Exposure to Ticks and their Pathogens in Northeast Missouri

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1892 125 YEARS LEADING 2017

Results from these surveys indicate that exposure to ticks is common and ehrlichiosis infections are likely underdiagnosed while Rocky Mountain spotted fever and Lyme disease are likely overdiagnosed.

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Abstract

While the prevalence of human pathogens has been quantified in ticks in Adair County, Missouri, the prevalence of residents acquiring tick-borne diseases and seeking medical treatment has not. A public survey (n=109) revealed that 96% of respondents reported finding attached ticks on their person; of these, 38% developed symptoms post tick bite; of these, 55% reported consultation with a health care provider. Overall, 89% of practitioners surveyed had treated at least one patient for tick-borne disease. Rocky Mountain spotted fever and Lyme disease were the most common illnesses diagnosed, however, the only confirmed cases reported by Missouri Department of Health and Senior Services from 2013-2017 were ehrlichiosis. Results from these surveys indicate that exposure to ticks is common and ehrlichiosis infections are likely underdiagnosed while Rocky Mountain spotted fever and Lyme disease are likely overdiagnosed.

Introduction

Land managers, farmers, and people who recreate outdoors have an increased risk of tick exposure and thus an increased risk of infection with tick-borne pathogens. Three tick species are present in Northeast Missouri: the lone star tick, *Amblyomma americanum*, (Linnaeus, 1758), American dog tick, *Dermacentor variabilis* (Say, 1821), and the blacklegged tick, *Ixodes scapularis* (Say, 1821). The lone star tick is the most prevalent species.[1-2] Due to the abundance of this tick and its propensity to feed on humans, pathogens transmitted by lone star ticks pose an important threat to human health. Lone star ticks transmit the etiological agents which cause ehrlichiosis, Heartland virus, Southern tick-associated rash illness (STARI), tularemia, and their bites have been associated with Alpha-gal allergy or mammalian meat allergy.[3-5] In addition, there is some evidence that lone star ticks may have a role in spotted fever group (SFG) rickettsiae like diseases.[6-8] In Adair County, 436 adult lone star ticks demonstrated infection rates of 6% for *Borrelia lonestari*, 19% for *Ehrlichia chaffeensis*, 3% for *Ehrlichia ewingii*, 36% for *Rickettsia amblyommatis*, and 1% for *Rickettsia montanensis*.[9] Briefly, *B. lonestari* and *R. amblyommatis* have been implicated, but not definitively proven, as putative agents of STARI which is a Lyme disease-like illness.[10-11] *Ehrlichia chaffeensis* and *E. ewingii* are the causative agents of ehrlichiosis which ranges from influenza-like symptoms in its mildest form to an occasionally fatal course. Both *R. amblyommatis* and *R. montanensis* have been implicated in the SFG rickettsiae like diseases.[6-8]

Mapping the public health threat of tick-borne diseases (TBDs) requires quantification of not only the density of infected host-seeking ticks but also the rate of human exposure to these ticks. The purpose of this study was to

Table 1. Residents of Northeast Missouri self-report annual exposure to and average number of ticks removed from persons

	Have seen a tick on their person	Have had an attached tick to their person		Average number of ticks removed per year from their person
Response	(n=109)	(n=109)	Response	(n=105)
			1-5	63 (60%)
Yes	106 (97%)	105 (96%)	6-10	24 (23%)
No	3 (3%)	4 (4%)	11-25	8 (8%)
Not Sure	0	0	26-100	10 (9%)

Table 2. Residents in Northeast, Missouri who self-report symptoms post tick bite, visited healthcare, and were treated for those symptoms

	Rash	(n=22)	(n=8)	flu-like symptoms	(n=6)	(n=4)	Both rash and flu	(n=12)	(n=10)
Response	(n=104)	visited healthcare	received treatment	(n=104)	visited healthcare	received treatment	(n=104)	visited healthcare	received treatment
Yes	22 (21%)	8 (36%)	4 (50%)	6 (6%)	4 (67%)	2 (50%)	12 (12%)	10 (83%)	7 (70%)
No	77 (74%)	14 (64%)	3 (38%)	86 (83%)	2 (33%)	2 (50%)	92 (88%)	2 (17%)	2 (20%)
Not sure	5 (5%)	0	1 (12%)	12 (11%)	0	0	0	0	1 (10%)

collect data on: a) the frequency of tick encounters in people who work outdoors in Adair County; b) the frequency of treatment of TBDs in clinics within Adair County; and c) the reported numbers of TBDs for Adair County by the Missouri Department of Health & Senior Services. It is known that many TBDs are widely underreported in the United States.[12-13] This study was designed to identify if people are actively seeking treatment for TBDs, if TBDs are being diagnosed in medical clinics, and provide a more accurate assessment and better understanding of the prevalence of these diseases in a highly endemic county.

Figure 1. Amblyomma americanum female tick (left) and male tick (right)
Photo credit: Kelly Rogers, ATSU photographer

Materials and Methods

Public Survey.

Public exposure to ticks and the potential to acquire TBDs was assessed by a nine question survey. The survey was distributed to employees of the Missouri Department of Conservation and USDA National Resource Conservation Service who routinely work outside. In addition, surveys were distributed to people who attended the Agricultural fair that occurred in Adair County (February 3rd, 2018) to include the local farmers. A total of 109 responses were obtained. Areas covered by the survey included: experiences with ticks; concerns about contracting TBDs; visits made to health care professionals due to tick bites. It was calculated that for a population of 20,000, a confidence level of 95%, and with 109 responses that the margin of error is 9.40%. No personal data were collected and so the ATSU IRB committee found this study to be exempt under Section 45CFR46.101(b)(2).

Clinician Survey

Four separate primary care clinics with approximately 25 health care providers in Adair County were contacted to fill out a six-question survey to determine how often they see patients with suspected TBDs, types of TBDs treated, if any, and if a blood sample is routinely sent off to screen for TBDs. A total of 9 responses were collected for a 36% response rate. No personal or medical data was collected and so the ATSU institutional review board (IRB) found this study to be exempt under Section 45CFR46.101(b)(2).

Database Query.

The past five years of tick-borne reported diseases for Adair County, Missouri 2013-2017 were obtained from the Missouri Department of Health and Senior Services (DHSS),

Bureau of Reportable Disease Informatics, Missouri Health Surveillance Information System.

Results

Public Survey

Tick bites are common in Adair County; 97% of all respondents report seeing a tick on their person and 96% report finding a tick attached to their body (Table 1). On average, 60% report that they remove 1-5 attached ticks per year, 23% remove 6-10 attached ticks per year, 8% remove 11-25 attached ticks per year, and 9% remove 26-100 attached ticks per year (Table 1). Thirty-eight percent of people reported developing a rash, influenza-like symptoms, or both following a tick bite (Table 2). Of those 38% who developed symptoms after a tick bite only slightly more than half (55%) sought medical attention and of those 59% were treated for TBDs (Table 2). If an individual developed a rash from a tick bite they were not as likely to seek medical attention (36%) when compared to individuals that developed influenza-like symptoms (67%) or had both rash and influenza-like symptoms (83%) (Table 2).

Sixty-one percent of the respondents stated that they always perform tick checks after spending time outdoors, 28% stated that they performed tick checks most of the time, 10% stated they sometimes perform tick checks, and only 1% stated that they almost never perform a tick check (data not shown). When asked how concerned they were about tick bites, 48% stated they were very concerned, 47% stated not very concerned, 4% stated they were not concerned at all, and 1% did not answer the question (data not shown). The level of concern about tick bites seems directly proportional to the number of individuals who had symptoms associated with a tick bite. The individuals that were not concerned at all about tick bites never experienced any symptoms post tick bite while 27% of the not very concerned group and 44% of the very concerned group had experienced symptoms post tick bite.

Clinician Survey

Of the nine survey results, only one health care provider had not treated a patient in the past year for tick bites (Table 3). Four of the health care providers had treated eleven or more patients each for tick bites in the past year (Table 3). Five of the providers had treated for Lyme disease, six for Rocky Mountain spotted fever (RMSF), and one for ehrlichiosis in this past year (Table 3). Most providers (78%) send a blood sample to a diagnostic lab when they suspect their patient is presenting clinically with a TBD (Table 3).

Database Query

For the past five years there were a total of 6 confirmed cases of *E. chaffeensis* and one confirmed case of *E. ewingii*. In addition, there was one probable case of *E. chaffeensis*, one probable ehrlichiosis/anaplasmosis undetermined, 16 probable RMSF, and one probable tularemia case in the past five years. A grand total of 26 probable and confirmed cases of TBDs in Adair County from 2013-2017 was reported (Table 4). Probable and confirmed cases are each characterized by clinically compatible illness. A probable case may have laboratory results that are consistent with the diagnosis but such results are not necessary. Confirmed cases have a fourfold or greater increase in antibody titer, polymerase chain reaction assay, or pathogen isolation in cellular culture.

Discussion

It has been indicated that a low human population density, a high white-tailed deer density, and greater proportions of deciduous forest cover were all positively correlated with elevated incidence of ehrlichiosis in the state of Missouri.[14] Adair County, which is located in Northeast Missouri, had a population of 25,607 (45 persons/mi^2) as of the 2010 census.[15] The white-tailed deer density is 18/mi^2 and 28% of the county is forested.[16] With an abundance of lone star ticks and white-tailed deer, a 22% infection rate in adult ticks with the pathogens that cause ehrlichiosis, and a rural population that includes 822 farms, it seems likely that ehrlichiosis would be a common diagnosis.[17] However, from the past five years (2013-2017) there have only been seven confirmed cases of ehrlichiosis (DHSS). This data implies that ehrlichiosis may be asymptomatic, underreported, or being misdiagnosed.

Ehrlichiosis presents clinically most often as fever, chills, headache, malaise, myalgia, and nausea, and fewer than 30% of adult patients present with a rash.[18] With 38% of all respondents developing symptoms post tick bite, whatever the TBDs may be, they are not asymptomatic. In addition, six percent of the respondents developed influenza-like symptoms with no concurrent rash and 12% developed a rash with influenza-like symptoms, which both would be symptomatically consistent with ehrlichiosis and thus make them probable cases.

Another possible explanation for the lower-than-expected number of reported ehrlichiosis cases is that 45% of those individuals that present symptoms post tick bite are not seeking medical attention, thus accounting for large numbers of unreported infections. As the infection tends to manifest as a generalized influenza-like illness, infected individuals may be less likely to visit a doctor unless more

Table 3. Estimates, by health care professionals, of number of patients treated for tick-borne diseases in the past year in Adair County, Missouri

# of patients		# of diseases treated		# of blood samples screened for tick-borne diseases	
Response	(n=9)	Response		Response	
None	1 (11%)	Lyme Disease	5	Never	0
1-5	3 (34%)	RMSF	6	Every time I suspect a tick-borne disease	7
6-10	1 (11%)	Ehrlichiosis	1	Only when the patient has insurance to cover the costs	2
11-25	2 (22%)	Tularemia	0	Only when the patient requests it	0
26-100	2 (22%)	STARI	0	Only when I am confident it is a tick-borne disease	3
		None of these	1		

severe symptoms emerge. However, 78% of all respondents did seek medical attention if they presented with influenza-like symptoms, which they self-reported was associated with a tick bite. Data from this study implies that ehrlichiosis is not asymptomatic, but it is likely under-recognized.

Misdiagnosis is another factor that may explain the lower-than-expected probable or confirmed cases of ehrlichiosis. In Adair County, in the past year alone, 9 clinicians reported that they treated 12 patients for TBDs, but only one was treated for ehrlichiosis while RMSF was diagnosed six times. The majority of health care providers (78%) stated that when they suspect their patient is presenting with a TBD, they send a blood sample to be screened under a "tick panel". In general, these tick panels test for RMSF IgG and IgM, ehrlichiosis, Lyme disease, and Tularemia antibodies. If a sample returns to the clinic as a positive for RMSF then RMSF will be the final diagnosis. Sixty-seven percent of the doctors surveyed stated that they never obtain a second blood sample from the patient to confirm the diagnosis unless the patient is still ill and 22% stated they never obtain a second blood sample. As a result, these RMSF cases are not confirmed because they cannot demonstrate a fourfold titer increase and may well represent false positive diagnoses because of the high background seropositivity for RMSF. It has been demonstrated that SFG rickettsiae like diseases with titers as high as 256 are not uncommon in children due to previous infections from tick bites which certainly meets the case definition for probable RMSF.[19] DHSS did not report one confirmed case of RMSF in the past five years even though it is the most prevalent TBD reported by local health care professionals.

Rickettsia ricketsii, the etiological agent of RMSF, was not detected in any of the 309 *D. variabilis* (American dog) ticks sampled in Adair County over two consecutive years.[2,9] The absence of *R. rickettsii* detection in American dog ticks and lone star ticks which were screened with polymerase chain reaction is suggestive that RMSF is being misdiagnosed. It has been suggested that the cross-reactivity of antibodies of other SFG rickettsiae, such as *R. amblyommatis*, may explain these positive results from tick panels when *R. ricketsii* appears to not be prevalent in the tick population.[20] In the 436 individual adult lone star ticks tested in 2015, *R. amblyommatis* demonstrated an infection rate of 36% and in the 189 individual American dog ticks screened four percent were infected.[9] This data may support the notion that *R. amblyommatis* is associated with clinical illness or in the very least masking the results of an ehrlichiosis infection.[21]

In this study, 12 cases of TBDs were diagnosed by health care providers in Adair County during 2017. That is nearly half of what DHSS reports in the county for the past five years. It would be unreasonable to speculate as to why four clinics would be reporting higher numbers of TBDs than DHSS as these findings are subject to several limitations. For example, all data collected were self-reported, potentially subject to recall bias, and not independently validated. Further, some of the survey questions to which clinicians and the public responded are subject to variable interpretation, and there is no way to confirm that all the patients seen in the clinics or all individuals who completed a survey reside in Adair County. The reports from DHSS, however, have been confirmed to be Adair County residents and this may explain, to some degree, why DHSS reports lower numbers than the clinics who may be attending to patients from surrounding counties.

It is important to note that five of those 12 TBDs were diagnosed as Lyme disease. To date, there is still great uncertainty regarding the occurrence of Lyme disease in Missouri. *Borrelia burgdorferi sensu lato* (s.l.) was first reported to be isolated and cultivated from Missouri in 1995 from

Table 4. Tick-borne reported diseases and conditions, Adair County, Missouri 2013-2017, Missouri Department of Health and Senior Services. Numbers reflect reported cases that meet the Centers for Disease Control and Prevention's definition of a probable or confirmed case.

Condition	2013		2014		2015		2016		2017	
	Confirmed	Probable	Confirmed	Probable	Confirmed	Probable	Confirmed	Probable	Confirmed	Probable
Ehrlichia chaffeensis	2	0	1	0	0	0	2	1	1	0
Ehrlichia ewingii	0	0	0	0	1	0	0	0	0	0
Ehrlichiosis/ Anaplasmosis undetermined	0	0	0	1	0	0	0	0	0	0
Rocky Mountain Spotted Fever	0	2	0	4	0	3	0	2	0	5
Tularemia	0	0	0	0	0	1	0	0	0	0

ticks that had been feeding on cottontail rabbits (*Sylvilagus floridanus*).[22] However *Borrelia burgdorferi sensu stricto* (s.s.), the cause of Lyme disease, has not been reported in Missouri ticks. Nor has *B. burgdorferi* (s.l.) yet been isolated from any patient in Missouri showing symptoms consistent with Lyme disease.[23] Data obtained here suggests that Lyme disease is continuing to be over-diagnosed in Missouri.

From 2008-2012 Missouri had the second highest reported incidence rate of *E. chaffeensis,* and was tied for the highest incidence rate of *E. ewingii*.[24] Given the preponderance of lone star ticks, its aggressive predilection for biting humans, clinicians in this region should maintain ehrlichiosis high in the differential diagnosis for tick-borne disease. In nearly 30,000 ticks examined for human pathogens in Adair County, *R. rickettsii* was never once detected, while *E. chaffeensis* and *E. ehrlichia* are very prevalent in the tick populations. In addition, the only confirmed cases for the past five years in Adair County have been for ehrlichiosis. This data implies that infections with *E. chaffeensis* and *E. ewingii* are under-recognized, at least in Adair County, if not throughout a larger portion of Missouri.

This information serves to contribute to a more accurate picture of the overall burden of TBDs in Adair County and highlights the need for better understanding in our community about what diseases are present, in particular ehrlichiosis, how those diseases present clinically, and when people should seek treatment if at all possible.

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References

1. Petry WK, Fore SA, Fielden LJ, Kim HJ. A quantitative comparison of two sample methods for collecting Amblyomma americanum and Dermacentor variabilis (Acari: Ixodidae) in Missouri. Exp Appl Acarol. Exp Appl Acarol. 2010;52:427-38.
2. Hudman DA, Sargentini NJ. Detection of Borrelia, Ehrlichia, and Rickettsia spp. in ticks in northeast Missouri. Ticks Tick Borne Dis. 2016;7:915-21.
3. CDC. Tickborne diseases of the United States. Available at: https://www.cdc.gov/ticks/tickbornediseases/index.html. Accessed January 30, 2018.
4. Savage HM, Godsey MS Jr, Lambert A, Panella NA, Burkhalter KL, Harmon JR, et al. First detection of Heartland Virus (Bunyaviridae: Phlebovirus) from field collected arthropods. Am J Trop Med Hyg. 2013;89:445–52.
5. Van Nunen S. Tick-induced allergies: mammalian meat allergy, tick anaphylaxis and their significance. Asia Pacific Allergy. 2015;5:3-16.
6. Apperson CS, Engber B, Nicholson WL, Mead DG, Engel J, Yabsley MJ, et al. Tick-borne diseases in North Carolina: is Rickettsia amblyommii a possible cause of rickettsiosis reported as Rocky Mountain spotted fever? Vector Borne Zoonotic Dis. 2008;8:597-606.
7. Billeter SA, Blanton HL, Little SE, Levy MG, Breitschwerdt EB. Detection of Rickettsia amblyommii in association with a tick bite rash. Vector Borne Zoonotic Dis. 2007;7:607-10.
8. Smith MP, Ponnusamy L, Jiang J, Ayyash LA, Richards AL, Apperson CS. Bacterial pathogens in ixodid ticks from a Piedmont County in North Carolina: prevalence of rickettsial organisms. Vector Borne Zoonotic Dis. 2010;10:939-52.
9. Hudman DA, Sargentini NJ. Prevalence of tick-borne pathogens in northeast Missouri. Missouri Medicine. 2018;115:155-61.
10. James AM, Liveris D, Wormser GP, Schwartz I, Montecalvo MA, Johnson BJ. *Borrelia lonestari* infection after a bite by an Amblyomma americanum tick. J. Infect. Dis. 2001;183:1810-14.
11. Parola P, Labruna MB, Raoult D. Tick-borne rickettsioses in America: unanswered questions and emerging diseases. Curr. Infect. Dis. Rep. 2009;11:40-50.
12. Schiffman EK, McLaughlin C, Ray JAE, Kemperman MM, Hinckley AF, Friedlander HG, et al. Underreporting of Lyme and other tick-borne diseases in residents of a high-incidence county, Minnesota, 2009. Zoonos Pub Hlth 2018; 65:230-37.
13. Connally NP, Hinckley AF, Feldman KA, Kemperman M, Neitzel D, Wee S-B, et al. Testing practices and volume of non-lyme tickborne diseases in the United States. Ticks Tick Borne Dis. 2016;7:193-98.
14. Bayles BR, Allen BF. Social-ecological factors determine spatial variation in human incidence of tick-borne ehrlichiosis. Epidemiol Infect. 2014;42:1911-24.
15. United States Census 2010. Interactive Population Search MO - Adair County. Available at: https://www.census.gov/2010census/popmap/ipmtext.php?fl=29:29001. Accessed February 19, 2018.

EDITOR'S NOTE

Buying Some Piece of Mind if You Get 'Ticked-off"

by John C. Hagan, III, MD, Editor

Few things creep me out anymore. But finding a tick embedded in my dermis sets off all kinds of alarm bells. My wife is a master-gardener and our home sits on over a quarter acre lot that she has lovingly and skillfully turned into a show garden. I have no botanical talents but do qualify as unskilled manual laborer. I am enthusiastic and have passable skills in weeding, mowing, spraying, clipping and raking. I'm always careful to check for ticks after a session of yard work.

Lone Star Tick embedded four days.

After an especially long and dirty session of winter clean-up in May of this year, I noted itching and irritation under my left lateral malleolus an area I could not visualize. Over a couple of days, this got much worse and I asked another person, who prefers to remain nameless, to look at this area and was told there was a small scab and some redness. After 4 days I could not wear my left shoe comfortably. I used my iPhone to photograph the area. I perceived the 'scab" to be an embedded tick feasting on my O positive blood (see photo). I did some deft surgery using a mirror and jeweler's forceps and removed the tick in one piece.

Since the tick had been embedded for over 100 hours, I was quite concerned about contracting a tick-borne illness. The examined tick had a partial blood meal but was difficult to identify. So, I emailed Deborah A. Hudman, MS who authored the adjacent article. This is her second manuscript on diseases vectored by Missouri ticks. I also emailed Eden M. Esguerra, MD our Missouri Medicine Infectious Disease specialist. After this conference of experts, I began doxycycline twice/daily and sent the entire tick to TickReport (www.tickreport.com) for identification and DNA/RNA pathogen testing.

TickReport is a commercial service of the University of Massachusetts' Laboratory of Medical Zoology. For a fee ranging from a low of $40 to a high of $200 within 72 hours they will: identify tick species and life stage, feeding status, send high resolution photomicrographs, and a report on up to 23 DNA and RNA tests for pathogens. Not being one to scrimp on peace of mind, I parted with $200, not covered by insurance, to hopefully have 23 'happy news' tests in 3 days. As promised within that time frame, I was emailed a very detailed report finding all 23 DNA/RNA tests were negative for pathogens, and a very detailed microphotograph of my lately deceased nemesis. It was a 'partially fed, nymph stage Lone Star Tick. With this report in hand, I stopped the antibiotics after 4 days and felt much relieved. Two weeks later, after another extended garden session in 90-degree weather, I noted a rash on my stomach and legs. Being a physician, and always quick to accept the worst possible outcome, without the TickReport testing I'm sure I would have concluded I had a tick-borne disease. With it I was able to surmise it was a heat rash with some contact dermatitis to the brand-new tick-repellant clothing I was wearing for the first (and last) time.

For physicians' practices or if you personally become a tick entrée this TickReport service is something to be aware of and consider. **MM**

16. MDC, 2015-16 Missouri Deer Season Summary& Population Status Report. Available at: https://huntfish.mdc.mo.gov/sites/default/files/downloads/Deer-Pop-status.pdf. Accessed February 19, 2018.
17. USDA, 2012. 2012 Census of Agriculture. Available at: http://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/Missouri/cp29001.pdf. Accessed February 19, 2018.
18. Centers for Disease Control and Prevention, 2016. Ehrlichiosis. Available at: https://www.cdc.gov/ehrlichiosis/symptoms/index.html. Accessed February 26, 2018.
19. Marshall GS, Stout GG, Jacobs RF, Schutze GE, Paxton H, Buckingham SC et al. Antibodies Reactive to Rickettsia rickettsii Among Children Living in the Southeast and South Central Regions of the United States. Arch. Pediatr. Adolesc. Med. 2003;157:443-48.
20. Delisle J, Mendell NL, Stull-Lane A, Bloch KC, Bouyer DH, Moncayo AC. human Infections by Multiple Spotted Fever Group Rickettsiae in Tennessee. Am. J. Trop. Med. Hyg. 2016;94:1212-17.
21. Gaines DN, Operario DJ, Stroup S, Stromdahl E, Wright C, Gaff H, et al. Ehrlichia and Spotted Fever Group Rickettsiae Surveillance in Amblyomma americanum in Virginia Through Use of a Novel Six-Plex Real-Time PCR Assay. Vector Borne and Zoonotic Dis. 2014;14:307-16.
22. Oliver Jr JH, Kollars Jr TM, Chandler Jr FW, James AM, Masters EJ, Lane RS, et al. First isolation and cultivation of Borrelia burgdorferi sensu lato from Missouri. J. Clin. Microbiol. 1998;36:1-5.
23. DHSS, 2009. Lyme Disease Position Paper. http://health.mo.gov/living/healthcondiseases/communicable/tickscarrydisease/ldpositionpaper.php. Accessed March 06, 2018.
24. Heitman KN, Dahlgren FS, Drexler NA, Massung RF, Behravesh CB. Increasing incidence of ehrlichiosis in the United States: A summary of national surveillance of Ehrlichia chaffeensis and Ehrlichia ewingii infections in the United States, 2008-2012. Am J Trop Med Hyg. 2016;94:52-60.

Disclosure

None reported. **MM**