

SPRING 2012 NEWSLETTER

Tick-borne Infections Council of North Carolina, Inc.



www.tic-nc.org

Highlights:

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Quote of the season

“My granddaughter’s school in Pittsboro, NC, called saying that she had a tick, but the school nurse wasn’t allowed to remove it. She would either have to sit with the tick attached all day, or a family member would have to go to the school to remove the tick. Luckily my daughter was available that day and went to the school with a pair of tweezers and removed the tick. I’m hoping the local school system teaches school nurses the importance of quick and proper tick removal.”

State Vector-Borne Disease Task Force Meeting Schedule

Next meeting: August 10, 2012, 10a.m – 12 noon. Cardinal Conference Room at the Division of Public Health Complex on Six Forks Road. Contact TIC-NC or Dr. Williams, State Department of Public Health, carl.williams@dhhs.nc.gov, for confirmation of date and place if interested in attending.

North Carolina Tick-borne Disease Surveillance Statistics

January 1, 2011 – December 31, 2011 (2010 data included for comparison)

Disease	Total cases by year of report 2011 probable/confirmed	Total cases by year of report 2010
Lyme disease	86/18	82
RMSF	330/15	286
Ehrlichia	83/27	99
Anaplasma	20/1	28

The following links are to the letters issued every year by the State Department of Public Health to medical providers on Lyme disease and the Rickettsial diseases such as RMSF:

http://epi.publichealth.nc.gov/cd/ticks/TBRD_memo_2012.pdf

http://epi.publichealth.nc.gov/cd/ticks/Lyme_memo_2012.pdf

The Lyme disease letter is much better than last year, but the distinction between clinical diagnostic criteria and surveillance criteria should be clearer.

Lyme disease cases acquired within a North Carolina County:

(2008 was the first year data on the county of acquisition were collected)

2008

Cleveland 1

2009

Wake 2

Wilkes 1

Wilson 1

Carteret 1

2010

Haywood 1

Wake 2

2011

Wake 1

Gates 1

Perquimans 1

Guilford 1

Data for cases acquired within the state (where the person left their county but not the state) is not available. TIC-NC has asked for this but the state does not have this available.

From a medical provider in NC who is recovering from a tick-borne infection and practices in a group setting:

“It is a different environment where I work. It's like an insulated bubble where the fixed idea rules instead of the ever-changing science. One provider includes how a person lives, their habits, their pets, when presenting a case. This person gets kidded. I think showing the others through these presentations-- that we live differently now, how we exchange our bacteria globally—shows how we must think in that frame of mind. Although I am at a medical center where one would think freedom of thought would be encouraged it is the opposite. They hold tight to their culture. I know the key to moving ahead is for the public to be smarter than they are to get the providers moving out of their comfort zone. I am a person living among them with long-term effects from a tick-borne disease. The positive is that I think everyone, including the medical community, is understanding that tick/mosquito/animal exposures are important pieces of information in diagnosing and treating the patient. The urgency and significance of this information is a learning curve that needs to happen. If not, the public will be there to demand it.”

Paper About Chronic Lyme Disease

Persistence of *Borrelia burgdorferi* in Rhesus Macaques following Antibiotic Treatment of Disseminated Infection

Monica E. Embers, Stephen W. Barthold, Juan T. Borda, Lisa Bowers, Lara Doyle, Emir Hodzic, Mary B. Jacobs, Nicole R. Hasenkampf, Dale S. Martin, Sukanya Narasimhan, Kathrine M. Phillippi-Falkenstein, Jeanette E. Purcell, Marion S. Ratterree, Mario T. Philipp

The persistence of symptoms in Lyme disease patients following antibiotic therapy, and their causes, continue to be a matter of intense controversy. The studies presented here explore antibiotic efficacy using nonhuman primates. Rhesus macaques were infected with *B. burgdorferi* and a portion received aggressive antibiotic therapy 4–6 months later. Multiple methods were utilized for detection of residual organisms, including the feeding of lab-reared ticks on monkeys (xenodiagnosis), culture, immunofluorescence and PCR. Antibody responses to the *B. burgdorferi*-specific C6 diagnostic peptide were measured longitudinally and declined in all treated animals. *B. burgdorferi* antigen, DNA and RNA were detected in the tissues of treated animals. Finally, small numbers of intact spirochetes were recovered by xenodiagnosis from treated monkeys. These results demonstrate that *B. burgdorferi* can withstand antibiotic treatment, administered post-dissemination, in a primate host. Though *B. burgdorferi* is not known to possess resistance mechanisms and is susceptible to the standard antibiotics (doxycycline, ceftriaxone) *in vitro*, it appears to become tolerant post-dissemination in the primate host. This finding raises important questions about the pathogenicity of antibiotic-tolerant persisters and whether or not they can contribute to symptoms post-treatment.

<http://www.plosone.org/article/info:doi/10.1371/journal.pone.0029914>

Researchers At The University Of North Florida Are Identifying And Testing Ticks

The University of North Florida (UNF) Public Health Research Laboratory accepts tick samples for identification and laboratory testing for tick borne disease agents using molecular (polymerase chain reaction/PCR) testing. Tick samples are commonly tested for *Borrelia burgdorferi* sensu lato (Lyme disease spirochetes), *Babesia microti*, and possibly for some other organisms (e.g., *Rickettsia*, *Ehrlichia*, *Anaplasma*, *Bartonella* species). The purpose of this activity is to document species of ticks that are biting humans and their pets in the southern United States, and to determine the disease agents they may transmit to them. This service is available primarily to residents of the southern United States.

For more information, view the information and submission forms on TIC-NC's website:
<http://www.tic-nc.org/>

Getting Ticks Tested For Infectious Organisms

University of Massachusetts offers tick testing. Testing is not necessarily helpful, however, since a negative result in the human doesn't guarantee that a bite didn't transmit the disease, and a positive result in the tick doesn't always mean the disease was transmitted to the bitten person.
<http://extension.umass.edu/agriculture/index.php/services/tick-borne-disease-diagnostics/tick-borne-diseases>

SAS Institute Event, Research Triangle

SAS held an event May 16, 2012 and used material from TIC-NC's website that our consultant, Marcee Toliver, adapted into a handout. Handouts were at the Health Care Center's booth at SAS's National Employee Health & Fitness Day Fair.

More On How Lyme Disease Bacteria Work

Population dynamics of *Borrelia burgdorferi* in Lyme disease.

Sebastian C. Binder, Arndt Telschow and Michael Meyer-Hermann

Many chronic inflammatory diseases are known to be caused by persistent bacterial or viral infections. A well-studied example is the tick-borne infection by the gram-negative spirochaetes of the genus *Borrelia* in humans and other mammals, causing severe symptoms of chronic inflammation and subsequent tissue damage (Lyme Disease), particularly in large joints and the central nervous system, but also in the heart and other tissues of untreated patients. Although killed efficiently by human phagocytic cells *in vitro*, *Borrelia* exhibits a remarkably high infectivity in mice and men. In experimentally infected mice, the first immune response almost clears the infection. However, approximately 1 week post infection, the bacterial population recovers and reaches an even larger size before entering the chronic phase. We developed a mathematical model describing the bacterial growth and the immune response against *Borrelia burgdorferi* in the C3H mouse strain that has been established as an experimental model for

Lyme disease. The peculiar dynamics of the infection exclude two possible mechanistic explanations for the regrowth of the almost cleared bacteria. Neither the hypothesis of bacterial dissemination to different tissues nor a limitation of phagocytic capacity were compatible with experiment. The mathematical model predicts that *Borrelia* recovers from the strong initial immune response by the regrowth of an immune-resistant sub-population of the bacteria. The chronic phase appears as an equilibration of bacterial growth and adaptive immunity. This result has major implications for the development of the chronic phase of *Borrelia* infections as well as on potential protective clinical interventions.

http://www.frontiersin.org/Microbial_Immunology/10.3389/fmicb.2012.00104/full

Project to Remove Outdated Guidelines from Government Website

Congress members are working to get outdated guidelines for treating Lyme disease removed from a government web site used by doctors as resource for medical protocols.

Washington, D.C. (January 20, 2012) – Three members of Congress who have worked to help people with Lyme disease want outdated treatment guidelines removed from a government web site that doctors use as a resource for medical protocols.

In a letter released today to the company that manages the National Guideline Clearinghouse (NGC), Rep. Frank Wolf (R-VA), Rep. Chris Smith (R-NJ) and Rep. Chris Gibson (R-NY) and Rep. Chris Gibson (R-NY) said the guidelines have not been thoroughly reviewed in over five years, a condition for inclusion in the database. They urged the company to “remove the guidelines until they have been fully reviewed and revised”.

“The Lyme disease guidelines of the Infectious Diseases Society of America (IDSA) have been highly controversial and have been responsible for insurance company denials of Lyme disease treatments,” the congressmen wrote. “We have recently been informed that these guidelines have been re-instated on the NGC Web site, notwithstanding the fact that they are more than 5 years old and, hence, are no longer current. Our constituents are concerned that these guidelines have not been subject to a complete review for currency and that the methodology of any review has not been disclosed as required by the NGC’s guidelines.”

For entire story: <https://mail.google.com/mail/?tab=mm#inbox/1350293e2a5ef16b>

The Diane Rehm Show on Lyme Disease

Transcript for February 29, 2012 show on NPR.

“I’m Diane Rehm. Questions as to whether chronic Lyme disease exists, how to test for it, how to treat it are dividing doctors and confounding patients. Joining me to talk about why diagnosing and treating this disease remains so challenging and so controversial, Dr. Samuel Shor. He’s an internist in private practice, associate clinical professor at George Washington University. For more of the transcript:

<http://thedianerehmshow.org/shows/2012-02-29/diagnosing-and-treating-lyme-disease/transcript>

Evidence That Ticks May Transmit Bartonella

Vector Competence of the Tick *Ixodes ricinus* for Transmission of *Bartonella birtlesii*.
PLoS Negl Trop Dis. 2011;5(5):e1186. Reis C, Cote M, Le Rhun D, Lecuelle B, Levin ML, Vayssier-Taussat M, Bonnet SI.

Source: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3104967/?tool=pubmed> Bartonella spp. are facultative intracellular vector-borne bacteria associated with several emerging diseases in humans and animals all over the world. The potential for involvement of ticks in transmission of Bartonella spp. has been heartily debated for many years. However, most of the data supporting bartonellae transmission by ticks come from molecular and serological epidemiological surveys in humans and animals providing only indirect evidences without a direct proof of tick vector competence for transmission of bartonellae. We used a murine model to assess the vector competence of *Ixodes ricinus* for *Bartonella birtlesii*.

Larval and nymphal *I. ricinus* were fed on a *B. birtlesii*-infected mouse. The nymphs successfully transmitted *B. birtlesii* to naïve mice as bacteria were recovered from both the mouse blood and liver at seven and 16 days after tick bites. The female adults successfully emitted the bacteria into uninfected blood after three or more days of tick attachment, when fed via membrane feeding system. Histochemical staining showed the presence of bacteria in salivary glands and muscle tissues of partially engorged adult ticks, which had molted from the infected nymphs. **These results confirm the vector competence of *I. ricinus* for *B. birtlesii* and represent the first in vivo demonstration of a *Bartonella* sp. transmission by ticks. Consequently, bartonellosis should be now included in the differential diagnosis for patients exposed to tick bites.**

Three Notable NIAID 2012 Research Projects On Lyme Disease

The National Institute of Allergy and Infectious Disease (NIAID) is conducting some Lyme disease related research which we think readers should know about. There are a number of projects to be found on the [Project Reporter web site](#) which may be fascinating, but we took the time to select and highlight a few projects which would be of greater interest to patients suffering with Lyme disease and/or its co-infections.

Project: AN INTRACELLULAR NICHE FOR BORRELIA BURGDORFERI

Institution: TEXAS A&M UNIVERSITY HEALTH SCIENCE CTR

PI: Skare, Jonathan

Link: http://projectreporter.nih.gov/project_info_description.cfm?aid=8300386&icde=12284856

Project: A COMMON DENOMINATOR OF PATHOGENESIS; A RARE OPPORTUNITY FOR NOVEL THERAPEUTIC DEVELOPMENT

Institution: UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

PI: Mitchell, Douglas

Link: http://projectreporter.nih.gov/project_info_description.cfm?aid=8145943&icde=12284856

Project: ASSESSMENT OF PATIENTS WITH BORRELIA INFECTION

Institution: NIAID

PI: Marques, Adriana

Link: http://projectreporter.nih.gov/project_info_description.cfm?aid=8336099&icde=12284856

New Tick Disease Found In Sweden

January 10, 2012

Researchers at the University of Gothenburg's Sahlgrenska Academy have discovered a brand new tick-borne infection. Since the discovery, eight cases have been described around the world, three of them in the Gothenburg area, Sweden. In July 2009 a 77-year-old man from western Sweden was out kayaking when he went down with acute diarrhea, fever and temporary loss of consciousness. He was taken to hospital where it was found that he was also suffering with deep vein thrombosis (DVT). After repeated bouts of illness, the patient's blood underwent special analysis to look for bacterial DNA -- and matched a bacterium in an online gene bank and the results were a sensation.

The man's blood contained DNA that derived with 100% certainty from the bacterium *Neoehrlichia mikurensis*. This bacterium was identified for the first time in Japan in 2004 in rats and ticks but had never before been seen in Sweden in ticks, rodents or humans. "This can be life-threatening. Fortunately, the infection can be treated successfully with antibiotics. "If the newly discovered bacterium is similar to those we already know, it has presumably spread from wild mammals to people via ticks, and it is unlikely that it can be passed on from person to person". The *mikurensis* in the bacterium's name comes from the Japanese island of Mikura, where it was first discovered.

How Surveillance Methods Effect Reports Of Lyme Disease Cases

Effect of Surveillance Method on Reported Characteristics of Lyme Disease, Connecticut, 1996–2007, *Emerging Infectious Diseases*, CDC

To determine the effect of changing public health surveillance methods on the reported epidemiology of Lyme disease, we analyzed Connecticut data for 1996–2007. Data were stratified by 4 surveillance methods and compared. A total of 87,174 reports were received that included 79,896 potential cases. Variations based on surveillance methods were seen. Cases reported through physician-based surveillance were significantly more likely to be classified as confirmed; such case-patients were significantly more likely to have symptoms of erythema migrans only and to have illness onset during summer months. Case-patients reported through laboratory-based surveillance were significantly more likely to have late manifestations only and to be older. Use of multiple surveillance methods provided a more complete clinical and demographic description of cases but lacked efficiency. When interpreting data, changes in surveillance method must be considered.

http://wwwnc.cdc.gov/eid/article/18/2/10-1219_article.htm

Revised Guidelines For Lyme Disease Treatment From Germany

Guidelines of the German Borreliosis Society

<http://lyme.kaiserpapers.org/pdfs/GERMAN-2010-LYME-GUIDELINES.pdf>

Lyme Disease In Cuba

Prevalence of antibodies to *Borrelia burgdorferi sensu stricto* in humans from a Cuban village.

Rodríguez I, Fernández C, Sánchez L, Martínez B, Siegrist HH, Lienhard R Tropical Medicine Institute Pedro Kourí, Havana, Cuba.

Lyme disease has not been officially reported in Cuba. However, clinical cases have been serologically reported. Seroprevalence survey of *Borrelia burgdorferi sensu stricto* antibodies in humans in the country has not been conducted.

OBJECTIVE: To estimate the prevalence of borrelial antibodies in inhabitants of a village with historically high level of tick infestation.

METHODS: Serum specimens from 247 persons randomly selected from the population of the village were examined by IgG Western blot using B31 strain for estimating the prevalence of antibodies profile.

RESULTS: A seroprevalence value interval (95% CI) of 0.6%-7.2% was estimated for the studied population. The prevalent borrelial protein bands on immunoblots were 41, 72, 90/93, 34, 47, 60, 58, 56, 65/66 and 31 kDa in a decreasing order of significance.

CONCLUSION: These results support the previous serological findings, suggesting the presence of this borreliosis in Cuba.

Fungus To Fight Blacklegged Ticks

Scientists find fungus that kills Lyme disease-carrying ticks

BRIDGEPORT, Conn. — Local scientists have found a way to control the ticks responsible for passing Lyme disease on to humans. A new natural pesticide, derived from a strain of fungus that is deadly to the black-legged tick could help keep tick populations under control. Unlike some synthetic pesticides that can be dangerous for more than just ticks, the fungus does not harm honeybees, earthworms or other beneficial insects. The product was developed by a Fairfield-based company that was bought out by the Danish industrial biotechnology company Novozymes.

The Connecticut Agricultural Experiment Station's field trials of the fungus helped obtain federal Environmental Protection Agency registration. Novozymes has built a plant in Canada to mass produce the product, Tick-Ex.

It will be commercially available in 2014, said Kirby Stafford, the station's vice director and chief entomologist. "A lot of people do have their yards sprayed with pesticides, and they are quite effective, because synthetic materials will give you an 85 to 100 percent success rate," Stafford said. "But there are a special number of people who don't want to use them. The (organic product) may be slightly less effective, but it's giving people options. It certainly would fit in to organic land care."

The pesticide is made of the F52 strain of the *Metarhizium anisopliae* fungus, which occurs naturally in soil. The station tested it on residential properties in northwestern Connecticut and found up to 74 percent fewer ticks after treatment. Entire story at:

<http://bangordailynews.com/2012/03/04/health/scientists-find-fungus-that-kills-lyme-disease-carrying-ticks/>

A Letter To A Patient With Chronic Disease

This is a letter written by an empathic doctor with hints on the best way for patients with a chronic disease to approach physicians. It is part of a larger blog authored by this “Dr. Rob”. It is well worth reading: <http://distractable.org/?p=3912>

ALS and Lyme Disease- the Story of David Martz, MD

David Martz, MD is the 2011 recipient of the Invisible Disabilities Association Research Honors Award. Dr. Martz has been chosen based upon his extensive ALS-Motor Neuron Disease and Lyme Disease research as a physician and a board member of the International Lyme And Associated Diseases Society (ILADS). Born out of his personal experience with ALS, Dr. Martz has a passion to discover possible treatments for patients living with these illnesses.

<http://www.invisibledisabilities.org/awardrecipients/2011awards/2011-research-award-david-martz-md/>

Added on July 3, 2012. We were saddened to learn that Dr. Martz lost his house in the recent fires in Colorado.

***Bartonella* spp. Bacteremia and Rheumatic Symptoms in Patients from Lyme Disease–endemic Region**

Bartonella spp. infection has been reported in association with an expanding spectrum of symptoms and lesions. Among 296 patients examined by a rheumatologist, prevalence of antibodies against *Bartonella henselae*, *B. koehlerae*, or *B. vinsonii* subsp. *berkhoffii* (185 [62%]) and *Bartonella* spp. bacteremia (122 [41.1%]) was high. Conditions diagnosed before referral included Lyme disease (46.6%), arthralgia/arthritis (20.6%), chronic fatigue (19.6%), and fibromyalgia (6.1%). *B. henselae* bacteremia was significantly associated with prior referral to a neurologist, most often for blurred vision, subcortical neurologic deficits, or numbness in the extremities, whereas *B. koehlerae* bacteremia was associated with examination by an infectious disease physician. This cross-sectional study cannot establish a causal link between *Bartonella* spp. infection and the high frequency of neurologic symptoms, myalgia, joint pain, or progressive arthropathy in this population; however, the contribution of *Bartonella* spp. infection, if any, to these symptoms should be systematically investigated.

http://wwwnc.cdc.gov/eid/ahead-of-print/article/18/5/11-1366_article.htm

International Conference on Bartonella Held in Raleigh, NC

7th International Conference on Bartonella as Animal and Human Pathogens
 April 25 - 28, 2012
 Raleigh, North Carolina, USA

<http://www.cvm.ncsu.edu/conted/icbmvp7.html>

Even Sheep And Yaks In China Are Carrying The Lyme Disease Bacteria

Development of Real-Time Polymerase Chain Reaction for Detection of *Borrelia burgdorferi sensu lato* in China. Vector Borne Zoonotic Dis 2012(Mar)

Using a more sensitive method, the research found: Tick DNAs from 369 field samples collected from Shangzhi City of Heilongjiang Province were tested, resulting in an infection rate of 42.80%, and a total of 332 genomic DNAs from the blood of 186 yaks and 146 sheep in the Gannan Tibetan Autonomous Prefecture of Gansu Province were tested, resulting in 24.19% positive rate for the yaks and 39.04% positive rate for the sheep.

Sex-based differences in Lyme Disease

See this link for a readable poster: http://www.lymemd.org/pdf/Slide2_gender.PNG

Another Difference between Boys and Girls: Sex-Based Differences in Lyme Disease

L. A. Crowder¹, V. A. Yedlin¹, M. Soloski², J. N. Aucutt²
¹Lyme Disease Research Foundation, Lutherville, MD ²Johns Hopkins University, School of Medicine, Baltimore, MD

INTRODUCTION

Lyme disease is an emerging infectious disease caused by the spirochete, *Borrelia burgdorferi*. It is transmitted to humans through the bite of an infected tick. Lyme disease is the most common vector-borne infectious disease in the United States of America.

With proper antibiotic treatment, most patients recover from acute infection, however a subset of patients develop Post-Treatment Lyme Disease Syndrome¹. Sex-based differences have been seen in other infectious diseases, but have not been thoroughly explored in early Lyme disease².

METHODS

- 77 patients with early, untreated erythema migrans and Lyme disease were enrolled in the study
 - 40 men, 37 women
- Patients were treated with 3 weeks of oral antibiotics, then followed for a period of up to 2 years, with study visits at 6 time points during that period
- At each visit, a physical exam, interval history, clinical symptoms, self-administered surveys, and laboratory evaluation was performed

Demographics:

Variable	Women (n=37)	Men (n=40)
Age**	53.89 ± 13.71 (20-77)	46.08 ± 16.66 (20-75)
Education (yrs schooling)	16.19 ± 2.77 (12-21)	16.33 ± 2.21 (12-21)
Income*	122,000 ± 93,000 (27,000-400,000)	151,000 ± 113,000 (35,000-500,000)
Illness duration (days)	10.32 ± 8.88 (1-42)	7.03 ± 5.27 (1-28)
# Symptoms (visit 1)	10.46 ± 5.88 (0-22)	9.33 ± 4.92 (1-19)
	N (%)	N (%)
Discriminated lesions	12 (32.43%)	13 (32.6%)

* n= 32 women; n= 37 men ** p= 0.0282

RESULTS

Symptom Reporting

Symptoms are self-reported by early Lyme disease patients at each study visit. Shown here are symptoms that differ significantly^a by gender at each time point.

Symptoms	Pre-treatment (Visit 1)	Post-Treatment (2W)	4 weeks Post-Treatment (4W)	3 months Post-Treatment (3M)	6 months Post-Treatment (6M)	1 year Post-Treatment (1Y)
Joint pain	A*		A*			
Muscle pain			A*			
Headache	A*	A*	A*	A*	A*	
Brain pain			A*			
Heart palpitations	A**	A**	A**			
Fatigue	A**		A*			
Unsteady	A*	A*				
Anxiety						A*
Numbness/tingling			A*			
Changes in vision			A*			

^a Bonferroni correction used for multiple comparisons
 * = p<0.05 ** = p<0.01 *** = p<0.001

Immunology – Flow Cytometry

- Patient samples are immediately processed and analyzed with polychromatic flow cytometry
- Pre-treatment, women have higher frequency of CD4⁺CCR5⁺ T-cells

CD4+CCR5+ Ratio	Women (n=37) (mean ± SD)	Men (n=40) (mean ± SD)	p-value
CD4+CCR5+	9.82	5.96	0.0288
CD4+CRTH2+	2.15	2.13	0.3708
CD4+RATIO (CD4+CCR5+/CD4+CRTH2+)	4.17	2.91	0.0499
CD8+CCR5+	26.1	24.55	0.4308
CD8+CRTH2+	2.15	2.23	0.7783
CD4+RATIO (CD8+CCR5+/CD8+CRTH2+)	11.9	9.2	0.7418

Commercial Testing – Lyme Serology

At the initial visit, all patients are tested by a commercial laboratory for Lyme disease following the CDC's 2-tier testing criteria. Those who are negative at the first visit (here, n=45, 59%), are retested at the second visit.

Similar proportions of men and women are sero-positive at time of diagnosis (pre-treatment), however significantly more men sero-converted during treatment (p=0.0440)

Average IgG Western blot bands at visit 1: 2.19 (men) vs. 1.75 (women); at visit 2: 2.65 (M) vs. 2.26 (W)

15% of men and 4% of women are IgG Western blot positive after 3 weeks of treatment

CONCLUSIONS

In a cohort of patients with clinically confirmed early Lyme disease, female patients display more clinical symptoms than their male counterparts. Women also have a lesser chance of sero-converting post-treatment. There is evidence for altered CD4 effector responses. The authors suggest the need for further research in the field of sex-based differences in the effects of early Lyme disease in otherwise healthy populations.

REFERENCES

1. Wormser, GP, Dattwyler, RJ, Shapiro, ED, et al. The clinical assessment, treatment, and prevention of Lyme disease, human granulocytic anaplasmosis, and babesiosis. Clinical practice guidelines by the Infectious Disease Society of America. Clin Infect Dis 2007; 43(10): 1088-1134.
2. Schwarzwald, A, Schneider, MF, Lydecker, A, Aucutt, JN. Sex differences in the clinical and serologic presentation of early Lyme disease: Results from a retrospective review. Gender Medicine 2010; 7(4): 320-329.

The authors would like to thank the Lyme disease Research Foundation for their support in this research.

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Insect Shield's EPA-registered technology converts clothing and gear into effective and convenient insect protection. The repellency is long-lasting and appropriate for use by the entire family with no restrictions for use.

Quick Facts:

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- Repels mosquitoes, ticks, ants, flies, chigger and midges including those that can cause Lyme disease, malaria and other dangerous insect-borne diseases

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We are all-volunteer and appreciate donations.

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