West Virginia Tickborne Disease Surveillance Summary, 2000–2010

Introduction

Tickborne diseases (TBDs) are diseases transmitted by the bite from an infected tick vector. In recent years, the incidence of several TBDs has been increasing nationally.[1–4] In West Virginia, the primary tick vectors responsible for transmission have been found for least 6 TBD conditions (Table 1). The diagnosis of TBDs can be challenging as some of these infections can initially produce similar, non-specific clinical symptoms (as in rickettsial diseases) while other TBDs produce highly variable symptoms (as in Lyme disease).[5,6] Early recognition and treatment of TBDs by healthcare providers are important to prevent complications from these disease and decrease morbidity and mortality. Certain TBDs are reportable to public health authorities in West Virginia from healthcare providers and laboratories. The purpose of this summary is to describe the epidemiology of TBDs reported in West Virginia from 2000–2010 and to provide recommendations on the prevention of these diseases.

TABLE 1. Tickborne diseases by causative organism and presence of tick vector(s) in West Virginia. [7–17]

Tickborne Disease[a]	Organism(s)	Tick Vector(s) Present in WV
Tularemia	*Franciscella tularensis*	Dog tick (*Dermacentor variabilis*) Lone star tick (*Amblyomma americanum*)
Anaplasmosis	*Anaplasma phagocytophilum*	Black-legged tick (*Ixodes scapularis*)[b]
Ehrlichiosis	*Ehrlichia chaffeensis,* *E. ewingii*	Lone star tick (*Amblyomma americanum*)
Lyme disease	*Borrelia burgdorferi*	Black-legged tick (*Ixodes scapularis*)
Powassan encephalitis	Powassan virus	Groundhog tick (*Ixodes cookei*)[c] Black-legged tick (*Ixodes scapularis*)
Rocky Mountain spotted fever and other spotted fever rickettsiosis	*Rickettsia rickettsii* (and other spotted fever group *Rickettsia*)	Dog tick (*Dermacentor variabilis*) Brown dog tick (*Rhipicephalus sanguineus*)

[a]Other tickborne diseases, including but not limited to Colorado tick fever, tickborne encephalitis, and Crimean-Congo hemorrhagic fever, may result from travel to regions where these illnesses are endemic.

[b]*I. scapularis* is also widely referred to as the deer tick.

[c]*I. cookei* does not have an official common name. Names that have been used include the groundhog tick, woodchuck tick, carnivore tick, and the American castor bean tick.

Methods

Surveillance and Case Ascertainment Methods

During the study period, passive surveillance was conducted for TBDs in West Virginia. West Virginia State Code 16-3-1 and 64CSR7 establishes infectious disease reporting requirements for healthcare providers and laboratories. Local health departments conducted the initial case investigation after receiving a case report or positive laboratory result for a reportable TBD. Cases were reported from local health departments to the state health department via paper (prior to 2007) or electronically using the West Virginia Electronic Disease Surveillance System (WVEDSS, 2007 to current). Cases reported by local health departments were reviewed by the state health department before assigning a final case classification status. All case classifications were determined using the "Case Definitions for Infectious Conditions under Public Health Surveillance," provided at: http://www.cdc.gov/ncphi/od/ai/casedef/case_definitions.htm. Once final case status was determined, cases were reported by the state health department to the Centers for Disease Control and Prevention (CDC) via the National Electronic Telecommunications System for Surveillance (NETSS).

Data Extraction and Analysis

Data was exported from NETSS or WVEDSS for each TBD condition name (see Table 1 for conditions) reported from 2000 through 2010. Analysis was restricted to cases with a probable or confirmed case status. For report years 2008 and 2010, data was obtained solely through WVEDSS as NETSS data was incomplete for these years at the time of analysis. County- and state-level census estimates were obtained through the U.S. Census Bureau for the years 1999–2009 at http://www.census.gov/popest/counties/ (2010 population estimates were not available at the time this summary was prepared). All data analysis was completed using SAS v.9.1.3 and ESRI ArcGIS v.9.3. Charts were created using Microsoft Excel 2007.

Results

Between 2000–2010, 831 confirmed and probable TBD cases were reported. Conditions documented included tularemia, ehrlichiosis, Rocky Mountain spotted fever, and Lyme disease. Table 2 summarizes the data reported from 2000–2010. No cases of Powassan or anaplasmosis were reported during this period. Overall, the highest annual mean, median and cumulative incidence was noted for Lyme disease during the study period, followed by Rocky Mountain spotted fever. Additionally, Lyme disease experienced the most variability in the number of reports by year as measured by the annual standard deviation compared with other documented conditions (Table 2).

Tularemia

Two confirmed cases of tularemia were reported from 2000–2010. Illness onsets occurred in 2002 and 2006 with cases residing in Jefferson and Putnam Counties, respectively. The month of onset for both cases was September and both cases were adult males. Two hospitalizations occurred. Neither case record indicated importation of disease or patient death.

TABLE 2. Summary reporting statistics of four tickborne diseases reported in West Virginia from 2000–2010.

Disease Name	Total Cases Reported	Annual Range	Annual Mean	Annual Median	Standard Deviation	Cumulative Incidence per 100,000
Tularemia	2	0–1	0.2	0	0.4	0.01
Ehrlichiosis	8	0–3	0.7	0	1.1	0.04
Rocky Mountain spotted fever	49	0–10	4.5	4	3.2	0.25
Lyme disease	772	17–201	70.2	39	58.1	3.88

Ehrlichiosis

Eight cases of ehrlichiosis were reported; 3 (37.5%) were confirmed and 5 (62.5%) were probable. Cases occurred in 2005, 2007, 2009 and 2010 (Figure 1). Although one case was reported as "Ehrlichiosis/Anaplasmosis, undetermined", all infections had positive laboratory results for *E. chaffeensis.* The case described above also had a laboratory result indicating possible co-infection with *A. phagocytophilum*, however the titer value for *A. phagocytophilum* (1:256) was lower than the titer result for *E. chaffeensi s* (1:2048). Illness onsets ranged from February to August (Figure 2). Based on county of residence, cases occurred in 6 counties throughout West Virginia (Figure 3). The highest cumulative incidence rates were noted among patients $\geq$60 years of age; males had a higher incidence rate compared with females in all age groups (Figure 4). Seven (88%) of the 8 cases were hospitalized; no deaths were reported. One case had documentation indicating out-of-state exposure (Virginia).

Rocky Mountain spotted fever

Forty-nine cases of Rocky Mountain spotted fever (RMSF) were reported; 11 (22.4%) were confirmed and 38 (77.6%) were probable. Cases occurred in all years, except 2010, with the highest number of cases occurring in 2005 (Figure 5). For the majority of cases, illness onset occurred between April and September, with incidence peaking in May (Figure 6). Twenty-one counties reported cases (Figure 7), however 5 counties (Berkeley, Jefferson, Morgan, Mercer and Wood) reported 44.9% of all RMSF cases. The highest cumulative incidence rate was observed among males aged 20–39 years (Figure 8). Twenty-four (49.0%) cases were hospitalized. Hospitalization rates were highest among 0–19 year olds and decreased with increasing age (Figure 9). One death was reported in a young child. No information indicating out of county or out of state exposure was noted among the case records.

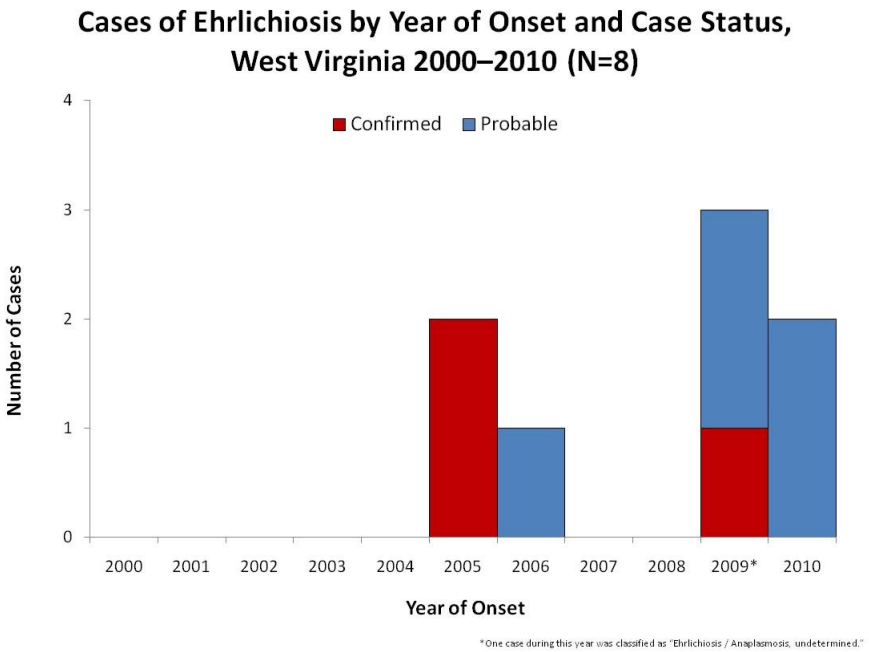


Figure 1. Cases of ehrlichiosis reported from 2000–2010 in West Virginia by year of onset and case status.

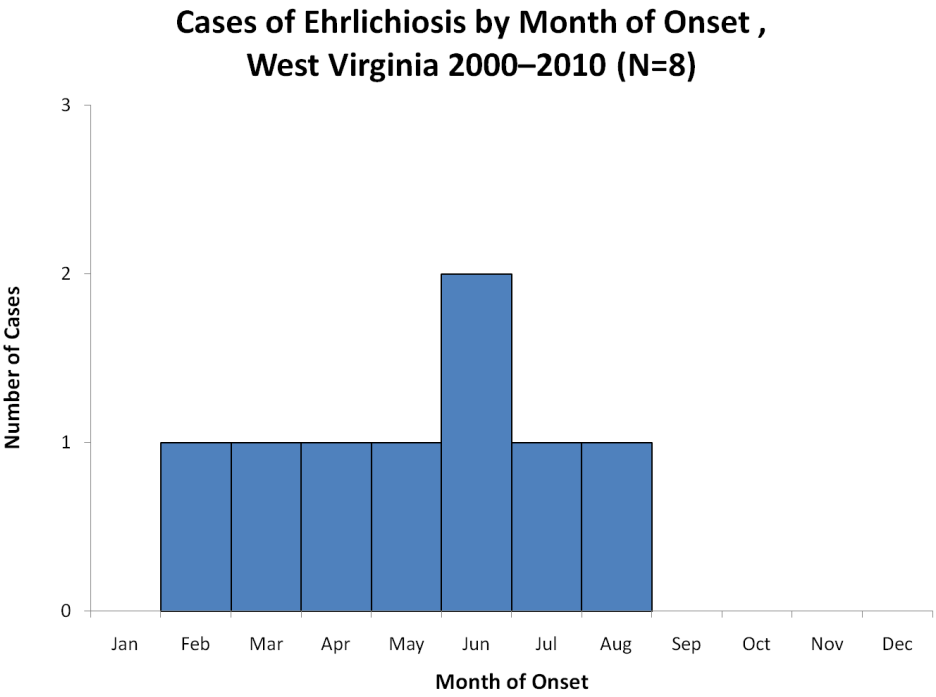


Figure 2. Month of onset for ehrlichiosis cases reported from 2000–2010 in West Virginia.

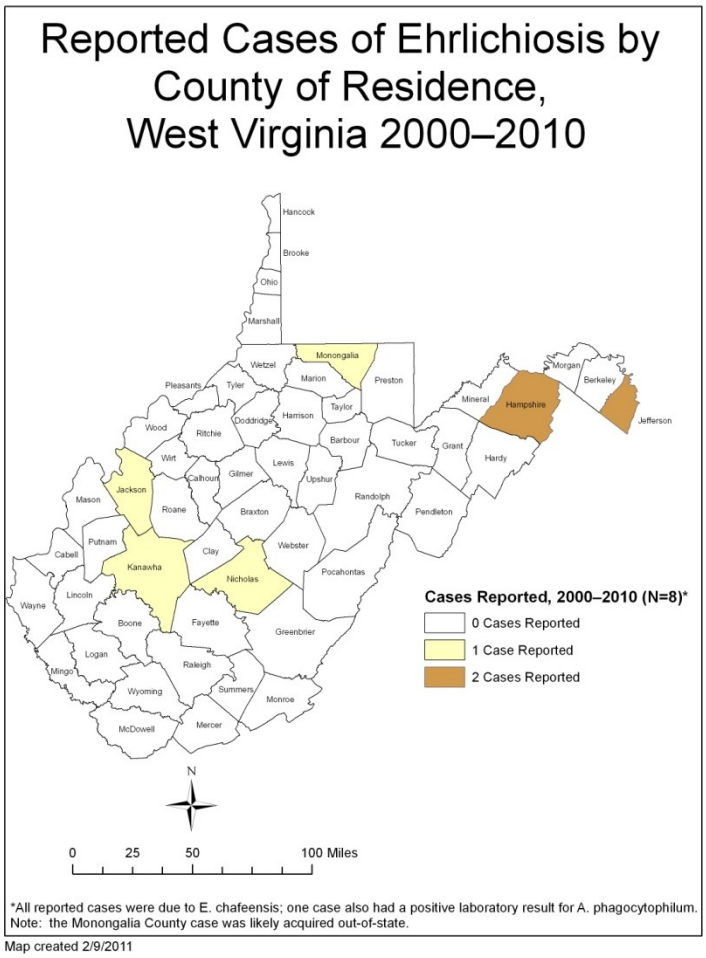


Figure 3. County of residence for ehrlichiosis cases reported from 2000–2010 in West Virginia.

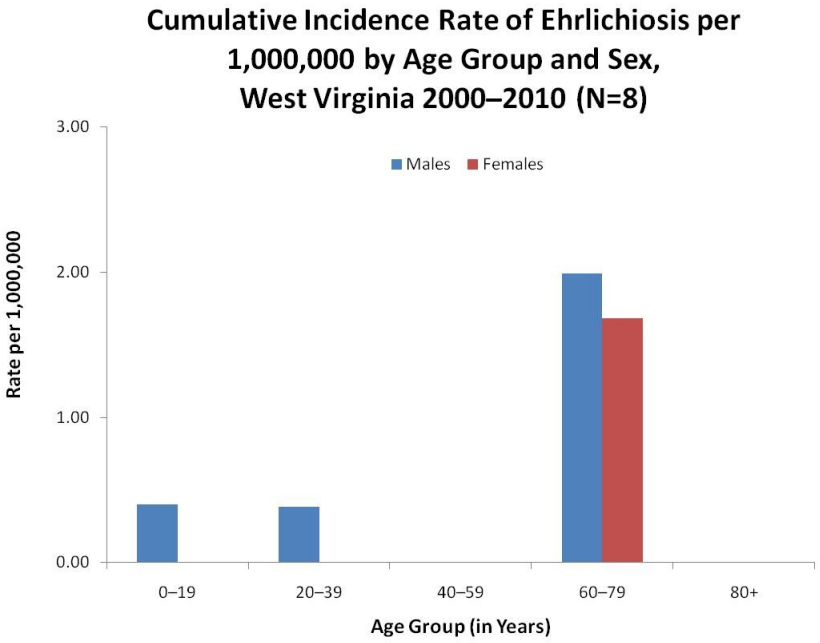


Figure 4. Cumulative incidence rate of ehrlichiosis reported per 1,000,000 by age group and sex from 2000–2010 in West Virginia.

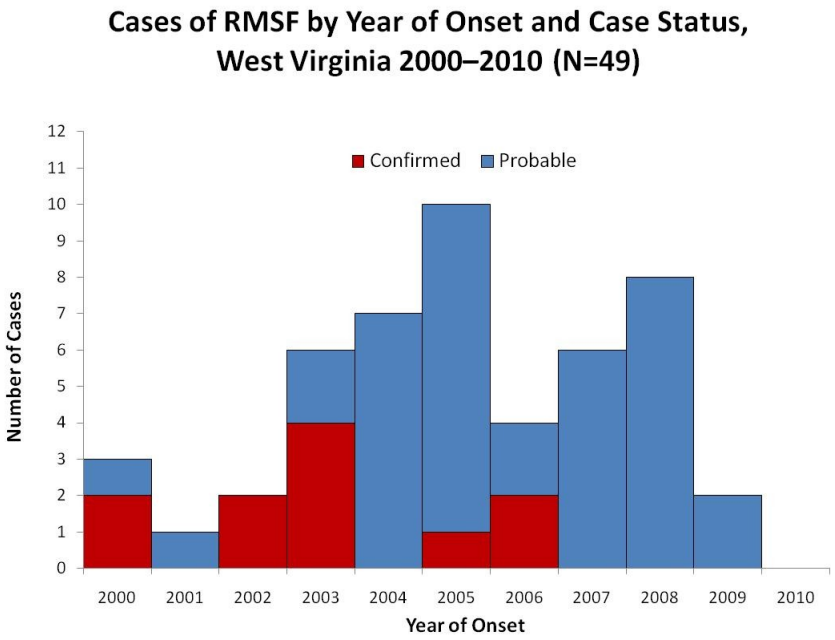


Figure 5. Cases of Rocky Mountain spotted fever reported from 2000–2010 in West Virginia by year of onset and case status.

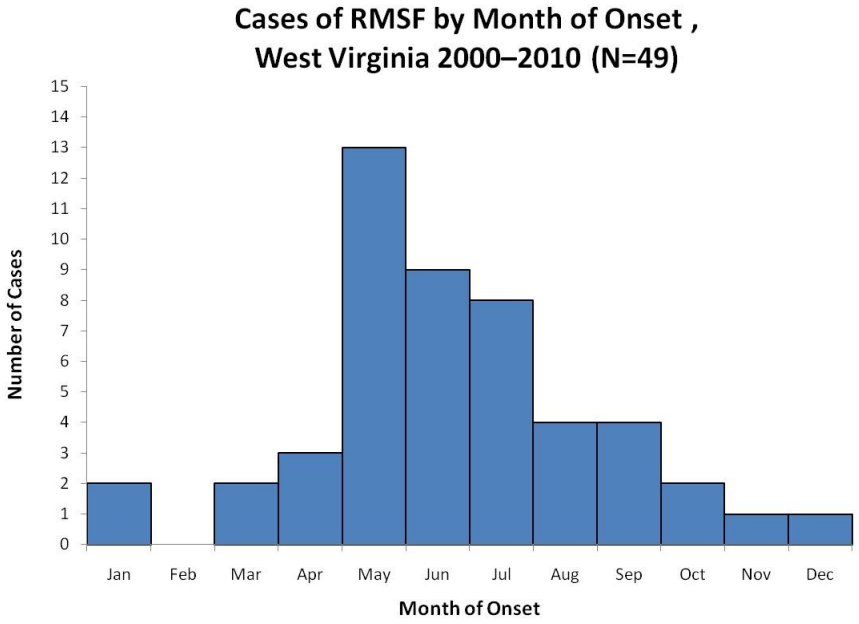


Figure 6. Month of onset for Rocky Mountain spotted fever cases reported from 2000–2010 in West Virginia.

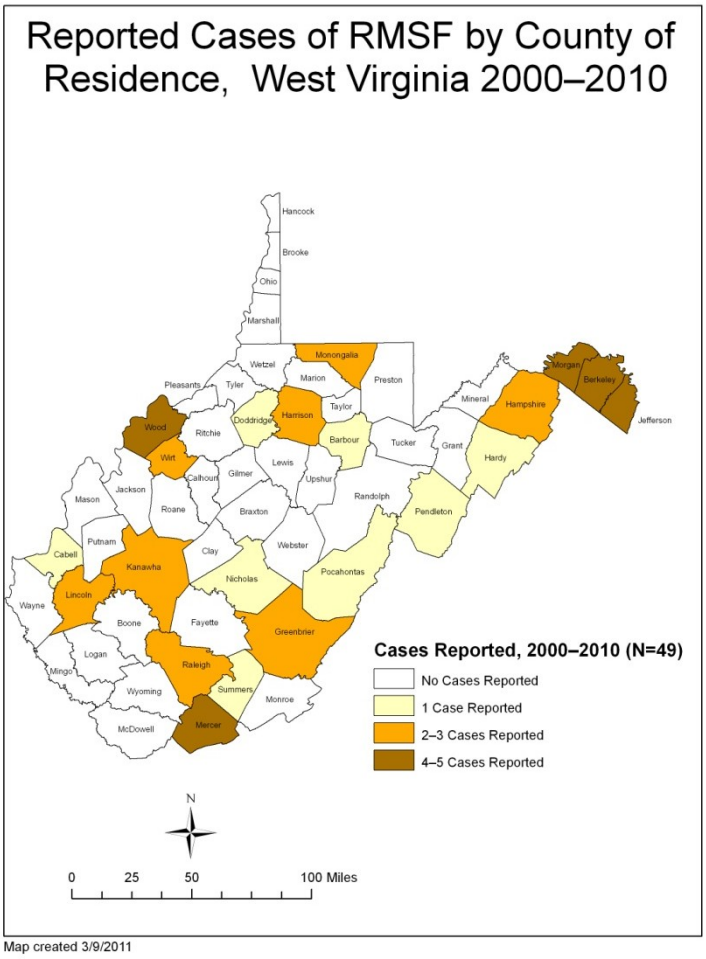


Figure 7. County of residence for Rocky Mountain spotted fever cases reported from 2000–2010 in West Virginia.

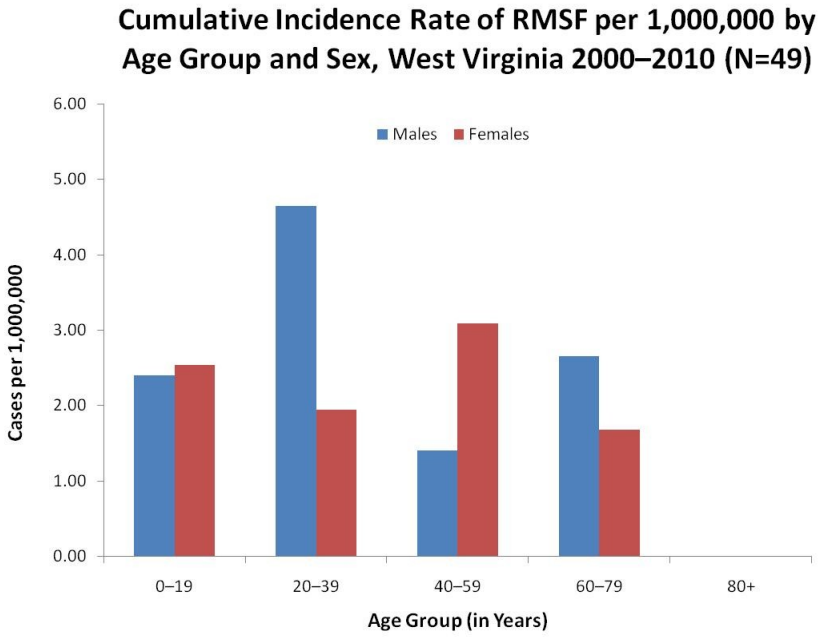


Figure 8. Cumulative incidence rate of Rocky Mountain spotted fever reported per 1,000,000 by age group and sex from 2000–2010 in West

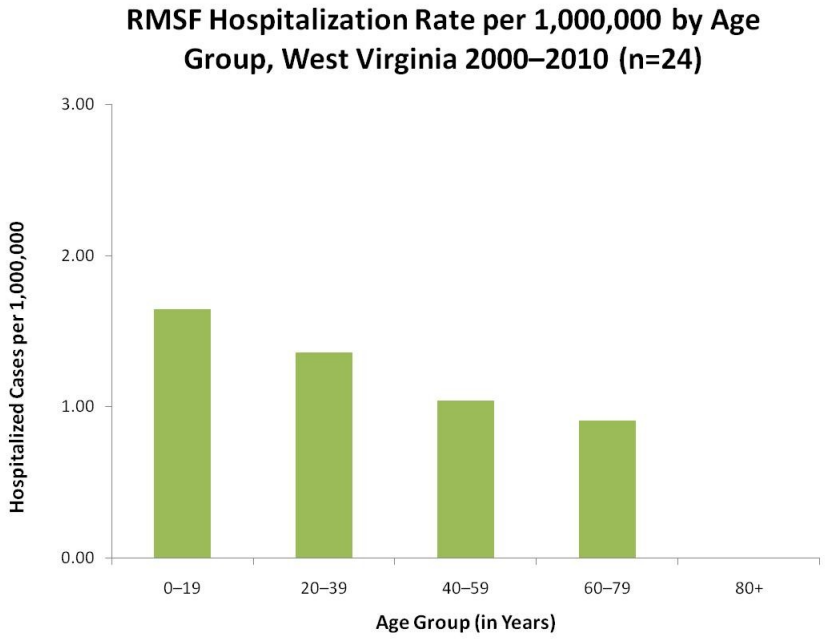


Figure 9. Hospitalization rate per 1,000,000 for cases of Rocky Mountain spotted fever reported by age group from 2000–2010 in West Virginia.

Lyme disease

A total of 772 cases of Lyme disease were reported; 681 (88.2%) were confirmed and 91 (11.8%) were probable. Supplemental data regarding clinical presentation, location of likely exposure, and antibiotic treatment were available for 766 cases and will be described in this section of the report. Based on the 696 (90.2%) cases for which date of illness onset was available and occurred in 2000 or after, disease activity increased throughout the study period peaking in 2009 (Figure 10). Although cases occurred throughout the year, the majority of illness onsets occurred between the spring and fall months with case onsets peaking in June (Figure 11).

Based on county of residence, cases were reported from 43 (78%) of 55 counties. The majority of cases, however, were reported from Morgan, Berkeley, and Jefferson counties in the Eastern panhandle. These 3 counties accounted for 646 (83.7%) of 772 cases (Figure 12). Additionally, information on the state and/or county of tick exposure was available for 537 cases with documented erythema migrans. Of these, 490 (91.2%) were reported as in-state exposures and 47 (8.8%) were reported as out-of-state exposures. For in-state exposures with county-level information, three counties (Morgan, Berkeley, and Jefferson) accounted for 443 (94.7%) of 468 cases (Figure 13). For out-of-state exposures, three states (Maryland, Pennsylvania, and Virginia) accounted for 35 (74.5%) of 47 cases.

Cases of Lyme disease were reported across multiple age groups. The highest cumulative incidence of disease occurred among children aged 5–9 years, with a secondary drawn out peak among persons aged 35–70 years (Figure 14). Females accounted for 405 (52.5%) of cases. Patients most commonly presented with erythema migrans (73.3%), followed by arthritis (45.7%), neurologic symptoms (13.8%), and cardiac (0.8%) symptoms (Figure 15). Nearly one-third (32.9%) reported >1 clinical symptom. For the 739 cases with documented antibiotic treatment, 509 (68.9%) indicated treatment with doxycycline and 163 (22.1%) indicated treatment with amoxicillin (Figure 16). The median duration of antibiotic treatment was 21 days. Of 689 cases with information on hospitalization, 46 (6.7%) were hospitalized; no deaths were reported.

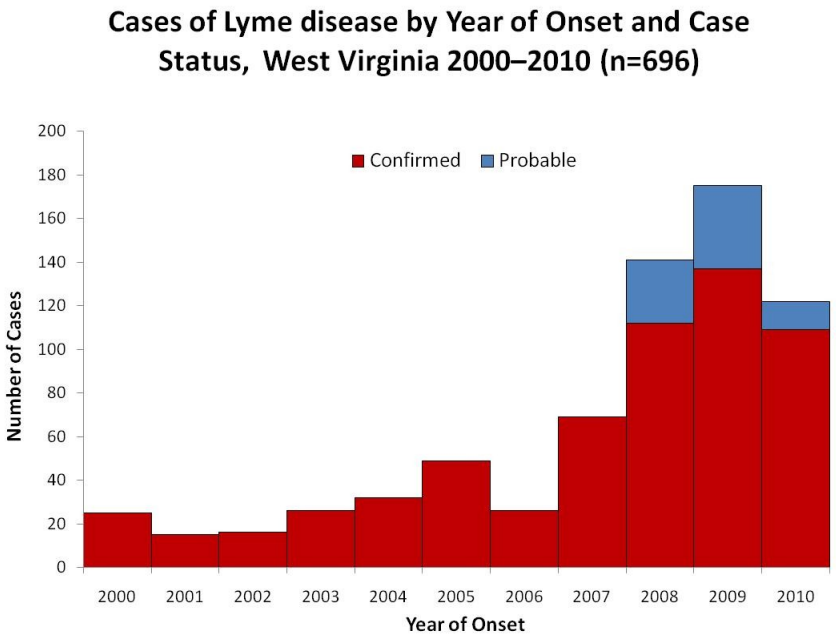


Figure 10. Cases of Lyme disease reported from 2000–2010 in West Virginia by year of onset and case status.

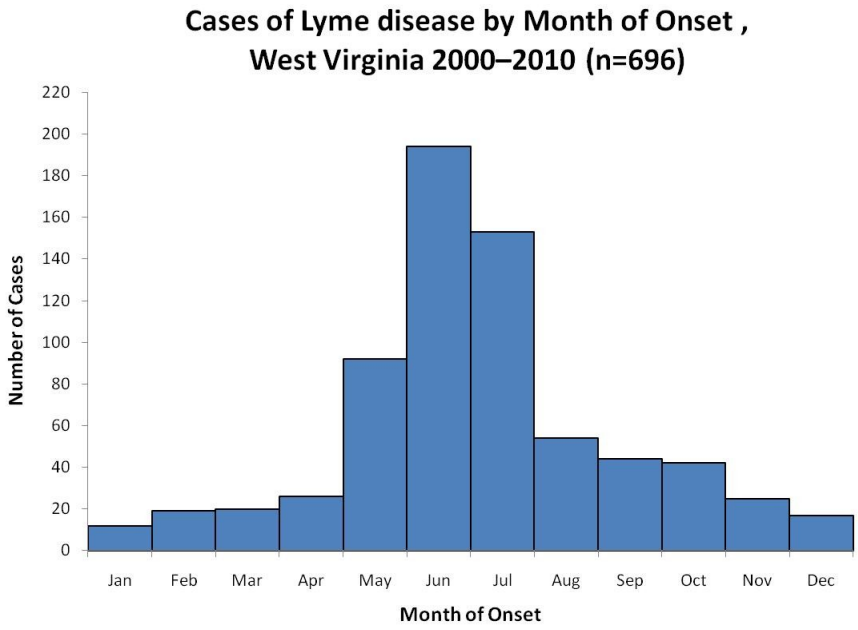
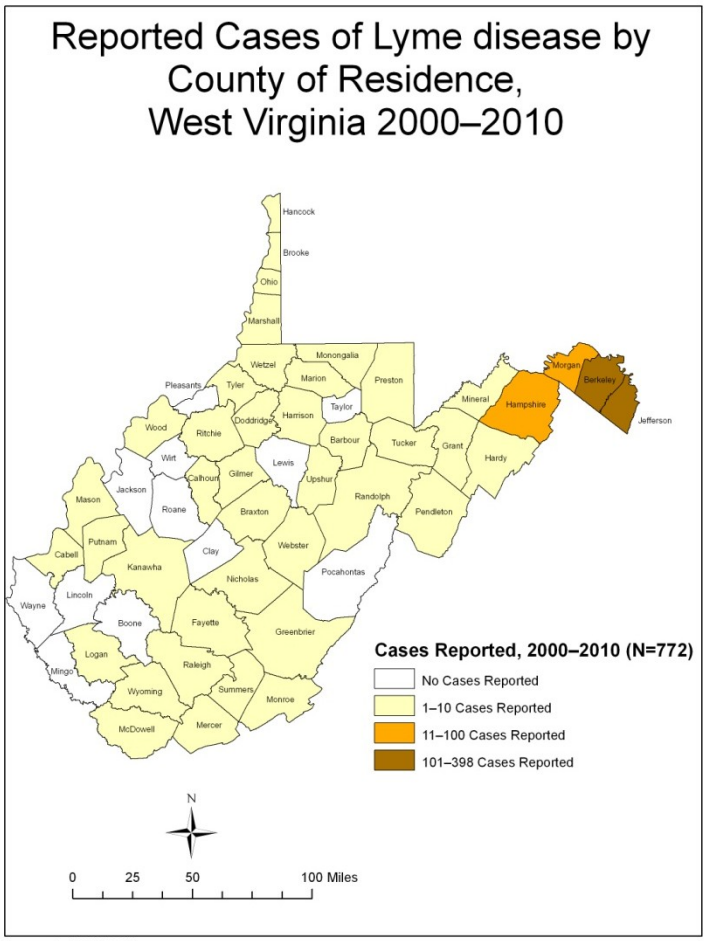
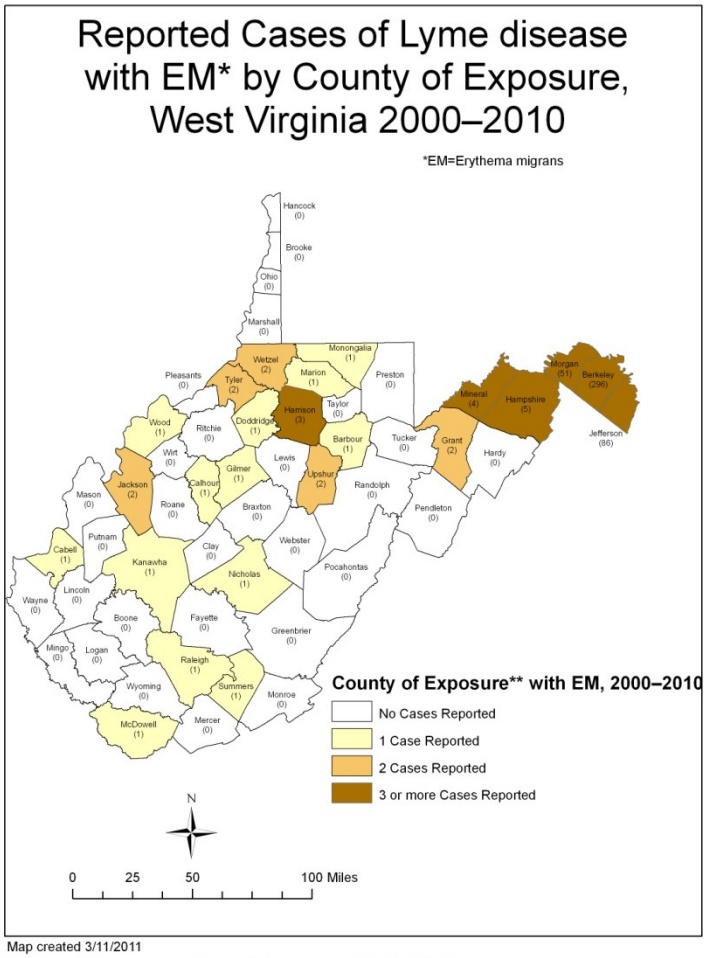


Figure 11. Month of onset for Lyme disease cases reported from 2000–2010 in West Virginia.



Map created 3/11/2011

Figure 12. County of residence for Lyme disease cases reported from 2000–2010 in West Virginia.



Map created 3/11/2011

**Includes only those exposures documented as occurring within West Virginia

Figure 13. County of exposure for Lyme disease cases with erythema migrans reported from 2000–2010 in West Virginia.

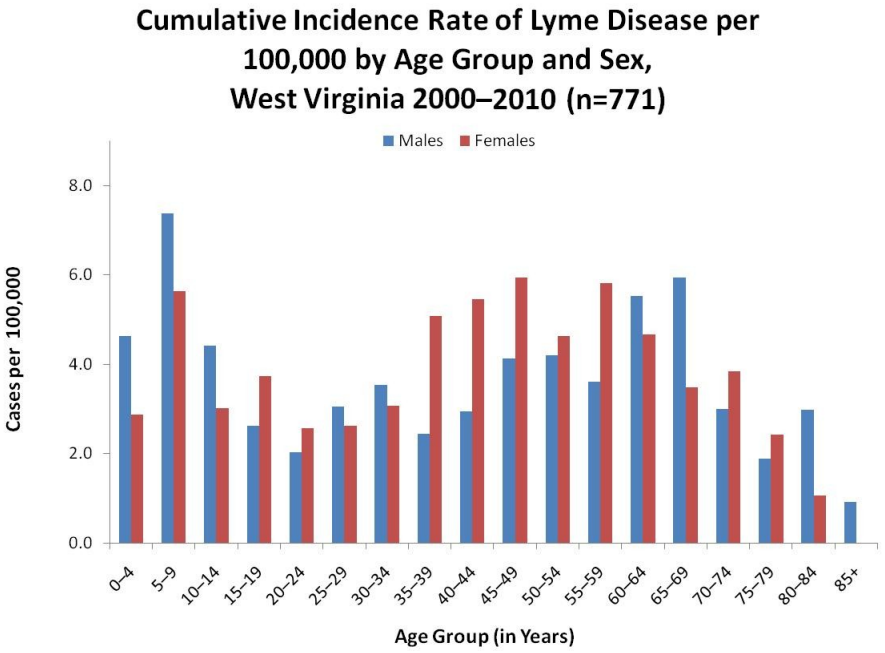


Figure 14. Cumulative incidence rate of Lyme disease reported per 100,000 by age group and sex from 2000–2010 in West Virginia.

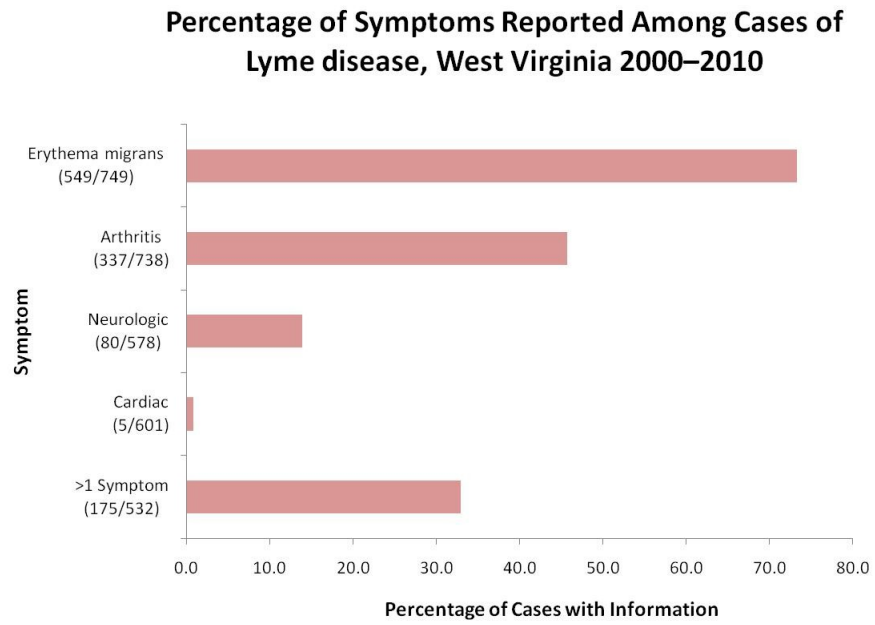


Figure 15. Percentage of symptoms reported among Lyme disease cases reported from 2000–2010 in West Virginia.

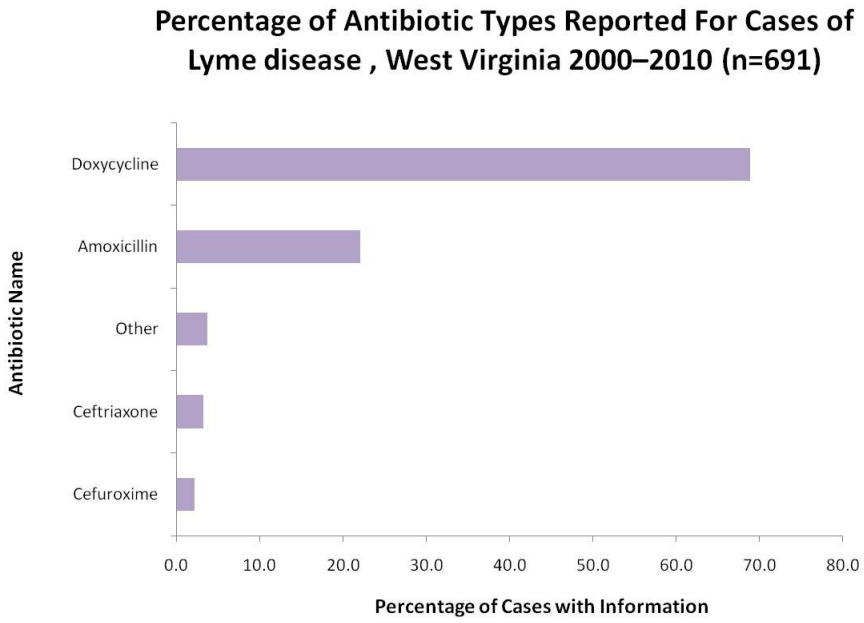


Figure 16. Percentage of antibiotic types reported among Lyme disease cases reported from 2000–2010 in West Virginia.

Discussion

Four types of TBDs were reported in West Virginia from 2000 through 2010 — tularemia, ehrlichiosis, Rocky Mountain spotted fever, and Lyme disease. Lyme disease accounted for the majority (92.9%) of TBD cases. Furthermore, 91.2% of Lyme disease cases appear to have been acquired in-state, indicating this is the primary TBD causing human illness in this state. The TBD cases identified are consistent with the known distribution of tick vectors in West Virginia. However, it is worth noting that although not detected during the study period, the primary tick vectors for Powassan encephalitis (*I. cookei*) and anaplasmosis (*I. scapularis*) do exist in West Virginia.[17–19] Two possible reasons for the lack of human cases of these two TBDs include that they have not yet become established in the tick populations of West Virginia and that these diseases are under recognized. Continued surveillance efforts are important to better understand the distribution of TBDs, to monitor changes in TBDs, and to identify emerging TBDs in West Virginia.

Public health surveillance for TBDs can be challenging, particularly due to complicated laboratory tests for TBDs and complex case definitions. For example, when using the current national case definition for Lyme disease, location of tick exposure, along with laboratory testing and clinical symptoms (e.g. EM), are important for determining case status. Exposure is defined as "having been (less than or equal to 30 days before onset of EM) in wooded, brushy, or grassy areas (i.e., potential tick habitats) in a county in which Lyme disease is endemic." And an endemic county is defined as "… one in which at least two confirmed cases have been acquired in the county or in which established populations of a known tick vector are infected with *B. burgdorferi*." Thus, for surveillance purposes, understanding is needed regarding which counties are classified as endemic for Lyme disease.

In West Virginia, a recent evaluation of Lyme disease cases reported during a three year, high-incidence period (2007–2009) was conducted to determine which West Virginia counties would be considered as endemic for Lyme disease. This evaluation examined cases that were laboratory-confirmed and had documented EM. Three counties of exposure (Morgan, Berkeley, and Jefferson) were identified that had 2 or more cases meeting these criteria. Reported Lyme disease data from West Virginia together with other published research data indicate the far-eastern panhandle is the only area of West Virginia that currently has established populations of *I. scapularis* and a high-degree of tick habitat suitability.[17,19–20] This corroborates the finding from this analysis that Morgan, Berkeley and Jefferson counties appear to be the only currently endemic West Virginia counties for Lyme disease based on the national case definition.

The analysis for this report, however, revealed more than 3 counties where exposure was documented in 2 or more cases with erythema migrans, potentially calling into question which counties should be considered Lyme disease endemic for surveillance purposes as identified in the analysis of the 2007–2009 data. One possible reason for this finding is that other questionable vectors of Lyme disease, including *I. cookei* and *I. dentatus*, have been identified in multiple counties throughout north central West Virginia.[12,17] Although transmission of Lyme disease by ticks other than *I. scapularis* or *I. pacificus* is not well-documented and there is evidence that *I. cookei* is an inefficient vector of Lyme disease, an anecdotal report of a West Virginia resident described a small (4cm) erythema migrans rash at the attachment site of an *I. cookei* tick.[12,22,23] It is also possible that tick bite hypersensitivity reactions could be mistaken as erythema migrans by healthcare providers less experienced in

evaluating patients with Lyme disease.[24] Thus, transmission of Lyme disease by tick vectors other than *I. scapularis* and/or misclassification of cases by providers or public health personnel could explain the apparent discrepancy in identifying potential Lyme disease endemic counties between the two analyses. The strict criteria of laboratory-confirmation and documented erythema migrans used in the analysis of 2007–2009 data, along with the data available on *I. scapularis* occurrence and tick habitat suitability in West Virginia, allows for the most conservative evaluation of tick exposure and case status. Therefore, for surveillance purposes, the only counties that are currently considered endemic for Lyme disease in West Virginia are Berkeley, Jefferson, and Morgan. However, sporadic transmission of Lyme disease in other counties cannot be completely ruled out. Routine review of surveillance data using these criteria will be needed to determine if or when other counties in West Virginia may also be classified as Lyme disease endemic counties.

In addition to surveillance, public health should be engaged in TBD prevention. Fortunately, prevention measures for all TBDs are similar and can be done primarily at an individual level. A risk perception survey conducted in 1998 found that approximately 60% of adults did not take any actions to avoid being bitten by ticks.[27] However, tick bite prevention for individuals is simple, effective, and inexpensive. The primary means of prevention is to avoid tick bites and this can be accomplished using a variety of tips (Box 1).[26–28] Educational messages for the public should focus on these prevention measures and serve to inform the public about tick vectors capable of transmitting diseases in their area. Any person bitten by a tick should monitor themselves for rash or flu-like symptoms (fever, muscle aches, headaches, fatigue, etc) and see a healthcare provider promptly. For most tickborne diseases, 24–72 hours of attachment is necessary before transmission occurs.[29] Antibiotic prophylaxis following a tick bite is rarely warranted.[30]

TBDs can also be challenging for healthcare providers, but several resources are available to aid healthcare providers in diagnosing, managing and treating tickborne infections. Two guideline documents, in particular, provide excellent information on the tickborne infections most commonly seen in West Virginia. The first document, published by the Infectious Disease Society of America (IDSA) in 2006, is a comprehensive guide on assessment, treatment and prevention for Lyme disease.[26] The second document was released by CDC in 2006 and outlines the management, treatment and prevention of tickborne rickettsial diseases (which includes Rocky Mountain spotted fever and ehrlichiosis).[5] Both documents are available online. Additionally, there are online training opportunities focused on tickborne diseases. IDSA has a web-based CME case study for Lyme disease available at http://lymecourse.idsociety.org and the Clinical Directors Network (CDN) has a web-based CME course on recognizing and treating tickborne infections available at http://www.cdnetwork.org/NewCDN/LibraryView.aspx?ID=cdn552a . Free laboratory support is available to healthcare providers for RMSF and Lyme disease. RMSF testing can be set up through the Division of Infectious Disease Epidemiology (DIDE) by calling 1-800-423-1271. Lyme disease testing is available through the West Virginia Office of Laboratory Services and more information about this testing service can be obtained at http://www.wvdhhr.org/labservices/labs/serology/index.cfm or by calling 304-558-3530 ext. 2410.

BOX 1. Key points for tick bite prevention.

- Be aware that ticks are most commonly found from April–September in grassy, brushy, and/or wooded areas with ample shade.
- Ensure family pets are under the care of a veterinarian and are receiving a preventative tick treatment
- Use an insect repellant such as DEET at concentrations of 20% to repel ticks; parents should assist children in application of any repellant.
- Wear light-colored clothing when spending time outdoors to easily spot crawling ticks.
- Stay in the center of trail areas to avoid questing ticks when hiking.
- Perform a full-body tick check using a hand mirror to identify crawling or attached ticks after spending time outdoors; parents should assist children in performing tick checks.
- Be aware that ticks can be as small as a poppy seed and can easily be missed.
- The following body areas should be checked when looking for ticks:
    - under the arms
    - in and around the ears
    - inside the belly button
    - back of the knees
    - under the arms
    - in and around the hair line
    - between the legs
    - around the waist
- Taking a shower within 2 hours of being in a tick habitat has been shown to be effective in reducing the risk of tickborne illness.
- If an attached tick is identified on the body, it should be removed by grasping the tick as close to the skin as possible with tweezers and applying steady upward pressure.
- Consider tick-safe landscaping methods such as a 3-foot boundary of wood chips or gravel to reduce ticks crawling into yards or playgrounds *

*More information on tick-safe landscaping is available in the Connecticut Agricultural Experiment Station's Tick Management Handbook, available at: http://www.cdc.gov/ncidod/dvbid/lyme/resources/handbook.pdf

There are several limitations to this study. First, all infectious diseases, including TBDs, are likely under-reported. Therefore, the ability of this report to accurately reflect true incidence of disease is limited. Second, misclassification or misdiagnosis of disease and case status is possible due to inaccurate laboratory tests, provider diagnostic error, and variations in case investigation and ascertainment among various public health personnel. It is possible that the quality and source of case-specific clinical and epidemiologic data may be inconsistent due to variations in how the data were collected. Ideally, all clinical data should have been collected from a healthcare provider and all epidemiologic or exposure data should have been collected from the patient or guardian, but this may not have occurred in all cases. Finally, some TBD case definitions did change over time, potentially affecting case ascertainment for these diseases. The most significant change occurred in 2008 when a probable case classification was added to the Lyme disease case definition.

In conclusion, TBDs, particularly Lyme disease, are an important concern in West Virginia. The number of human TBD cases in West Virginia is expected to rise due to predicted climate change, increased human encroachment into the forest habitat conducive to I. scapularis development, increased host population (white-tailed deer), and proliferation of exotic plant species beneficial to ticks and their hosts.[21, 31–34] Fortunately, preventative measures are available to reduce the risk of disease transmission to humans. Public education should focus on these prevention measures and outreach to healthcare providers is needed to provide

important clinical information, including available testing services in West Virginia. Tick surveillance should be helpful for describing the distribution of other tick species in West Virginia. And, newly reportable tickborne diseases, such as babesiosis, may reveal new information on other tickborne infections affecting West Virginians.

References

1. Centers for Disease Control and Prevention (CDC). Surveillance for Lyme disease --- United States, 1992—2006. *MMWR* 2008:57(SS10);1–9.
2. CDC. Ehrlichiosis statistics and epidemiology. Available at: http://www.cdc.gov/ticks/diseases/ehrlichiosis/statistics.html Accessed 2011 Feb 08
3. CDC. Rocky Mountain spotted fever statistics and epidemiology. Available at: http://www.cdc.gov/rmsf/stats/ Accessed 2011 Feb 08.
4. CDC. Anaplasmosis statistics and epidemiology. Available at: http://www.cdc.gov/anaplasmosis/stats/ Accessed 2011 Feb 08.
5. CDC. Diagnosis and management of tickborne rickettsial diseases: Rocky Mountain spotted fever, ehrlichioses, and anaplasmosis --- United States. *MMWR* 2006:55(RR04);1–27.
6. Steere AC, Coburn J, Glickstein L. The emergence of Lyme disease. *J Clin Invest* 2004 113:1093–1101
7. CDC. Tularemia – transmission. Available at: http://www.cdc.gov/tularemia/transmission/ Accessed 2011 Mar 10.
8. CDC. Geographic distribution – ticks. Available at: http://www.cdc.gov/ticks/geographic_distribution.html Accessed 2011 Mar 10.

9. CDC. Anaplasmosis. Available at http://www.cdc.gov/anaplasmosis/ Accessed 2011 Mar 10.
10. CDC. Ehrlichiosis. Available at: http://www.cdc.gov/ehrlichiosis/ Accessed 2011 Mar 10.
11. Pesko KN, Torres-Perez F, Hjelle BL, Ebel GD. Molecular epidemiology of Powassan virus in North America. *J Gen Virol*. 2010 Nov;91(Pt 11):2698-705.
12. Hall JE, Amrine JW Jr, Gais RD, et al. Parasitization of humans in West Virginia by Ixodes cookei (Acari: Ixodidae), a potential vector of Lyme borreliosis. *J Med Entomol.* 1991 Jan;28(10): 186–9.
13. CDC. Rocky Mountain spotted fever. Available at: http://www.cdc.gov/rmsf/ Accessed 2011 Mar 11.
14. Paddock CD, Sumner JW, Comer JA, et al. Rickettsia parkeri: a newly recognized cause of spotted fever rickettsiosis in the United States. *CID* 2004 38:805–811.
15. CDC. Tickborne diseases of the U.S. Available at: http://www.cdc.gov/ticks/diseases/index.html Accessed 2011 Mar 11.
16. Dennis DT, Nekomoto TS, Victor JC et al. Reported distribution of Ixodes scapularis and Ixodes pacificus (Acari: Ixodidae) in the United States. *J Med Entomol* 1998 Sep;35(5):629-38.
17. West Virginia University Extension Service. West Virginia tick information. Available at: http://www.wvu.edu/~agexten//ipm/insects/2tick.htm Accessed 2011 Mar 18.
18. Hardy, JL. "Arboviral zoonoses of North America." Handbook of zoonoses, 2nd ed. Section B: viral. Ed GW Beran. Boca Raton, FL: CRC Press Inc, 1994.
19. Artsob, H. "Powassan encephalitis" The arboviruses: epidemiology and ecology, Vol 1. 2nd ed. Ed TP Monath. Boca Raton, FL: CRC Press Inc, 1988.
20. Brownstein JS, Holford TR, Fish D. A climate-based model that predicts the spatial distribution of the Lyme disease vector *Ixodes scapularis* in the United States. *Environ Health Perspect* 2003 Jul;111(9):1152-7.
21. Brownstein JS, Holford TR, Fish D. Effect of climate change on Lyme disease risk in North America. *Ecohealth* 2005 Mar;2(1):38–46.
22. Ryder JW, Pinger RR, Glacy T. Inability of *Ixodes cookei* and *Amblyomma americanum* nymphs (Acari: Ixodidae) to transmit *Borrelia burgdorferi*. *J Med Entomol*. 1992 May;29(3):525-30.
23. Barker IK, Lindsay LR, Campbell GD et al. The groundhog tick *Ixodes cookei* (Acari: ixodidae): a poor potential vector of Lyme borreliosis. *J Wildl Dis*. 1993 Jul;29(3):416-22.
24. Dandache P and Nadelman RB. Erythema migrans. *Infectious Disease Clinics of North America*, Volume 22, Issue 2, Tick-borne Diseases, Part I: Lyme Disease, June 2008, Pages 235-260.
25. Herrington JE. Risk perceptions regarding ticks and Lyme disease: a national survey. *Am J Prev Med* 2004;26(2): 135–140.
26. CDC. Stop ticks. Available at: http://www.cdc.gov/Features/StopTicks/ Accessed 2011 Mar 15.
27. CDC. Preventing ticks on your pets. Available at: http://www.cdc.gov/ticks/avoid/on_pets.html Accessed 2011 Mar 15.
28. CDC. Preventing ticks in the yard. Available at: http://www.cdc.gov/ticks/avoid/in_the_yard.html Accessed 2011 Mar 15.
29. Heyman, H.L., Ed. (2004). Control of communicable diseases manual, 18th ed.. American Public Health Association, Washington D.C.. 459-461.
30. Wormser GP, RJ Dattwyler, ED Shaprio, 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. CID 2006;43: 1089-134.

31. Killilea, M. E., Swei,A., Lane, R. S. et al. Spatial dynamics of Lyme disease: A review. *Ecohealth* 2008; 5: 167-195
32. Allan, B. F., Dutra, H. P., Goessling, L. S. et al. Invasive honeysuckle eradication reduces tick-borne disease by altering host dynamics. Proceedings of the National Academy of Sciences of the United States of America 2010; 107 (43): 18523-18527.
33. Williams, S. C., Ward, J. S., Worthley, T. E. et al. Managing Japanese Barberry (Ranunculales: Berberidaceae) infestations reduces blacklegged tick (Acari: Ixodidae) abundance and infection prevalence with Borrelia burgdorferi (Spirochaetales: Spirochaetaceae). *Environmental Entomology* 2009; 38 (4): 977-984.
34. Piesman, J. "Ecology of Borrelia burgdorferi sensu lato in North America." Lyme borreliosis: Biology, epidemiology and control. Ed. J. Gray et al. New York: CABI Publishing, 2002.