subsequent rabies exposure cost roughly 37% of the farm's yearly income. This affected their ability to make their farm equipment loan payment. They had to shuffle money around in order to not miss that payment and the sale of the herd to slaughter was also significantly delayed, resulting in additional fee costs, and delay in income from the sale. Next slide.

This investigation highlights the lack of support for farmers that find themselves in this position. These losses are not covered by the USDA Livestock Indemnity program and are not typically covered by farm insurance either.

When I spoke to the farm owners, they told me they felt unsupported while this was happening. They had to pay all associated costs and had a loss in delay and income that made it hard for them to make a loan payment.

On top of all of that, all four of them had to go through getting four shots over a two week time period missing both work and school. They were also worried and wondering when the steers would stop coming down with rabies. Their quarantine kept getting extended as

more steer would test positive, and so that led them to decide to not tell anyone at the Board of Animal Health or the health department about the fifth steer because they didn't want to incur more feed costs and further delay the income from selling this herd. Next slide.

Having a rabid animal on a farm is a rare but high consequence event. Preventative vaccination of cattle should be considered in areas where terrestrial rabies is prevalent, the value of the animals is high, and there's potential for human exposure. Governments should work to ensure animal rabies surveillance programs are fully funded, so the cost of rabies testing can be completely covered. Many programs in the United States do not currently have much dedicated funding for their surveillance systems. Programs that help farmers with the cost incurred if rabies do come to their farm should also be considered. Next slide.

Just want to take a moment to acknowledge everyone that helped with this investigation. It was a true one health investigation of human and animal colleagues working together. Dr. Wallace also helped with this investigation. And we also wanted, I would like to thank the farm owners and the farm veterinarian for the cooperation as well. And now I'm going to turn it over to Dr. Donovan. Thank you.

Thank you so much for having us. My name is Alexia Goodman, and today Katie Donovan and I will be presenting on Rhode Island's Centralized Rabies Control Program: Reducing Unnecessary Post-exposure Prophylaxis and Associated Healthcare Savings. Next slide.

And next slide.

The CDC estimates that 100, 000 people in the United States receive rabies post-exposure prophylaxis, otherwise known as PEP, at emergency departments annually. Rabies PEP should be recommended after a comprehensive exposure history and risk assessment have been completed. Administration of rabies PEP often does not follow ACIP guidelines and may be provided unnecessarily. This may be due to a lack of physician education and or clarity regarding ACIP recommendations, a lack of coordination with public health, or lack of time to do a full risk assessment. Health department consultation has been shown to be the most significant factor in preventing inappropriate PEP administration. Next slide.

Rhode Island is unique. We have a centralized state health department, meaning we have no local health departments, and animal bites are reportable within 24 hours of recognition by a healthcare professional. And perhaps what makes Rhode Island most unique is that RIDOH authorizes the release of rabies PEP after completing an internal risk assessment. RIDOH receives reports from multiple sources. The flow of information from reporter to

RIDOH and from RIDOH to our agency partners is crucial to our investigation process. Next slide.

In January 2025, RIDOH moved our animal bites reporting system to REDCap. In this system, all cases must be reported directly into REDCap. From there, RIDOH completes our investigation, a rabies risk assessment, and PEP authorization all within REDCap. Moving the animal bite reporting system to REDCap was a major project, but ultimately worth it. An internal evaluation estimated that REDCap has saved our animal bite team between 6 and a half and 7 months of work by eliminating the need for several work tasks. Next slide.

When submitting an initial report, certain data points are required in REDCap, such as demographic information like name, date of birth, and phone number, next slide, incident details like the exposing species, wound type, and a description of the incident, next slide, and the investigation outcomes, including the animal's vaccination and quarantine status, and any rabies testing results. The data collected upon report is used to drive the early stages of our investigation. Next slide.

A nurse assesses each case to determine if rabies PEP should be authorized. These assessments can be like a puzzle, piecing information together to make the best recommendation for the patient. Next slide.

Let's say that piece #1 is healthcare professionals. These are our most common reporters who give us the incident information, including when, where, what, and how in addition to healthcare professionals reporting to RIDOH, RIDOH reports back to healthcare professionals in instances where rabies PEP is authorized. Next slide.

Piece #2 animal control officers, also known as ACOs, an essential piece of the puzzle for cases involving dogs and cats. RIDOH reports cases involving a dog or cat to the local ACO, who then reports back whether the animal is either quarantined or alive and well after 10 days. With this information from the ACO, RIDOH is able to safely advise the patient that rabies PEP is not needed. Next slide.

Piece #3 The Rhode Island State Health Laboratory. This is where all of the rabies testing for Rhode Island is completed. When the Rhode Island State Health Lab reports a negative result, RIDOH is able to inform the patient that rabies PEP is not needed. Next slide.

Piece #4 pest control companies. These services are frequently used by patients who need an animal captured and submitted for rabies testing. Upon reporting to RIDOH, pest control companies can inform RIDOH whether there appeared to be multiple animals in the home, such as a colony of bats, and describe the status or behavior of the animal. Next slide.

Piece #5 The Department of Environmental Management, a resource used for wildlife capture and submission to the Rhode Island State Health Laboratory for rabies testing. Next slide.

And Piece #6, the patient—the key piece to this puzzle as they confirm or correct information given by the initial reporter. We can only make an informed rabies PEP recommendation after gathering information from our partners and then confirming the details with the patient. Stories frequently changed throughout the course of the investigation, so connecting with the patient is essential. Next slide.

Once we put all of the puzzle pieces together, we can see the larger picture—the final rabies PEP recommendation for the patient. While the partners we work with and the information we collect is routine and structured. The PEP authorization process is highly nuanced and each investigation is handled on a case-by-case basis. Our guidance and education to the patient is what allows them to act upon accepting a PEP recommendation. Next slide.

For cases recommended rabies PEP, RIDOH communicates all vaccine recommendation details to the healthcare facility where the patient will be treated via REDCap, including the type of vaccine recommendation such as HRIG, and 4 doses, the patient's weight, insurance coverage, and immunocompromised status, the date the vaccine was released, in addition to writing out an anticipated vaccine schedule to assist the facility in scheduling the patient. RIDOH also documents the last possible date the patient can receive the first vaccine dose also to assist with scheduling when the patient cannot begin treatment immediately. Next slide.

Since we started releasing the rabies vaccine in REDCap, RIDOH has also gained access to data never available before, including dates when the patient actually showed up to receive each dose, vaccine schedule deviation occurrences, and instances when the case does not complete the entire vaccine series. For cases who do not complete the vaccine series, RIDOH sends a follow up letter reminding them of the risk of rabies, and asking them to contact us to reschedule if they change their mind about treatment. This new information will be monitored by RIDOH to assess how often cases deviate, stop treatment, and the reasons behind these decisions.

I'll now pass it over to Dr. Donovan.

Thanks, Allie. So I'm going to review some of the data on our program in Rhode Island and an investigation we conducted to estimate healthcare savings generated by preventing PEP.

In Rhode Island, the animal bite rate shown here in blue has been steadily increasing since 2020, reaching a 10 year high in 2025, at the same time, the rate of post-exposure

prophylaxis shown in green has remained relatively stable. The stable PEP release rate in this setting of increasing animal bites could be the result of increased animal testing, increased PEP refusals, or improved risk assessment and counseling for animal bite patients regarding the need for PEP. Next slide.

If we look at animal testing, we can see here in the gray bars that testing has increased during the last two years, while the number of positive, rabid animals shown in purple has remained relatively stable. Next slide.

The increased testing and confirmation of negative animals could have contributed to the stable PEP release rate in green, despite the increase in animal bite exposures shown in blue. Next slide.

Additionally, if we look at the number of people with reported animal bites shown here by the blue bars, and the proportion who refused PEP shown in red, we can see that the proportion refusing PEP has remained relatively constant over time at around 5%. Also, the proportion of exposed people who were recommended to receive PEP in green actually decreased over time from about 30% in 2016 to 20% in 2025. This demonstrates the effectiveness of RIDOH Rabies Control Program. The decrease in PEP recommendations is likely a combination of the increased negative animal testing, animal monitoring and quarantine, and an in-depth risk assessment, and counseling offered to all patients. Next slide, please.

Over the past 10 years in Rhode Island, dogs have been the animal responsible for a majority of animal bites reported to RIDOH shown in the blue bars, but bats are the exposing animal that is most likely to result in a PEP recommendation as you can see in the middle and shown by the orange bars. Next slide.

RIDOH Rabies Control Program is quite comprehensive and does require significant resources. However, as demonstrated by the data, it also has a significant impact on PEP administration in the state. To investigate the impact that the program has on preventing unnecessary PEP and healthcare dollars saved, we conducted an investigation looking at data from 2013 through 2022. We use the state's rabies surveillance data and PEP cost data from Brown University Health. Brown University Health is Rhode Island's largest healthcare system and responsible for a majority of PEP releases in the state. Their billing department provided us with the average charges for patients who received PEP. Next slide.

We use this data to estimate the number of patients who are potentially prevented from receiving PEP by our program and the associated healthcare savings. Next slide.

In the 10 year period of the study, there were about 30,000 animal bite exposures reported to the state. PEP was authorized for 25% of those individuals who were exposed, or about

7,500 people, which means that over 22,000 people with animal bites did not receive PEP. Next slide.

We used previous research to estimate the proportion of patients with animal bite exposures who may have gotten PEP without RIDOH comprehensive rabies control program. We looked at two previous studies, one from Illinois and one on emergency departments across the United States, and found that 40 to 50% of PEP treatments administered did not meet recommended ACIP criteria. Based on these studies, we made a conservative estimate assuming 25% of patients who did not receive PEP in Rhode Island may have without the RIDOH Rabies Control Program. Next slide.

Using the estimated average PEP cost for each year during the study period, we got an estimated healthcare savings of $68 million over 10 years. Next slide.

If we make the same assumptions and look at data from only 2022, we can see that the program saved at least $8 million in healthcare expenses in just a single year. Next slide.

Looking at savings from PEP prevention by animal type and using the same assumptions over the 10 year period, $33 million were saved through careful counseling and testing of dogs alone, and another $15 million were saved each for cat and bat exposures. Next slide.

Savings from dog and cat exposures were driven largely by counseling, risk assessment, and animal monitoring, while savings for bat exposures were predominantly from the state lab testing program. Next slide.

Although we did not investigate additional impacts of the program, it's worth noting that preventing unnecessary PEP also saves time for clinicians, next slide, and patients by eliminating time spent in the emergency department or the clinic for multiple PEP injections. Next slide.

Likewise, the program prevents unnecessary visits to the emergency department, easing strain on busy EDs. Next slide.

In conclusion, health department-led risk assessment and evaluation that accounts for local rabies epidemiology combined with animal quarantine and testing is far more economical than the cost of even moderately increased PEP administered in the acute care setting without public health intervention, guidance, and control. Next slide.

Here we can do our self-knowledge check. Of the options below, what has had the biggest impact on ensuring PEP is given appropriately following an animal bite? Is it A) Patient age, B) Time of day when the patient presents for care, C) Provider consultation with the local health department, or D) That the patient has health insurance coverage? Next slide.

The answer is C) Provider consultation with the local health department. Rabies PEP guidance is nuanced as we've discussed and does require consideration of many factors, and consulting with the health department can help improve adherence to PEP guidance. Next slide, please.

Thank you very much. I'll pass it back now to the moderator.

Presenters, thank you so much for providing this timely information to our audience. We will now go into our Q&A session. Audience, you may submit questions in the Q&A box via the Microsoft Teams platform. Again, please note the ability to ask a question during the live webinar is limited to the first 1,000 attendees who join the webinar. If you're unable to ask a question during the webinar, you may submit your questions after the live session by emailing COCA@CDC.gov.

Now for our first question. As there have been multiple issues with organ donation from undiagnosed cases of rabies, is there more work being done around rabies testing of donor organs?

Yeah, this is Ryan. I can take that question. So we have had three organ donor derived rabies events in the United States since 1990. They resulted in six recipients developing rabies and dying. So it's a relatively rare event, but it's a very high consequence event when they do happen. Because of the most recent event, there are discussions with different organ donation safety groups about some additional screening, but it's a careful balance of making sure that this rare event does not cause any detrimental impact to the, you know, incredibly life-saving activity of our organ donation system here in the U.S. At CDC, we are working on an analysis to better understand our case detection rate of human rabies.

There was a amazing study done in California over the last 20 years, looking at causes of undiagnosed encephalitis. And they actually found three human rabies deaths that were missed by the surveillance system. So we know human rabies case detection is not perfect. It's a very complex disease to diagnose, but there are several activities going on right now to try to make that system safer.

Thank you for that.

Our next question, what is the recommendation for those who received the post-exposure vaccine series at an irregular interval?

So maybe I can take that from the federal perspective, and then I'm sure Carrie and Katy and Allie get this question daily.

But the so ACIP recommends that that obviously you adhere to the schedule, but deviations of several days up to a week are not going to really cause any issue with

response to the vaccine. So we have come up with the--that language and ACIP is a bit vague. We have come up with a more quantitative bounds upon which a deviation would still be acceptable versus unacceptable, and public health needs to be consulted, and that is worked into the calculator of the scheduler that is on the CDC website now. So for those of you that do have an interest or need, you can go to that website, you can put in your schedule of what someone has received, or schedule you're recommending, and it will alert you to if you have made a deviation that would be considered significant and public health folks like Carrie, Allie, and and Katy should be brought in to consult. And I'll pass it over those two to talk about how they handle it in the real world.

This is Carrie from Minnesota. It is a pretty common question that we get from clinicians. And we actually use that calculator that Ryan mentioned. But typically you know it, we get the whole story. Try to figure out. A lot of times it's, you know, someone wasn't compliant and didn't show up. Or they might be going on vacation, and so typically, yeah, it fits in within a few days on either side of the vaccine, it's typically safe to adjust that schedule and then resume as normal.

And it's the. Sorry.

It's the same in Rhode Island. If someone deviates by a few days, that happens all the time, and if it's a bigger deviation, we often consult with the CDC team, or help our patient schedule appointments if they are traveling elsewhere.

Thank you for that.

Our next question, what would you do with an exposure where the animal is low risk and in a low risk area?

So this is Ryan again. I think you've seen from all three presentations that risk assessment process is what our rabies epidemiologists always reach to. Obviously, if the animal is available for observation or testing, you can get a definitive risk result from those two options. When that animal's not available, has disappeared, it's a stray, you can't find it, then it gets very tricky for health departments to try to figure out do you recommend this, you know, $10,000 vaccine series or not? We think about 25 to 50% of rabies PEP in the U.S. is administered in these exact situations. And of everybody, those 100, 000 that get rabies post-exposure prophylaxis every year, probably about 10 to 15% legitimately had a rabies exposure, so some is still going to people that are in these low-risk scenarios.

Thank you for that.

And we have time for one more question. Can you comment on the practice of giving PEP if people are scratched by a bat or wake up in a room with a bat and are not sure they need PEP?

Let's hear from the states on this one. I know it's another common call y'all get.

Allie here. So, oh yeah, go ahead.

Sorry, Allie, with the Rhode Island. I think the biggest question we would have to start is whether they were able to capture the bat. Our first stop is always going to be testing it for rabies, if that's possible. But at the end of the day, if someone like let's the bat out of the house, they woke up, they were sleeping when the contact happened, we would likely end up recommending PEP.

This is Carrie from Minnesota. And yeah, the same thing here. We also always prefer to test the animal if possible, and if the animal's not available, then if they woke up to the bat in the bedroom, or they had direct bare skin in contact with the bat, we do assume that's a potential exposure, might be a low-risk. But it's not a no risk exposure. And so, in the absence of being able to test that bat, then we would recommend PEP in those situations.

Okay.

Thank you so much presenters for answering these questions and for sharing your expertise with us today.

CDC has fully transitioned from the Training and Continuing Education Online system that provides access to CDC educational activities for continuing education to CDC TRAIN. If you do not already have a TRAIN account, please create one at www.train.org. All new activities that offer continuing education from CDC will only be listed in CDC TRAIN. CDC TRAIN is a gateway into the TRAIN Learning Network, the most comprehensive catalog of shared public health training opportunities. This transition will allow you to access non credit and for credit educational activities and track your learning including CE all in one place. Many CDC accredited activities are already listed in CDC TRAIN. The move to one system improves efficiency and makes it easier for learners, CDC staff, and partners to offer and earn CE in one place.

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