Effects of Tick-Control Interventions on Ticks, Tickborne Diseases in New York Neighborhoods

[Announcer] This program is presented by the Centers for Disease Control and Prevention.

[Sarah Gregory] Hello, I'm Sarah Gregory, and today I'm talking with Dr. Felicia Keesing, a David & Rosalie Rose Distinguished Professor of the Sciences, Mathematics, and Computing at Bard College in New York. We'll be discussing the effects of tick control interventions in New York.

Welcome, Dr. Keesing.

[Felicia Keesing] Thank you so much for having me. I'm delighted to be joining you on your podcast.

[Sarah Gregory] How many different tickborne diseases are there in the United States? And what are they?

[Felicia Keesing] Well, there are about a dozen different tickborne diseases, so I won't list all of them. The most familiar to probably everyone listening is Lyme disease, which occurs in every state in the country, basically. It's more common in the northeastern US and in the midwest, but it occurs everywhere. So that's going to be the most familiar. And then the second most familiar is probably Rocky Mountain spotted fever. But there are a lot of other tickborne diseases that people might be familiar with, especially depending on whether that disease occurs where they live. So I'll list a few of them: anaplasmosis, babesiosis, ehrlichiosis. There's a disease that was discovered more recently called Powassan fever disease. So some of these, if you don't have them where you live, they might sound very exotic, but many places have several of these diseases present at the same time.

[Sarah Gregory] In fact, I'm doing another podcast on Heartland virus, which is starting to spread in more and more places.

So one is bacterial, and one is viral. What's the difference?

[Felicia Keesing] Well, about half of the tickborne diseases in the US are bacterial, roughly, and about half are viral. All that means is what type of pathogen causes the disease. So Lyme disease—again, this very familiar one—is caused by a bacterium called *Borrelia burgdorferi*. On the other hand, Powassan fever disease is caused by a virus called Powassan virus. And actually, one of the more common tickborne diseases in the US is caused by neither—it's caused by a protozoan. This is babesiosis, it's caused by the protozoan *Babesia microti*. And that's, again, neither a bacteria nor a virus. It's actually caused by an organism that's more similar to the parasite that causes malaria. And the reason we care what causes these diseases, whether they're bacterial or viral or protozoal (in the case of babesiosis) is because the kind of organism determines a lot about how we can treat that particular disease—what kinds of medicines would work to kill those organisms living in your body.

[Sarah Gregory] Which causes the worst infections? And which are the hardest to treat and why?

[Felicia Keesing] Well, in general...not specific to tickborne diseases, but in general, infections caused by viruses are harder to treat than those caused by bacteria. But as some of your listeners may be aware, some of these tickborne diseases are a bit more complicated than that. For example, Lyme disease is caused by a bacterium which, in principle, should make it relatively

easy to treat. And it can typically be treated quite effectively if it's diagnosed and medicated early. But Lyme disease can get much harder to treat in its later stages.

So even though it's bacterial, it has some of the difficulties of treatment that some viral diseases do. And one of the reasons that viral diseases are typically harder to treat is that there are fewer targets. Viral particles just have less stuff in them, and so there's less for drugs to target, whereas bacteria are a little more complicated and their cells are quite different from ours. And so, we have lots of things to target. Lyme disease is a little bit harder to treat for reasons we're still trying to uncover, but it includes the ways that the bacteria move through the body and where they sequester themselves. But again, that's something that people are still trying to figure out how to treat them effectively at their later stages.

[Sarah Gregory] How many tickborne infections in the United States are there annually?

[Felicia Keesing] Well, I can answer that two ways. One is to tell you how many diagnosed confirmed cases there are. There are about 50,000 diagnosed confirmed cases of tickborne diseases in the US each year. Most of those are Lyme disease, over 35,000 in a typical year. But the reason...the second way that I can tell you how many cases there are, is by estimates of how many real cases there are, including cases that aren't confirmed. So estimates for that are about 10 times higher.

So about 500,000 cases of tickborne disease are what we estimate are what we estimate are actually happening, with only about one in 10 of those being confirmed and documented at the CDC. And that's because people get an infection but don't necessarily report it, or they don't get a test that allows it to be confirmed, etcetera—some issues that might be familiar from people's experiences from the COVID-19 pandemic. And so, we have some of those same kinds of dynamics going on in Lyme disease, but there are ways that we can estimate how many cases there probably are, and that's about half a million. But that's a lot of cases.

[Sarah Gregory] That is a lot of cases.

Is there a tick season?

[Felicia Keesing] In some parts of the country, there is. So I live in the northeastern US, and here there are distinct periods when ticks are active. In other parts of the country, particularly in the south and southeast, there's much less seasonality. Even if there's seasonality in one tick, there will be another tick that's present at all times.

So it's seasonal in some places and not in others. And there's two really important things to think about that. One is that you should know the tick seasonality where you live, because it can affect the way that you adjust your precautions about keeping yourself safe. So it's important to know when you might be at risk and to take particular precautions then. And then the other thing to toss in there with that is that climate change caused by human activities is changing tick seasons in much of the country.

So here in the northeast, May has typically been what we call Tick Awareness Month (or Lyme Disease Awareness Month). But we've shown from looking across over 20 years of research that the date of tick activity is going...becoming earlier and earlier. So in not that much many more years, we will have to move Lyme Disease Awareness Month back to April. Ticks are staying active longer in the year as well. So more of the year is becoming tick season in the northeast, even though we've had the benefit, such as they are, of having a more seasonal period. And so,

people should be aware not only of what their current tick season is, but what kind of directional changes are likely to happen as a result of ongoing climate change.

[Sarah Gregory] So not only are tick diseases spreading, like Lyme spread from the northeast, like you said, clear across the US, but now the season is expanding. That's a lot to keep track of.

What are the economic costs of all these infections?

[Felicia Keesing] Well, the estimate is about a billion dollars a year, just for the medical cost of Lyme disease. So that's a substantial financial hit borne out again. And that's just the medical cost. That doesn't include other kinds of lost productivity, for example, that might go with people being sick.

[Sarah Gregory] Like time off from work, and that sort of thing?

[Felicia Keesing] Exactly, exactly.

[Sarah Gregory] Your study is specifically about tick interventions in New York. Which disease is most prevalent there?

[Felicia Keesing] Well, Lyme disease is by far the most prevalent here. We're sort of the national hotspot for Lyme disease and have been for some time. But we also have anaplasmosis and babesiosis, and there are several other tickborne diseases here as well. So we've got quite a lot going on in New York.

[Sarah Gregory] So there's greater spread and there's longer seasons of ticks. So are these diseases and infections...I imagine they are increasing in the United States?

[Felicia Keesing] Definitely. The number of cases of tickborne diseases in the US has roughly doubled over the past 15 years or so. So we definitely see an increase in cases nationally. The other thing is that there are new infections. So it's not just that the cases of diseases we know about or have known about for a long time is increasing, but that we're also recognizing new diseases. So I mentioned earlier that Powassan fever virus (or Powassan virus disease) is a relatively newer disease, and so we've got that to add to the list. And then there's another more newly discovered disease called...that's caused by the bacterium *Borrelia miyamotoi*. So we're not only adding new cases of existing diseases but adding some new diseases as well.

[Sarah Gregory] Right. And as we said, it's spreading...the ticks are spreading geographically, so infections are also spreading geographically, correct?

[Felicia Keesing] Yes. So the ranges of different tick species and the pathogens that can live inside them are shifting. For example, Maine and Vermont in the far northeast are now hotspots for Lyme disease, but there was very little Lyme disease in those states about 20 years ago. We see the same kind of western spread...same kind of spread to the west of New York, for example. Western New York is now having a huge number of Lyme disease cases, whereas 20 years ago, there really wasn't anything for them to worry about substantially regarding Lyme or any other tickborne disease. And now it's a common concern.

[Sarah Gregory] And why did you want to do this study?

[Felicia Keesing] Well, not only do I live in the state that's a hotspot, but I happen to live in the county in the state that's a hotspot (the biggest hotspot). I've lived here for a long time, and Dutchess County (where I live and work) had more cases per capita for many years than just about anywhere else. And so this affects our friends and our neighbors really profoundly and has

a huge effect on people's health here and their comfort with being outdoors. So we wanted to figure out whether there was some intervention that we could do that would protect people from ticks and, hopefully, from getting tickborne diseases.

[Sarah Gregory] Okay. So specifically, the purpose of your study was what?

[Felicia Keesing] We tested two environmentally friendly methods of reducing tick numbers to determine whether those methods could prevent Lyme and other tickborne diseases in residential neighborhoods in this county.

[Sarah Gregory] And what time period did you cover?

[Felicia Keesing] We began using the treatments in people's yards in 2017, and they were applied for four seasons (so through the end of 2020). We started collecting data in people's yards before we put these tick-killing products to use (so that was in 2016), and we continued our data collection into 2021. So altogether, it was six years of data collection.

[Sarah Gregory] So tell us about the study. How did you structure it?

[Felicia Keesing] We recruited participants from 24 neighborhoods in Dutchess County that had high risk for tickborne disease based on prior cases over the last five to 10 years. And then, once we recruited participants, each neighborhood was randomly assigned to a particular combination of these two tick control interventions that we selected. One of those is a fungal spray that's commercially available and can kill questing ticks (ticks that are seeking a host), and the other intervention is a box that has a little bit of bait in it. Inside the box is a tick-killing chemical that gets dabbed onto the back of the small animals that go inside this box.

So we used those two interventions, but we also had placebo controls. So people couldn't tell whether their property was getting the active treatment or the placebo treatment. From their experience, the treatments were exactly the same. We call that a masked—or sometimes people say a blinded—study. And the people we had collecting data for the project didn't know, either. So it was a placebo control, it was randomized, and doubly masked study (or double-blinded study), which is that sort of Gold Standard for clinical trials, for example. And we did this in people's yards. We had teams of people out collecting data in people's yards on ticks and small mammals. And then we also had our participants report to us every two weeks by either text or email, or in some cases phone call, letting us know if anyone in their household (including one of their pets) had encountered a tick or had been diagnosed with a tickborne disease. So it was a really massive project involving a lot of components and a lot of people.

[Sarah Gregory] And you ended up with a lot of data. So how was the data analyzed?

[Felicia Keesing] We did have a lot of data. We asked about how each of the interventions affected the number of ticks that we found in people's yards, the number of ticks on small mammals, and then most importantly, the number of encounters people had with ticks and the number of diagnosed cases of tickborne diseases for people. But we also did all of that for pets, as well.

[Sarah Gregory] And most importantly here, what did you find?

[Felicia Keesing] Well, we found that the boxes—which are commercially available as what's called the Tick Control System (or TCS)—reduced the number of ticks in people's yards by about half. We did not find that effect from the fungal spray that we tried. But we found that the boxes reduced the number of ticks in people's yards by about half. And we found that that

reduction in tick abundance in people's yards was associated with fewer cases of Lyme disease and other tickborne diseases in pets, but we didn't find that effect in people. So we reduced the number of ticks in people's yards, but we didn't see any corresponding reduction in the number of cases in people. We did in their pets, but not in people.

[Sarah Gregory] Any idea why this would be the case?

[Felicia Keesing] We can't tell for sure. We have a few ideas. First, pets and, here you should think dogs.... we think that pets use more of the yard than a typical person. For example, they might cover the entire yard, including forested areas or shrubby areas in a way that people would be less likely to. So when we reduce ticks in the yard, it had a bigger impact on pets than it did on people. This might be particularly true in a neighborhood with a high risk of tickborne diseases because people who know that they're at high risk of tickborne diseases in their neighborhood might have adapted their use of their yards to minimize their risk, whereas their pets wouldn't have, potentially.

And second, we still...even after all these years of trying to prevent cases of Lyme disease, we still don't know where people encounter the ticks that make them sick. There's been a long, somewhat data-backed expectation that people encounter ticks in their yards, when...that people encounter the tick that make them sick while people are in their yards. But that very well might not be the case, at least not for people, in general. So it might be the case that pets pick up ticks in their yard, but people pick up ticks more frequently somewhere else. And we just don't know that.

[Sarah Gregory] Okay, back to pets, because I know a lot of people are very concerned about their dogs in the yards, and some of these interventions are sort of iffy if they're working. What about medicine that people have for their dogs, like collars or pills (I give my dog pills)? Do those actually work?

[Felicia Keesing] Well, there are quite a few studies showing that collars used on dogs and cats are effective at reducing tick and flea burdens. Typically...I'm not an expert on this particular topic, but I think they typically show that they are up to 90% better than control subjects. So they really are...can be quite effective, and their safety record appears strong. And you get similar results with Frontline. So generally, those products seem to work well. We just...we have them available for our pets, but we don't have them available for ourselves.

[Sarah Gregory] Is there a reason for that?

[Felicia Keesing] That's a good question, I knew I set myself up for that. How long do you have? Look, there are...I would say, there are a lot of people working on ways to protect us from tickborne diseases—to prevent tickborne diseases in a biomedical way. So our approach has been to try from an environmental or ecological way, but there are also biomedical approaches. One way to do that would be through a vaccine, and there's a long history of vaccine research related to Lyme disease, in particular, which I won't go into unless you ask me to. But I will say that one of the more promising directions right now is that there's some progress in developing a tick vaccine, or I should say an anti-tick vaccine. The idea would be that if you had this vaccine, your body would react when a tick started to embed its mouth parts (gross as that is to think about) in such a way that you would know that you were being bitten and could remove the tick before it could do harm to you or transmit a pathogen to you. So there has been some recent success just about six months ago now, where a tick vaccine was tried on guinea pigs and shown to be

effective. So there is hope that that might come to...into clinical practice over the next period of time.

[Sarah Gregory] Okay, that is really interesting. So it wouldn't actually mitigate the virus or pathogen or whatever, but it would sort of make the tick feel like you were getting a bee sting or something, and you'd be very aware of it. Is that what I'm hearing?

[Felicia Keesing] Yeah. Ticks have a pharmacopeia of chemicals in their saliva that they inject into you to keep you from knowing that they are there. So that's why we have to do these very thorough tick checks and things. If we knew they were biting us, we could remove them. But we don't know they are biting us because they have this set of chemicals that they inject into us to prevent their detection. But if our immune systems recognize them (recognize those chemicals), then they would know that the tick was biting us and we could pull it out before it did damage.

One of the advantages of that approach over focusing on a particular pathogen is that we talked about there being a dozen tickborne diseases in the United States, each caused by a different pathogen. So if we target, for example, Lyme disease and come up with an effective vaccine for Lyme disease, that might make us less vigilant about ticks, which could make us more at risk for some of the other tickborne pathogens that are also present in our region. So an anti-tick vaccine has some benefits in that way, that it's addressing all the tickborne diseases by going after the ticks themselves.

[Sarah Gregory] That's interesting. Yeah, especially since some of these newer tickborne diseases are quite deadly, you wouldn't want to be not paying attention.

[Felicia Keesing] That's exactly right.

[Sarah Gregory] I'm sure there were a lot of challenges. Can you tell us about those?

[Felicia Keesing] Well, this was an absolutely huge project that involved thousands of people...thousands of people participating in the project with us treating their yards. But we also had quite a number of people on our staff. We had hundreds of pets involved in the study and all kinds of permissions and protocols and things. So getting the whole project up and running in a couple of months from the moment we got funded was hard. But we had a great team and I have to say, looking back, in a way that experience of going from zero to 60 so quickly was kind of exhilarating.

Another notable challenge was COVID, because our last year of the study was 2020. Officially, that's when we were supposed to start, and so we went into that...we were just about to start that field season when we had to radically shift what it was that we were doing. So we were incredibly grateful to our participants and to our staff for handling that so gracefully and so nimbly. And as it turned out, we were able to continue with the tick interventions through the summer of 2020, taking all appropriate safety precautions because we were in people's yards and people were willing to allow us to continue access to their yards through all of that. We had, by that point, developed these really trusting relationships with our community, and so we were able to keep going. And that was a huge boon. But it was definitely a logistical challenge.

[Sarah Gregory] Yeah. That's all pretty remarkable.

Were there any surprises?

[Felicia Keesing] Well, let's see. I... we'd been warned from the very beginning that we'd have a lot of trouble retaining participants in this study. We'd been told that people would start dropping

out very quickly and that we wouldn't have very many people left by the end of the five years that we had planned for the study. So I would say one of the most welcomed surprises was that our participants remained so committed and so engaged with the project from start to finish. Over the six years that we ended up running the study, only a handful of people dropped out, and most of the people who dropped out, dropped out because they had to (because they moved out of one of our neighborhoods). And typically, we were able to recruit the people who moved into their house to join the study at that point, and we continued following them. So the engagement of our participants and their sustained enthusiasm was one of the biggest surprises.

[Sarah Gregory] That's very interesting. I would guess it's because it didn't involve them taking any medicine, but people are also very curious and wanting not to have ticks in their yards, so. Well, that's good.

What do you think is the biggest public health aspect of what you found?

[Felicia Keesing] One really important takeaway from this study and several other recent ones is that reducing the number of ticks in a small area (like someone's yard) appears to not have a very direct effect on whether people get tickborne diseases. In fact, we don't have any interventions on that kind of small scale that have been shown to reduce people's actual incidence of tickborne diseases. So one of the things that's so critical about that result is that going forward, we need to make sure that researchers can do larger scale studies that can measure whether their efforts of tick control actually translated into impact on people's health (if that's the goal of the study). That's going to require appropriate funding and possibly some consolidation of projects so that people can actually track through to human impact, which will require larger scales and potentially a longer timeframe.

We also, as I mentioned before, we also really need to figure out where people actually encounter the ticks that make them sick. People have tried to do this in various ways, but none of those efforts is (so far) up to the task. So this is going to take, again, an infusion of support and some really creative research to figure it out in a way that we can use to address interventions. If it's not people's yards, then where is it?

[Sarah Gregory] Anecdotally, I have a friend who lives in New Hampshire, and she has a husband and two children. And her husband and one of her sons had gotten Lyme disease, and... but one had avoided it all those years. And then they took a trip to Scotland and weren't really in the bush or anything, and he got it there. So it's hard to tell with these things.

[Felicia Keesing] Right. So it can be that you pick something up while you're traveling. But we also don't know whether people tend to pick up the ticks that make them sick in their yards or when they're on a hike, or when they're at a park, or when they're visiting their neighbors. These are all remaining questions, and because people typically don't see ticks when they get on them.

[Sarah Gregory] Right, yes. Well, I think I'm very frightened of my own yard, but...
Does this study change any guidance about how people should protect themselves?

[Felicia Keesing] That's a good question. I think the basic answer is no. People still need to use all the personal protection measures that, hopefully, they've been learning, like wearing protective clothing, using repellant as appropriate, and doing tick checks as well as being aware of the symptoms and the times of year to be aware of potential tickborne diseases. So no, I don't think this really changes that. We had hoped that we would find a way to effectively reduce risk

by doing these interventions in people's yards, but this...the approaches we used did not have the...that impact. So people are still with their established personal protection measures.

[Sarah Gregory] Tell us about your job and how you came to be studying ticks and tick control?

[Felicia Keesing] Well, I'm a biology professor and a disease ecologist. So for the last 25 years or so, I've been studying how changes to the environment affect people's risk of being exposed to infectious diseases. In some ways, I would say this project was a natural extension of that earlier work, because I became interested in how to intervene in ways that might reduce people's risk once it was already high. So this was, again, a natural extension, but it is bigger and distinctly more applied than any work that I've ever done before.

[Sarah Gregory] What do you do in your leisure time? New York is a beautiful state with lots of outdoor activities. Given your knowledge of ticks, do you still participate in any?

[Felicia Keesing] New York is a beautiful state, and I do participate in outdoor activities a lot. I'm outside a lot every day whether the weather is good or bad. I love to hike, I love to walk, I'm an avid gardener. So I'm aware of ticks, I'm aware of the seasons when ticks are a risk. I take precautions, like wearing protective clothing and doing regular tick checks. I know the symptoms to look for, and again, what times of year to be concerned (which seasons have the highest risk). I will say that I also have a fortunate quirk, given my line of work, which is that my immune system reacts very strongly if a tick tries to embed its mouth parts (this might sound familiar to what we were talking about when we mentioned the tick vaccine). It's...the tick vaccine is based on this same reaction that I have, and some other people do. So if a tick tries to embed its mouth parts in me, I typically get a very strong reaction at the site of that bite, and I'm aware of it. It's much more intense than a mosquito bite, for example. And so, I wake up sometimes, my immune system has actually killed the tick and...so I pull off a... remove a tick (a dead tick) from the surface of my skin. So it's a great occupational advantage, but I don't take it for granted. I still do all the tick checks and everything else, as well. So... but yes, I absolutely spend time outside. It's one of my favorite things about living in this beautiful place.

[Sarah Gregory] Well, that's very fortunate for you. I wish we all had that, even without the vaccine.

Well, thank you so much for taking the time to talk to me today, Dr. Keesing.

[Felicia Keesing] It has been my pleasure, thank you for having me.

[Sarah Gregory] And thanks for joining me out there. You can read the May 2022 article, Effects of Tick-Control Interventions on Tick Abundance, Human Encounters with Ticks, and Incidence of Tickborne Diseases in Residential Neighborhoods, New York, online at cdc.gov/eid.

I'm Sarah Gregory for *Emerging Infectious Diseases*.

[Announcer] For the most accurate health information, visit cdc.gov or call 1-800-CDC-INFO.