ASSESSING COMMUNICATION NEEDS ABOUT TICKS AND TICK-BORNE DISEASES FOR INDIANA PUBLIC HEALTH PROVIDERS

by

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I would like to dedicate this thesis to my mom, Mrs. Surinderpal Kaur, and my PI, Dr. Catherine A. Hill, for their love and support through this journey.
This thesis is also dedicated to those who themselves or have loved ones suffering from tick-borne diseases.

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ABSTRACT

More than 15 tick-borne diseases have been recognized in the United States (US) (Eisen (2020). Collectively, TBDs have been linked to seven different tick species in the US. Climate change, urbanization, and host migration exacerbate the threat of increasing TBD incidence and the expanding geographic distribution of ticks. Furthermore, data suggests that less than a tenth of the reportable TBDs were reported to the CDC annually. Studies from a national survey and high incidence states for Lyme disease provided evidence that healthcare providers have knowledge gaps about TBD epidemiology and diagnostics, which has yet to be examined in Indiana to our knowledge.

An anonymous survey of 597 Indiana healthcare providers was conducted between February 28th and April 10th, 2020 to assess knowledge about ticks and tick-borne diseases (TBDs). The survey comprised 22 discrete and ordinal questions and one open-ended question. The study revealed that 92% of the respondents reported Doctor of Medicine (MD) (71%), Doctor of Osteopathic Medicine (DO) (8%), Physician Assistant (PA) (12%) and Registered nurse (RN) (1%) as their highest level of training and practiced in a diversity of settings including Primary care office (28%), Specialty care office (23%) and Hospital (inpatient) (20%). Analyses revealed that 39% of respondents had practiced for more than 25 years, consulted between 1-25 patients with confirmed or suspected TBD per year, and predominantly served both rural and urban communities (62% respondents). Seventy percent of respondents recognized the clinical signs and symptoms of TBDs endemic to Indiana and 96% of DOs, 94% of PAs, and 91% of MDs were aware of the limitations of the erythema migrans (EM) rash as a diagnostic criteria for Lyme disease (LD), the most common TBD in Indiana and the U.S. The majority of respondents (75%) reported using fine tip tweezers, considered best practice for the removal of an attached tick. Among respondents who used online resources to obtain information regarding diagnostic and treatment guidelines, 25-45% visited federal (CDC) and state (Indiana Department of Health, IDOH) websites.

Survey data revealed several potential knowledge gaps among Indiana state providers. Respondents reported that they were unsure about the following topics: (1) the tick species capable of disease transmission in IN (47% unsure), (2) the geographic distribution of the black legged tick, *Ixodes scapularis,* the vector of LD in the U.S. (56% unsure), (3) northwest Indiana as the

region of the state associated with highest LD risk (49% unsure), and (4) May-July as the months considered highest risk for TBD transmission (48% unsure or answered incorrectly). These findings provided evidence to support the hypothesis under investigation in the present study that Indiana healthcare providers lack knowledge of tick vectors and TBDs risks specific to the state.

Qualitative analysis was conducted for open-ended question (Q23) and resulted in coding of 597 responses into six major categories (Healthcare provider, Healthcare system, Patient Knowledge, Disagreement, Education and Not applicable) and 15 associated subcategories. Coding analyses revealed that healthcare providers are aware of their shortcomings and are receptive to online interventions. Here we present the first focused study to assess provider knowledge of ticks and TBD in Indiana. Taken together, the survey findings provide information to guide development of region-specific educational material and guidelines about ticks and TBDs for healthcare providers. We provide evidence to suggest that a continued provider education program may improve diagnosis and treatment of TBDs.

CHAPTER 1. LITERATURE REVIEW

1.1 Biology and Public Health Importance of Hard ticks (Family Ixodidae)

There are 898 known species of ticks (Class Arachnida; Subclass Acari; Order Parasitiformes; Suborder Ixodida) worldwide, of which 690 are classified as members of the Family Ixodidae (hard ticks) (Yamaji et al. 2018, Nicholson et al. 2019). Species of ixodid ticks are responsible for transmitting a variety of bacterial, protozoan and viral diseases to humans and animals worldwide (Nicholson et al. 2019) and are second only to mosquitoes in terms of their impact on human health (Nicholson et al. 2019). Lyme disease, Anaplasmosis/ehrlichiosis and Spotted fever rickettsiosis, transmitted by ixodid ticks, are the most prevalent vector-borne diseases (VBDs) in the United States (Eisen et al. 2017, Rosenberg et al. 2018, Nicholson et al. 2019).

At least seven species of ixodid ticks are recognized as pests of public health concern in the United States (Centers for Disease Control and Prevention, CDC, 2020) due to their ability to transmit pathogens to humans (Eisen et al. 2017). The vertebrate host may encounter multiple tick species depending on habitat and time of year, increasing the chance of exposure to pathogens (Nieto et al. 2018, Salkeld et al. 2019). The risk of pathogen and parasite transmission rises with the increasing duration of tick attachment to the vertebrate host (Eisen 2018). Ticks can transmit multiple pathogens and parasites to humans and animals during a single blood meal; a phenomenon referred to as "co-infection" (Wormser et al. 2006, Hersh et al. 2014, Nieto et al. 2018). If left untreated, TBDs can cause high morbidity (e.g., Lyme disease (LD)), and in some cases, high mortality (e.g., Rocky Mountain Spotted Fever; (RMSF)) (Wormser et al. 2006, Hook et al. 2015).

Amblyomma americanum (Lone star tick) is the vector of *Ehrlichia chaffeensis*, *Ehrlichia ewingii*, Heartland virus, and *Francisella tularensis* (See Table 1.1 for diseases associated with these pathogens) and has been reported in the southeastern and eastern United States (U.S.) (CDC 2020, Eisen et al. 2017). The recent documentation of *A. americanum* in Kansas and Nebraska suggests that the range of this tick is expanding westward (Raghavan et al. 2019). *Amblyomma maculatum* (Gulf Coast tick), is the vector of *Rickettsia parkeri*, and has been reported along the Atlantic coast and the coastal regions of the Gulf of Mexico (Eisen et al. 2017). The geographic

range of *A. maculatum* is expanding northward and has been documented in the State of Illinois and Indiana (ERI 2020, Phillips et al. 2020).

Dermacentor variabilis (American Dog tick) is the vector of *Rickettsia rickettsia* (causative agent of RMSF) and *Francisella tularensis* (See Table 1.1 for diseases associated with these pathogens), and has been reported in all states east of the Rocky Mountains and in some Pacific Coast states (CDC, 2020, Eisen et al. 2017, Salkeld et al. 2019). *Dermacentor andersoni* (Rocky Mountain wood tick), the vector of Colorado tick fever virus (Eisen et al. 2017), *Rickettsia rickettsii* and *Rickettsia philipii*, has been reported in the northwestern U.S. (Sonenshine 2018, Boorgula et al. 2020).

Ixodes scapularis (blacklegged tick) is the vector of the human pathogens *Anaplasma phagocytophilum*, *Babesia microti*, *Borrelia miyamotoi*, *Ehrlichia muris eauclairensis*, *Borrelia burdorferi* (causative agent of LD, the most common vector-borne disease (VBD) in the US), *Borrelia mayonii*, and Powassan virus (See Table 1.1 for diseases associated with these pathogens) and has been reported in all states east of the Rocky Mountains (CDC 2020, Eisen et al. 2017). *Ixodes pacificus* (Western blacklegged tick), the vector of *Anaplasma phagocytophilum*, *Borrelia miyamotoi*, and *Borrelia burdorferi* has been reported in all states west of the Rocky Mountains (CDC 2020, Eisen et al. 2017).

Rhipicephalus sanguineus (Brown dog tick) has been identified in all 50 U.S. states (CDC, 2020) and is the recognized vector of *R. rickettsii* (Eisen et al. 2017, Jones et al. 2017). This species possess a lower risk of disease transmission to humans due to its host preference for canines (Dantas-Torres 2008, Eisen et al. 2017).

An invasive tick species, *Haemaphysalis longicornis* (Asian long-horned tick), first detected in New Jersey (2017), has become established in the U.S. and is a vector of severe fever with thrombocytopenia syndrome virus (SFTSV) and *Rickettsia japonica*, and a potential vector of various species of *Anaplasma*, *Babesia*, *Borrelia*, *Ehrlichia*, and *Rickettsia* (Beard et al. 2018, Rainey et al. 2018). The sexual and asexual (parthenogenesis) reproduction mechanism of *H. longicornis* and tolerance to a wide range of temperatures make this species of further concern for public and veterinary health in the U.S. (Tufts et al. 2019).

Of the seven ticks described above; four tick species have been documented in the state of Indiana. *Dermacentor variabilis* and *R. sanguineus* are considered established in all 92 Indiana

counties (IDOH, 2020). Research is ongoing to determine the geographic range and confirm establishment of *I. scapularis* and *A. americanum* around the state. To date, *I. scapularis* is considered established in 72 counties and *A. americanum* is considered established in 46 counties (IDOH, 2020). The Indiana Department of Health (IDOH) has defined "establishment" as the collection of either multiple ticks of a single life stage or more than one life stage from a county within a year (IDOH, 2020).

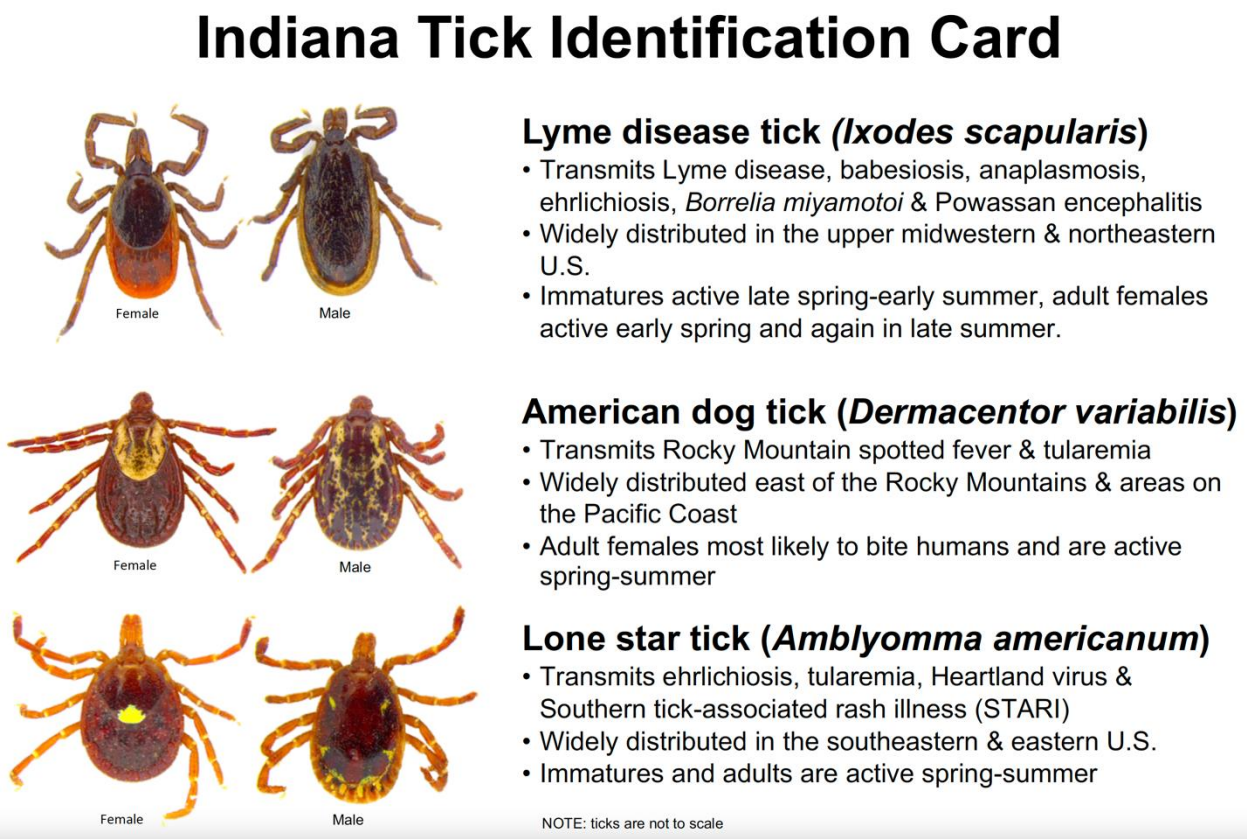


Figure 1.1. Front side of Indiana tick identification card. Left: images of ticks collected from Indiana. Right: species name, diseases transmitted by each tick species, geographic distribution, and seasonal activity (Tick INsiders, 2019).

Multiple longitudinal studies have sampled species of ixodid ticks in Indiana. These studies have been undertaken to better understand the prevalence of *A. phagocytophylum* and *B. odocoilei* (Steiner et al. 2006) in *I. scapularis*, the geographical and spatial distribution of *I. scapularis* and the LD pathogen, *B. burgdorferi* (Keefe et al. 2009), and composition of bacterial communities in *D. variabilis* and *I. scapularis* (Hawlena et al. 2013). More recently, the Purdue University Tick INsiders project and the Indiana University Project Vector Shield were established to understand

the prevalence and risk of disease associated with vectors in Indiana, and to improve healthcare for residents of the state. Tick INsiders is a community science project focused on the surveillance of *A. americanum, I. scapularis*, and *D. variabilis* in Indiana, as shown in figure 1.1., to analyze microbes carried by these species and to develop a region-specific disease risk map. (Murgia et al. in review). Project Vector Shield is a surveillance project established by the Environmental Resilience Institute (ERI), Indiana University, Bloomington, IN, focused on sampling ticks and mosquitoes to determine spatial and temporal activities of vectors in Indiana (ERI, 2020). In an earlier study, 2009 and 2011 sampling of *A. americanum*, *D. variabilis* and *I. scapularis* at eight sites from southern Indiana revealed an abundance of ticks, increasing with temperature over the season (Rynkiewicz and Clay 2014), which correlates with the higher number of TBDs reported in warmer months in Indiana (IDOH 2020).

1.2 Tick-borne Diseases in the U.S. and Indiana

The incidence and range of tick-borne diseases (TBD) is increasing around the world, including the United States (Dantas-Torres et al. 2012, Tokarz et al. 2018). Data shows that reported TBD cases to CDC have doubled between 2004-2016 (CDC, 2020). Several studies have identified climate change, urbanization and host migration and other factors that may contribute to the increase in incidence of TBDs (Ostfeld and Brunner 2015, Petersen et al. 2019). The geographic distribution of ticks is closely tied to that of TBDs cases globally (Dantas-Torres et al. 2012, Nieto et al. 2018). In the United States, notable TBDs include Anaplasmosis, Babesiosis, Ehrlichiosis, LD, RMSF, Southern Tick-Associated Rash Illness (STARI), and tularemia (CDC, 2020, Dantas-Torres et al. 2012). The CDC reported that TBDs more than doubled in the period 2004-2018 (CDC, 2019). New and emerging TBDs recognized in the U.S. recognized since 2012 include *Borrelia mayonii*, *Borrelia miyamotoi* (2012), Bourbon virus (2014), and 364D rickettsiosis (Eisen et al. 2017, Savage et al. 2017, Wroblewski et al. 2017). In 2019, there were 34,945 confirmed and probable LD cases reported to the CDC, but estimates suggest that the actual number may be ten times higher than this (CDC 2021, Nelson et al. 2015, Petersen et al. 2019).

The IDOH collects and tracks data for six TBDs considered reportable to the state: anaplasmosis, babesiosis, ehrlichiosis, LD, RMSF, and tularemia. Epidemiological data suggest that the incidence of TBDs has increased in Indiana (IDOH, 2020). The incidence of LD, a bacterial pathogen transmitted by *I. scapularis* has doubled in Indiana since 2007, according to the

CDC, and cases of RMSF, transmitted by *D. variabilis*, have tripled since 2013 (IDOH, 2020). The increase in vector-borne disease incidence may be due to increased human population, increased urbanization, increased travel, change in the range of the vertebrate hosts, land-use change, and climate change. Petersen et al., 2019 discuss the importance of a national vector-borne disease control and prevention system to address the phenomena of increasing vector-borne disease incidence.

1.3 Resources and Guidelines for Diagnosis and Treatment of TBDs in the U.S.

In the U.S., the public and medical practitioners have access to epidemiological data and other information regarding the incidence of TBDs through a variety of public sources. The CDC provides coverage of TBDs, their transmission, epidemiology, diagnosis, and treatment via the CDC website (https://www.cdc.gov/ticks/). Medical practitioners have access to guidelines for the clinical diagnosis and treatment of TBDs through a reference manual: Tickborne Diseases of the United States, produced by CDC (CDC, 2019).

The IDOH reports epidemiological data for six of the 16 TBDs reported by CDC as public health threats. TBD statistics for Indiana are available via the IDOH website (https://www.in.gov/health/erc/zoonotic-and-vectorborne-epidemiology-entomology/diseases/). The IDOH also communicates information regarding the epidemiology, diagnosis, and management of ehrlichiosis/anaplasmosis, LD and RMSF via the Indiana Health Alert Network (IHAN-IN) mechanism. IHAN-IN is an online notification system utilized by the IDOH to mass distribute health alerts to Indiana healthcare providers and public health officials. The summary of diseases documented by IDOH, their causative agents, associated vectors in Indiana, and diagnostic criteria are shown in table 1.1. Table 1.1 also lists resources available to healthcare providers for guidelines on the diagnosis of TBDs.

Table 1.1. Summary of TBDs documented in Indiana by IDOH, showing causative agent(s), tick species associated with transmission, diagnostic criteria, and resources of information available to health care providers.

Disease	Causative Agent(s)	Vector(s)	Diagnosis	Resources
Anaplasmosis	*Anaplasma phagocytophilum*	*Ixodes scapularis*	Clinical symptoms Patient history Blood smear microscopy Polymerase chain reaction (PCR) amplification IgG-class antibodies serology	CDC, IDOH, Rodino et al. (2020)
Babesiosis	*Babesia microti*	*Ixodes scapularis*	Clinical symptoms Patient history Blood smear microscopy	CDC, IDOH, Krause et al. (2020), Rodino et al. (2020)
Ehrlichiosis	*Ehrlicchia chaffeenis, E. ewingii, E. muris eauclairensis*	*Amblyomma americanum, Ixodes scapularis*	Clinical symptoms Patient history Blood smear microscopy Polymerase chain reaction (PCR) amplification IgG-class antibodies serology	CDC, IDOH, Rodiono et al. (2020)
Heartland Virus	Hearthland virus (*Phlebovirus*)	*Amblyomma americanum*	Clinical symptoms Patient history	CDC, IDOH
LD	*Borrelia (Borreliella) burgdorferi sensu stricto/ B. mayonni*	*Ixodes scapularis*	Clinical symptoms Patient history Erythema migrans Two-tiered testing: 1. enzyme immunoassay or Immunofluorescence assays. 2. IgM (<4 weeks) or IgG (>4 weeks) immunoblots	CDC, IDOH, Krause et al. (2020), Rodiono et al. (2020)
Powassan Virus	Powassan Virus (arbovirus)	*Ixodes scapularis*	Clinical symptoms Patient history IgM antibodies test of serum or cerebrospinal fluid	CDC, IDOH
RMSF	*Rickettsia ricketssii*	*Dermacentor variabilis, Rhipicephalus sanguineus*	Clinical symptoms Patient history IgM and IgG antibodies serology	CDC, IDOH, Rodiono et al. (2020)
Tularemia	*Fancisella tularensis*	*Amblyomma americanum, Dermacentor variabilis*	Clinical symptoms Patient history Bacterial culture Direct immunofluorescence assay IgM and IgG antibodies serology Immunohistochemical assay	CDC, IDOH, Rodiono et al. (2020)

Note: Centers for Disease Control and Prevention (CDC), Indiana department of Health (IDOH), immunoglobulin G (IgG), immunoglobulin M (IgM)

The CDC's current guidelines recommend diagnosing TBDs based on clinical signs and symptoms of disease, evidence of exposure to a tick bite, and patient travel history (CDC 2020, Wormser et al. 2006). The diagnosis of TBDs is complicated by various factors such as disease presentation and the potential involvement of one or more tick species. Serology, microscopy, and PCR-based lab test are some options available for diagnosis of TBDs (Rodino et al., 2020). Generally, a four-fold increase in pathogen-specific immunoglobulin G (IgG) antigen is the conventional serologic indicator of an acute TBD infection (Rodino et al., 2020). For LD, in the absence of an erythema migrans (EM) rash (a clinical diagnosis of LD) and unknown tick exposure, a two-tier serology test is recommended by CDC (CDC 2020, Rodino et al., 2020). The two-tier serology test consists of an initial enzyme immunoassay (EIA) or immunofluorescence assay (IFA), followed by IgG or IgM western blot (Figure 1.2). The CDC recommends consideration of alternate diagnoses if the first test is negative; further testing is not recommended in such cases. Diagnosis of LD requires positive or indeterminant first and second tests (CDC, 2021). While serology and PCR-based tests are used for diagnosis of most TBDs, bacterial culture is the preferred method for laboratory diagnosis of tick-transmitted tularemia (Rodino et al., 2020).

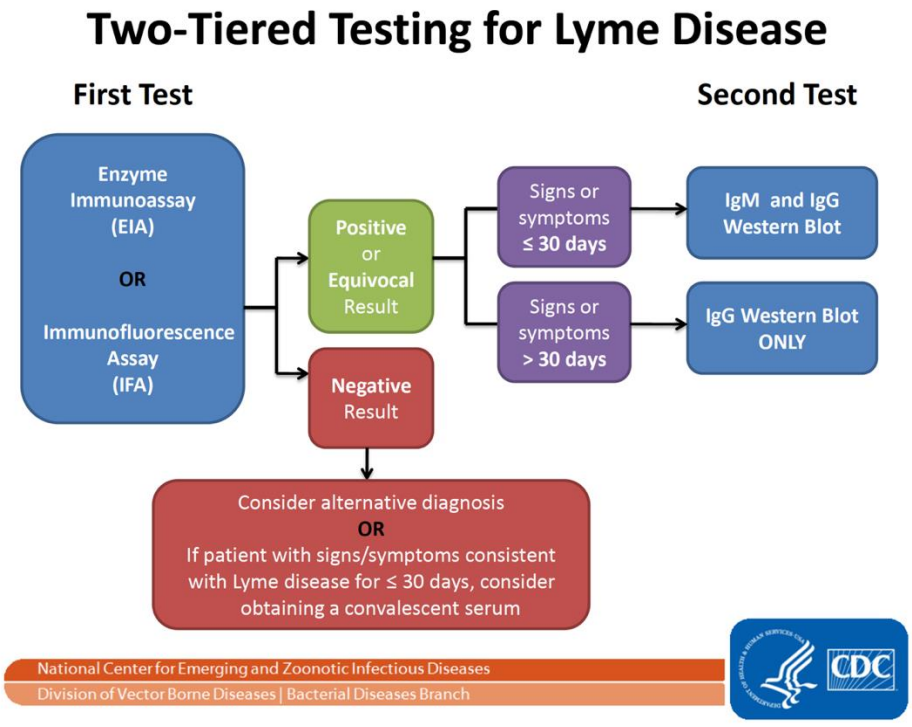


Figure 1.2. Two-tiered testing decision tree for Lyme disease by Centers for Disease Control and Prevention (CDC) (CDC, 2020).

Healthcare providers registered to practice in Indiana are required to follow federal and state medical laws to ensure the safety and privacy of patients. For example, the Health Insurance Portability and Accountability Act of 1996 (HIPAA) protects the privacy and security of patient's personal health information nationally (US Department of Health and Human Services; DHHS) 2013). In addition, the Indiana Department of Insurance (IDOI) has enforced Indiana's Medical Malpractice Act on healthcare providers to ensure provision of care without negligence or unlawful act that may cause harm to the patient (IDOI, 2021). Violation of these laws can result in the loss of healthcare provider license to practice medicine.

1.4 General Public Knowledge and Practices Regarding Ticks and TBDs:

Studies have analyzed public perception of ticks and TBDs at national and regional level. Most surveys conducted to date have focused on sampling the public. The CDC HealthStyles survey is a national survey of adults 18 and over to understand health orientations and practices. Using the national HealthStyles survey, Hook et al. (2015) explored the experience of public exposure to ticks and TBDs, and the use of prevention measures such as pesticide control and tick checks. Their study revealed that respondents were highly informed about LD compared to other TBDs and showed that the respondents from low to zero LD incidence regions reported that LD occurred in their areas (Hook et al., 2015). Cooper and Feder, 2004, investigated online sources for accuracy on LD and found that seven out of eight websites with 'Lyme' in the domain name gave inaccurate information about LD, suggesting that the general public faces issues of misinformation associated with online sources (Cooper and Feder 2004). Similarly, Hook et al. (2015) found that respondents did not practice personal (tick checks) or environmental (pesticide control) prevention measures routinely, suggesting a need to understand reasons for public resistance to prevention practices, especially given the high levels of public awareness regarding LD.

Bayles et al. (2013) compared knowledge of recreational park visitors regarding TBDs transmitted by *A. americanum* and tick-bite prevention behaviors between rural versus urban land-use gradients in Missouri. The investigators reported that participants had greater awareness of LD when ehrlichiosis is endemic to Missouri. Further, individuals visiting rural parks were less likely to avoid tick habitat compared to those visiting ex-urban (an area between rural and suburban areas) or suburban parks, with the latter also more likely to perform tick checks (Bayles et al.,

2013). This study suggested a need for targeted interventions towards the public based on rural and urban land use to increase awareness of ticks and TBDs and preventions behaviors.

Butler et al., 2016 reported that the majority of the participants (82%) in southwestern Connecticut performed one of four preventive behaviors recommended by CDC to reduce risk of TBDs (wearing protective clothing, applying repellent, performing a tick check, and showering after outdoor activities). However, more than half of those who performed a tick check failed to perform a comprehensive check of the entire body and scalp (Butler et al. 2016). Conversely, a study in Delaware, a state considered high-risk for LD, reported that few study participants performed a tick check, applied repellent, or wore protective clothing (Gupta et al., 2018). In addition, Niesobecki et al. (2019) reported that respondents from Connecticut and Maryland were more likely to apply a tick repellent to their pets than to perform a personal tick check.

Bron et al. (2020) compared behavior and risk factors associated with tick exposure in high LD-incidence states in the Northeastern US (New York and New Jersey) versus the Midwest (Wisconsin). The investigators found evidence that respondents from the Midwest were more likely to engage in outdoor activities and employ personal protection measures such as protective clothing, use of repellent, performance of tick check, or showering after outdoor activities, compared to respondents from the Northeast. In addition, the latter were more likely to utilize peri-domestic interventions such as deer-proof fencing or pesticide application to the yard. Similar to Niesobecki et al. (2019), Bron et al. (2020) found that respondents were less likely to use permethrin-treated clothing. However, the researchers noted a positive trend (0.7-14%) in acceptance of permethrin-treated clothing between 2005-2018 (Connally et al. 2009). Finally, a study in Indiana found that participants in rural areas were more likely to adopt risk reduction behaviors such as walking on established trails or wearing light-colored clothing (Omodior et al., 2020) as compared to respondents in urban areas.

1.5 Healthcare Provider Knowledge and Practices Regarding Ticks and TBDs:

Studies to analyze healthcare provider knowledge of ticks and TBDs have been conducted in the northeastern US and as part of the national DocStyles survey. DocStyles surveys are conducted by the CDC to assess healthcare provider knowledge on specific topics. Based on the 2009 DocStyles survey, Brett et al. (2014) identified consistency between the geographic distribution of TBDs diagnosed by physicians and the number of cases reported to CDC and found

evidence that healthcare providers in the northeast US diagnosed LD and providers in the southeast diagnoses RMSF. These findings suggest that there is need for region-specific guidelines for the diagnosis and treatment of TBDs, as the incidence varies by region.

Brett et al. (2014) showed that while 90% of healthcare providers reported treatment of a patient with an EM rash, 75% also ordered a laboratory test, despite the fact that presence of an EM rash is a diagnostic criteria for LD and laboratory tests can return false-negatives when performed in the acute phase of LD infection. Testing was justified to confirm the diagnosis in the case of an indistinguishable EM rash. Furthermore, Brett et al. (2014) suggest that providers may also lack knowledge of diagnostics tests in early stages of LD, have legal concerns regarding medical practice, or were requested by patients. Similarly, in a survey of Connecticut physicians regarding procedures for LD diagnosis, (Murray and Feder 2001) identified a reliance by providers on serologic testing for patients with *I. scapularis* bites or EM rash. Serologic testing was not a recommended diagnostic practice at the time of the study due to high false-positive and false-negative rates associated with commercial laboratory tests. These findings suggest that healthcare providers require regular updates regarding federal and state testing guidelines and information regarding the laboratory tests available for diagnosis of endemic and emerging TBDs recognized in the U.S.

A study of New Hampshire primary care physicians to assess knowledge, beliefs, and practices related to diagnosis and treatment of LD (Magri et al. 2002), reported that physicians lacked knowledge of epidemiology and the clinical diagnosis for LD, but were aware of signs and symptoms associated with LD. Butler et al. (2016) surveyed 76 primary care providers from Northeastern states (Connecticut, Pennsylvania, Delaware, New York and Massachusetts) to assess improvement in tick identification following training using a visual reference manual ("Tick-borne disease of the United States" by CDC). The study reported improvement among participants' inaccurate identification of ticks, with the most noticeable improvement being the accurate identification of engorged adult female *I. scapularis*. These findings are important because the CDC's recommendations for tick-bite prophylaxis, an administration of a single dose of doxycycline to prevent LD, is based on identifying an attached tick as a nymph or adult *I. scapularis*, and history and geographic location of tick exposure.

In conclusion, multiple published studies, surveillance, and epidemiological data support that the geographic range of ticks and TBDs is expanding, TBD incidence is increasing, and TBDs are underreported in the U.S. Knowledge of TBDs and tick-bite prevention among the general public is highly variable and the practice of personal protection measures is inconsistent among states and regions. Multiple published studies highlight that diagnosis and treatment of TBDs is complicated by the fact that many U.S. providers lack knowledge regarding the epidemiology of TBDs and may require region-specific guidelines for the diagnosis and treatment of TBDs. To date, there have been no studies dedicated to assessment of Indiana healthcare provider knowledge of ticks and TBDs. Therefore, an assessment of Indiana healthcare providers represents an important first step to identify knowledge gaps and educational needs, design interventions to assist with provider-patient consultation, and improve healthcare outcomes for Indiana residents.

CHAPTER 2. ASSESSING KNOWLEDGE GAPS ABOUT TICKS AND TICK-BORNE DISEASES FOR INDIANA PUBLIC HEALTH PROVIDERS

2.1 Summary

To identify knowledge gaps and communication needs about ticks and tick-borne diseases (TBDs) among Indiana healthcare providers based on evidence of increasing geographic range of ticks and TBDs, increasing TBD incidence, and underreporting of TBDs in the United States (U.S.), we conducted an anonymous 23-question survey to evaluate the knowledge of healthcare professionals regarding ticks and TBDs in the state of Indiana. In addition, we assessed their preferred sources of information on TBDs, treatment, and diagnosis. Five hundred ninety-seven individuals completed the "Indiana Public Health Professionals Ticks, and Tick-borne Diseases Needs Assessment Survey" between February 28th-April 10th, 2020. While most respondents correctly answered questions regarding the clinical characteristics of TBDs and diagnostic procedures, the survey revealed that a percentage of respondents could not correctly answer questions regarding the biology of tick vectors or the epidemiology of TBDs. For instance, 56% of the respondents were unsure that *Ixodes scapularis* had been documented in most Indiana counties, and 49% were uncertain about the highest risk of disease transmission in the northwest part of Indiana.

2.2 Introduction

The geographic range of ticks and the incidence of TBDs continues to increase, raising public health concerns globally and locally (Yamaji et al. 2018, Raghavan et al. 2019, Boorgula et al. 2020). The geographic range expansion of ticks may be impacted by climate change, urbanization and host abundance (Ostfeld and Brunner 2015, Petersen et al. 2019). Increase in tick abundance and range is noticeable in Indiana (ISDH,2020). The tick species of major importance to public health in Indiana include: *Amblyomma americanum* (lone star tick) responsible for transmission of ehrlichiosis, Southern tick associated rash illness (STARI) and other TBD agents , *Dermacentor variabilis* (American dog tick), the vector of Rocky mountain spotted fever (RMSF) , *Ixodes scapularis* (black legged tick), the vector of Lyme disease (LD), babesiosis, anaplasmosis

and Powassan virus, and *Rhipicephalus sanguineus* (brown dog tick), the vector of RMSF (Table 1.1).

The total number of reported cases of TBDs have more than doubled in the United States (US) between 2004-2019 (CDC, 2021). From 2014 to 2018, reported cases of ehrlichiosis and anaplasmosis increased from 49 to 74 cases per year, cases of LD increased from 112 to 155, and cases of RMSF increased from 36 to 80 cases per year (ISDH 2020). The incidence of TBDs is less in Indiana as compared to 'high incidence' states in the Northeast (e.g., New Jersey and New York) and some Midwestern states (e.g., Wisconsin). However, it has been suggested that the actual TBD cases in the US may be higher than reported (Nelson et al. 2015, Petersen et al. 2019) due to under-reporting and misdiagnosis. Approximately 30,000 LD cases are reported to the Centers for Disease Control and Prevention (CDC) annually, but recent estimates based on insurance claim data suggest that 476,000 people may get infected with LD per year (CDC, 2021). Schiffman et al. (2018) found evidence of underreporting in high incidence counties of Minnesota with high incidence of TBDs; 79% of reportable TBD cases were not reported to the Minnesota Department of Health in 2009. Kobayashi et al. (2019) reported that 86% of patients without active or recent LD had received antimicrobial treatment and concluded that misdiagnosis of TBDs hints to over usage of antibiotics.

In the US, federal and state guidelines for diagnosis and testing of TBDs recommend the following: 1) patient's history of potential exposure to tick bite, 2) clinical signs and symptoms, and 3) laboratory test when indicated or available. Caution is recommended by Centers for disease control and prevention (CDC) during interpretation of laboratory test results due to variation in sensitivity of tests from different laboratories. Anecdotal evidence suggests that there is need to understand preferred information sources utilized by Indiana healthcare providers, especially with respect to information regarding diagnosis and treatment of TBDs. Many online resources provide information regarding ticks and TBDs, the geographic range and incidence of ticks, and the epidemiology, diagnosis, and treatment guidelines for TBDs. Among these are resources published by federal and state agencies (e.g., CDC, Indiana State Department of Health (ISDH)), universities and a variety of non-profit organizations (e.g., Infectious disease society of America (IDSA), International Lyme and associated diseases society (ILADs)).

Increase in TBDs incidence, evidence of underreporting and reliance on antibiotic treatments calls for investigation of healthcare provider knowledge about ticks and TBDs. Historically, studies to understand healthcare provider knowledge regarding ticks and TBDs have focused on states considered 'high incidence' for TBDs, especially the Northeast, US (Murray and Feder, 2001; Magri et al., 2002). Studies by Murray and Feder (2001), Magri et al. (2002), and Brett et al (2014) focused on provider knowledge regarding testing and diagnostic criteria for LD. Butler et al, (2016) investigated tick identification by healthcare providers in the northeastern U.S. Both studies concluded that healthcare providers may have knowledge gaps regarding epidemiology and diagnostic criteria for TBDs. Notably, in a national CDC Docstyles study of more than 2,000 providers, Brett et al., 2014 reported a reliance on tick-bite prophylaxis among providers in low-LD-incidence states, suggesting the need for greater education to reduce over usage of single-dose antibiotic given as a tick-bite prophylaxis to prevent LD. The same study also suggested that future surveys include Physician assistants (PAs) and emergency medicine physicians. To our knowledge, there have been no detailed assessments of Indiana healthcare providers and their knowledge of tick biology, to date. The goal of the present study was to investigate the knowledge of Indiana healthcare providers regarding ticks and TBD threats and preferred resources for TBD diagnosis and treatment guidelines. Based on national evidence of under-reporting and misdiagnosis of TBDs and anecdotal evidence of poor patient experience and outcomes, we explored the hypothesis that Indiana healthcare providers may have less understanding of tick vectors and TBD risks relative to those who practice in high incidence states.

2.3 Methods and Materials

2.3.1 Survey design and Institutional Review Board (IRB) exemption:

An anonymous 23-question survey was developed to evaluate the knowledge of Indiana healthcare professionals regarding ticks and TBDs. The survey was developed in consultation with public health and extension specialists, and medical doctors. The survey comprised 22 discrete and ordinal questions, and one open-ended question (refer to Appendix A), with questions organized into four sections as follows: Section 1. professional qualifications, training, and nature of practice; Section 2. knowledge of ticks and tick-borne diseases; Section 3. prevention and diagnosis, and Section 4. information and resources. The survey was reviewed by the Purdue University

Agricultural Extension service (PUAES), the ISDH and a TBD specialist licensed to practice medicine in the state of Indiana. An exemption to conduct this survey was obtained from Purdue University Human Research Protection Program and Institution Review Board on December 10th, 2019 (IRB-2019-791: Exempt). A copy of the survey is included in appendix A.

2.3.2 Survey distribution:

The survey was conducted via the Qualtrics online survey tool. The survey was distributed by electronic mail to subscribers of (1) the Purdue University Agricultural Extension Educators distribution list on February 28, 2020, and (2) the Indiana State Department of Health (ISDH) physician network distribution list (Table 2.1) on March 18th, 2020. The Purdue University Agricultural Extension Educators distribution list comprised approximately 750 recipients and included Extension Educators, county support staff and program managers. The ISDH physician network distribution list comprised 62,564 recipients licensed by the following Indiana medical professional boards: Advanced Practice Registered Nurse (APRN) prescriptive authority, licensed practical nurse, non- Educational Commission of Foreign Medical Graduates (ECFMG) training permit, Osteopathic Medicine (DO), Physician, Physician Assistant (PA), temporary DO permit, and temporary Doctor of Medicine (MD) permit. Recipients in the PUAES distribution list received a reminder notice on April 8th, 2020. The data collection was terminated on April 10th, 2020.

Table 2.1. List of providers included in the survey distribution by licensing board and licensing type.

Profession Name	**License Type**	**Counts**
Nursing Board	APRN Presciptive Authority	7665
Nursing Board	Licensed Practical Nurse	24394
Medical Licensing Board	Non-ECFMG Training Permit	10
Medical Licensing Board	Osteopathic Physician	2704
Medical Licensing Board	Physician	25720
Physician Assistant Committee	Physician Assistant	2042
Medical Licensing Board	Temporary DO Permit	2
Medical Licensing Board	Temporary DO Permit	27
Total		**62564**

2.3.3 Survey analyses:

The survey data were extracted from the Qualtrics database by T. Luck. The raw data were analyzed using Microsoft Excel and displayed using GraphPad Prism (version 8.0.2 (159)). Quantitative analyses were performed for Questions 1 – 22 (discrete and ordinal questions) and qualitative analysis was performed for question 23 (open-ended question) (refer to Appendix B for full list of responses to question 23).

Coding and qualitative data analyses for Question 23:

The open coding method (Corbin & Strauss, 2008) was used to code question 23. This coding system enables coding of sentences containing multiple clauses into separate themes. The unit of analysis was established as one unit per sentence unless the respondent used conjunction. Acceptable conjunctions included: ‘comma’, ‘and’, ‘but’, ‘or’, ‘so’, or, ‘which’. In the case of multiple clauses per sentence, the unit of analysis was established as one unit per clause. Coding of any one clause as 'Not Applicable' resulted in all remaining clauses of the response coded as 'Not Applicable'. In the case of responses comprising conjunctions, coding was shifted to unit(s) per clause. In the case of a response comprising multiple clauses of identical themes, the entire response was considered one unit. In the case of responses comprising multiple clauses and themes, each clause was coded as a single unit. The unit, either per sentence, per clause, or per response was coded once. Double coding into more than one theme was not permitted.

Themes and associated subcategories were identified via the inductive and iterative approach (Corbin & Strauss, 2008, Cho & Lee, 2014). After the data was received, themes and associated subcategories were established by consensus among three individual coders. The open coding system was used to identify six major categories: 1. *Healthcare provider*; 2. *Healthcare system*; 3. *Patient*; 4. *Disagreement*; 5. *Education*; and 6. *Not Applicable*. Between one to three subcategories were established for each of the major categories using axial coding to further cluster themes that emerged. See Table 2.12 for definition and examples of subcategories. Following the assessment of intercoder reliability, final coding of all Q23 responses was performed (see Table 2.12).

Intercoder reliability (ICR):

Initially three coders with knowledge of ticks and TBDs tested the code and ICR was assessed to determine suitability of the code. Coders underwent virtual training, and the process of test coding led to revisions in the codebook. Separate coders underwent training and were then supplied with 20% (120 of 597) of the responses for Q23 (What are the major issues you have faced in diagnosis and treatment of TBDs in Indiana?), along with the final version of the codebook and 40 example coded responses as reference. Twenty percent of the responses were randomly chosen by using the Google random number generator tool. Krippendorff's alpha of 0.8 (Krippendorff, 2011) was calculated to determine a reliability score where a value greater than 0.7 is considered "tolerable for exploratory studies" (Nili et al, 2020).

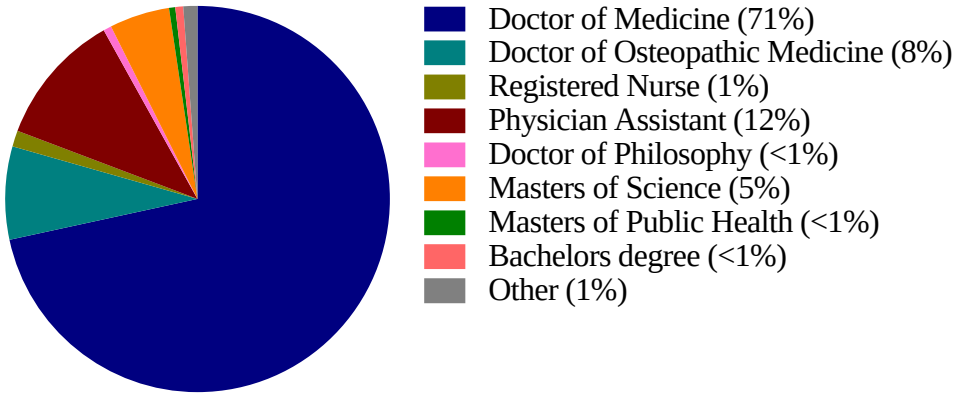
2.4 Results

In total, 597 individuals successfully completed the "Ticks and Tick-Borne Diseases: Assessing and Addressing Communication Needs for Indiana Public Health Providers" survey between February 28th, 2020 to April 10th, 2020.

2.4.1 Professional qualifications, training, and nature of practice

Section 1 responses provided information regarding qualifications, years of training, the nature of the medical practice, the medical practice setting and whether respondents served Urban or Rural communities.

Highest level of training: In total, 597 responses were received for what Q1. Seventy one percent of respondents selected Doctor of Medicine (MD), 12% Physician Assistant (PA), 8% Doctor of Osteopathic Medicine (DO), 5% Master of Science (MS), with the remaining respondents selected Registered Nurse (RN) (1%), Doctor of Philosophy (Ph.D.) (1%), Master of Public Health (MPH) (1%), Bachelor's degree (<1%) and other (<1%) (Figure 2.1.). Among those who reported other were PA (0.8%), MD Ph.D. (0.3%), Internal Medicine (IM) residency (0.2%), MS in anesthesia (0.2%), Master of Business Administration (MBA) (0.2%), Master for Social Work (MSW) (0.2%), and office administrator (0.2%) (Table 2.2).



Total Respondents = 597

Figure 2.1. The highest level of professional training indicated by survey respondents. Numbers in parentheses represent the number of respondents per category expressed as a percentage of the total number of respondents.

Table 2.2: Highest level of training reported by 1% respondents who selected "other" for Question 1.

Highest level of training:"other"	**Total Number of Respondents (% respondents)**
Physician (no S) Assistant	5 (0.8%)
MD, PhD	2 (0.3%)
IM Residency	1 (0.2%)
Master of science in anesthesia	1 (0.2%)
MBA	1 (0.2%)
MSW	1 (0.2%)
Office Administrator	1 (0.2%)

Note: MD, Doctor of Medicine; PhD, Doctor of Philosophy; IM, Internal Medicine; MBA, Master of Business Administration; MSW, Master of Social Work

Medical practice setting: In total, 743 responses were received for Q2 as respondents had the option to select more than one response for this question. Twenty eight percent of survey respondents indicated practice in a Primary care office (Figure 2.2A). Seventy seven percent of those who practiced in a primary care setting were MDs, 11% were DOs, 10% were PAs, and 1% or less were RNs, Ph.Ds, MS, MPHs, BSs or other (Figure 2.2B). Twenty three percent of respondents practiced in a Specialty care office and of these, 83% were MDs, 8% were PAs, 6% were DOs, 2% were other, and 1% or less were RN, Ph.D., MS, MPH or BS. Twenty percent of respondents indicated practice in a Hospital (Inpatient) setting and of these, 79% were MDs, 8% were DOs, 8% were PAs, 3% were other, and 1% or less were RN, Ph.D., MS, MPH or BS. Fourteen percent of respondents selected "other" (Table 2.3) of which, 79% of were MDs, 6%

were DOs, 6% were RNs, 5% were MS, 2% were PAs, and 1% or less were RN, Ph.D., MPH or BS. Eleven percent of respondents practiced in a Hospital (Outpatient) setting, and of these, 83% were MDs, 8% were DOs, 5% were PAs, 2% were RN's, 2% were MPH, and 2% were "other". Ten percent of respondents practiced in Hospital (Emergency Department), and among these individuals, 54% were MDs, 32% were PAs, and 14% were DOs. Seven percent of respondents indicated that they did not currently practice, and 77% of these were MDs, 9% were MS, 5% were PAs, 5% were Ph.D.s, 2% were DOs and 2% were RNs. Six percent of respondents reported that they did not practice medicine and 67% of these individuals listed an MS degree as their highest level of training. Lastly, 5% of respondents practiced in an Urgent care office, and of these individuals, 56% were MDs and 37% were PAs. Among respondents who listed "Other" for medical practice setting, the most common settings by term were 'retired' (2%), 'academic/teaching' (1%), and 'county/ local health department' (<1%) (Table 2.3).

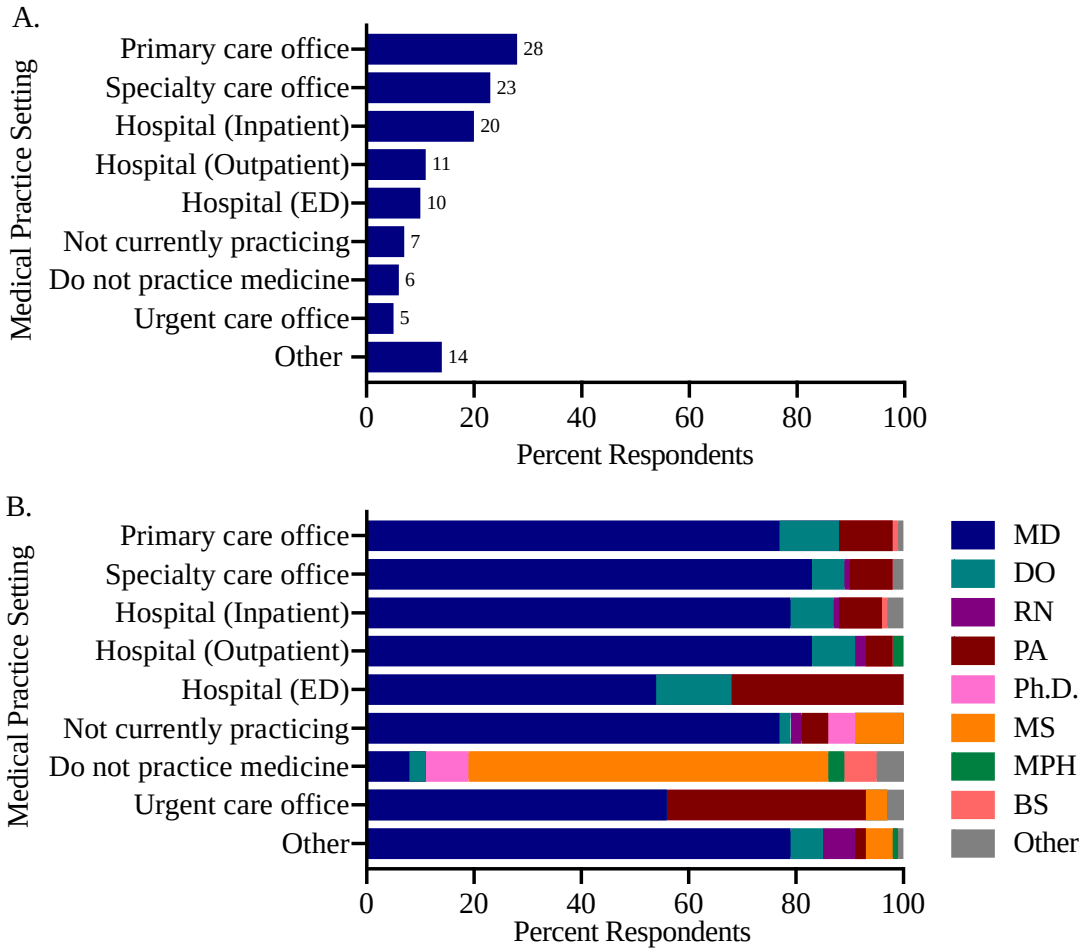


Figure 2.2. Medical practice setting indicated by survey respondents. A: medical practice setting indicated by respondents expressed as a percentage of total respondents (numbers to the right of bars show percent respondents per category). B: The highest level of training by medical practice setting shown as a percentage of the total number of respondents. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; RN, Registered Nurse; PA, Physician Assistant, Ph.D., Doctor of Philosophy; MS, Master of Science; MPH, Master of Public Health; BS, Bachelor of Science; and other. ED, Emergency Department

Table 2.3. Medical practice settings reported by respondents who selected “other”

Medical practice setting: "other"	Total Number of Respondents (% respondents)
Retired	12 (2.0%)
Academic/ Teaching	6 (1.0 %)
County/ local health department	5 (0.8%)
Anesthesiology	4 (0.7%)
Lab	4 (0.7%)
Public Health	4 (0.7%)
Telehealth/ telemed	4 (0.7%)
Ambulatory surgery center	3 (0.5%)
Hospital-surgery	3 (0.5%)
Nursing home	3 (0.5%)
Occupational health/ Medicine	3 (0.5%)
Radiology	3 (0.5%)
Residency	3 (0.5%)
Inpatient and Outpatient	2 (0.3%)
College health	2 (0.3%)
Commercial medical lab	2 (0.3%)
Extended care facility	2 (0.3%)
Home care	2 (0.3%)
Pathologist/ pathology	2 (0.3%)
Clinic for the uninsured	1 (0.2%)
Dermatopathology lab out of state	1 (0.2%)
Extension office	1 (0.2%)
For corporate employees only	1 (0.2%)
Forensic laboratory	1 (0.2%)
Radiology	1 (0.2%)
Lyme practice	1 (0.2%)
Medical informatics	1 (0.2%)
Medical examiner	1 (0.2%)
Offsite facility for elderly	1 (0.2%)
Perioperative care	1 (0.2%)
Presently and last 40 years in Kenya	1 (0.2%)
Specialty care training	1 (0.2%)
Subacute care	1 (0.2%)
Wound care clinic	1 (0.2%)

Area of specialty: In total, 668 responses were received for Q3, as the respondents had the option to select more than one response for this question. Forty percent of the respondents reported specialty as “other” (Table 2.3). Twenty two percent of respondents selected Family Medicine, 11% Internal Medicine, 11% Emergency Medicine, 10% Pediatrics, 6% Purdue Cooperative Extension Service (PCES), and 5% or less of respondents selected General Practice (5%), Urgent Care (3%), Public Health (3%) and Infectious Disease (1%) (Figure 2.3A).

Among respondents who practiced in a “Specialty care office”, 83% selected ‘other’ as specialty area, and among these, the most common specialty based on use of term were Obstetrics

and Gynecology (10%), Orthopedics (10%), and Dermatology/Dermatopathology (9%). Among respondents who 'Do not practice medicine', 81% reported "Purdue Cooperative Extension Service" as specialty. 78% of respondents who practiced in an 'Hospital (Emergency Department)' reported 'Emergency Medicine' as their specialty. Sixty five percent of respondents who practiced in a Hospital (outpatient) indicated 'other' as their specialty, and among these, the most common specialty based on use of term was Anesthesiologist (24%), Surgery (10%), Neurologist (6%), OB/GYN (6%) and Radiology (6%). "Other" was selected as a specialty by 58% of respondents who report that they practiced in a Hospital (inpatient) setting, and among these, the most common specialties based on use of terms were Anesthesia (19%), Surgery (9%), Neurologist (8%), and OB/GYN (8%). 54% of respondents who reported practice in a Primary care office selected 'Family Medicine' as their area of specialty (Figure 2.3B; Table 2.4).

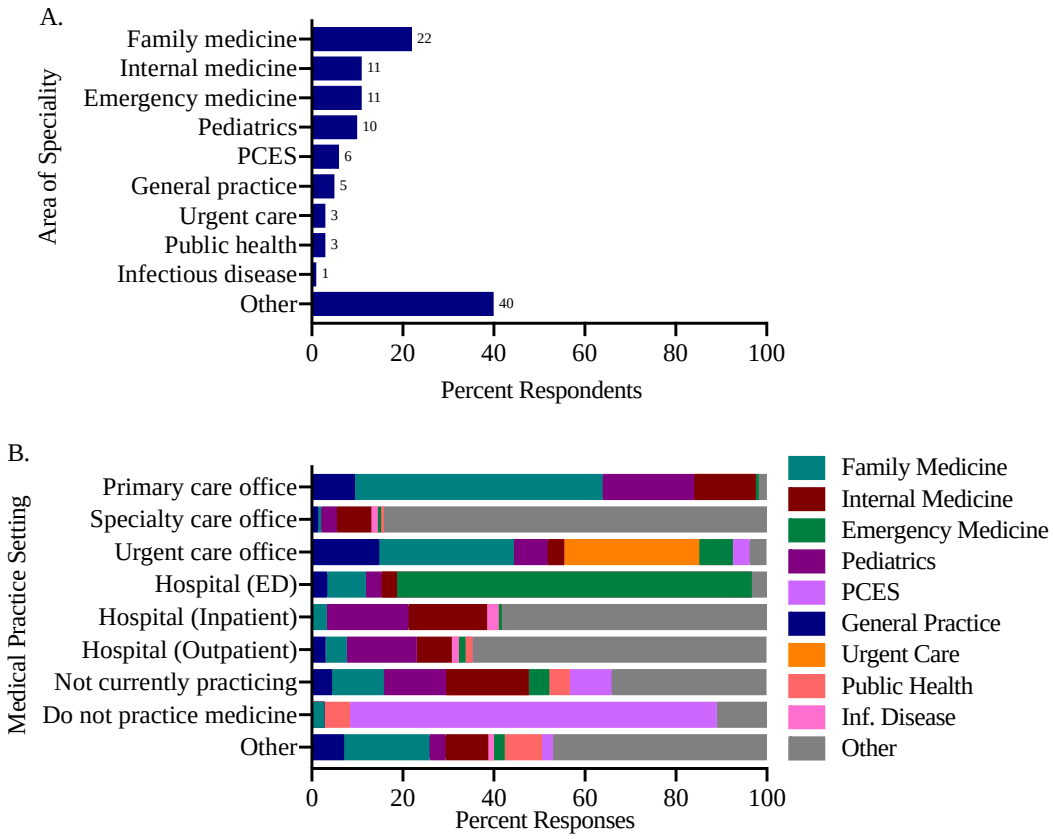


Figure 2.3. Area of specialty indicated by survey respondents. A: Area of specialty expressed as a percentage of the total number of respondents (numbers to the right of the bars show percent respondents). B. Area of specialty by medical practice setting, expressed as a percentage of total responses. ED, Emergency Department; Inf. Disease, Infectious Disease; PCES, Purdue Cooperative Extension Service.

Table 2.4: Area of specialty reported by respondents who selected “other”

Area of specialty: "other"	**Total Number of Respondents (% respondents)**
Anesthesiology and Pain Management	28 (11.8%)
Obstetrics and gynecology	18 (7.6%)
Neurologist/Neuroradiology	13 (5.5%)
Orthopaedics	13 (5.5%)
Radiology	12 (5.0%)
Surgery	12 (5.0%)
Dermatology/Dermatopathology	11 (4.6%)
Psychiatry	11 (4.6%)
Pathology	9 (3.8%)
Cardiology	8 (3.4%)
Ophthalmology	8 (3.4%)
Allergy and Immunology	6 (2.5%)
Pediatric	6 (2.5%)
General surgery	5 (2.1%)
Gastroenterologist	4 (1.7%)
Hematology/Oncology	4 (1.7%)
Palliative Care	4 (1.7%)
Rheumatology	4 (1.7%)
Endocrinology	3 (1.3%)
Medical Genetics	3 (1.3%)
Occupational Medicine	3 (1.3%)
Otolaryngology	3 (1.3%)
Physical medicine and rehabilitation	3 (1.3%)
Urology	3 (1.3%)
Child and Adolescent Psychiatry	2 (0.8%)
Critical care	2 (0.8%)
Diagnostic radiology	2 (0.8%)
Forensic Pathology/ Forensics	2 (0.8%)
Geriatrics	2 (0.8%)
Laboratory/ Microbiology	2 (0.8%)
Pulmonologist	2 (0.8%)
sports medicine	2 (0.8%)
Adolescent medicine	1 (0.4%)
Aerospace medicine, military medicine	1 (0.4%)
Behavioral health	1 (0.4%)
College health	1 (0.4%)
Cosmetic	1 (0.4%)
Ct	1 (0.4%)
Electrophysiology	1 (0.4%)
Functional Medicine	1 (0.4%)
Genetics	1 (0.4%)
Gynecology	1 (0.4%)
Hospitalist	1 (0.4%)
Integrative Medicine	1 (0.4%)
Interventional Radiology	1 (0.4%)
Legal	1 (0.4%)

Table 2.4 continued

Lyme Practice	1 (0.4%)
Mammography	1 (0.4%)
managed care	1 (0.4%)
Medical informatics	1 (0.4%)
Morgue	1 (0.4%)
MSK Pain	1 (0.4%)
Neonatology	1 (0.4%)
Nephrology	1 (0.4%)
Nuclear medicine	1 (0.4%)
Operating room	1 (0.4%)
Plastic surgery	1 (0.4%)
Trauma	1 (0.4%)
tropical infectious disease	1 (0.4%)
womens health	1 (0.4%)

Number of years of practice in health care: In total, 597 responses were received for Q4. Thirty nine percent of respondents reported that they had practiced for more than 25 years. The remaining respondents reported 21-25 (11%), 16-20 (10%), 11-15 (10%), 6-10 (11%), 1-5 (13%), or <1 (5%) years of practice in health care (Figure 2.4A).

Among MDs completing the survey, 47% indicated that they had practiced for 25 years or more. Among DOs and PAs, 30% and 35%, respectively had practiced for 1-5 years. Sixty seven percent of those with an MS degree had practiced for less than 1 year (Figure 2.4B).

Thirty seven percent of those who practiced in a Primary care office indicated that they have practiced for more than 25 years. Forty four percent of respondents who practiced in the Specialty care setting reported in excess of 25 years practice. Thirty seven percent of respondents who practiced in the urgent care setting had practiced for 6-10 years. Twenty percent of respondents who practiced in the Hospital (Emergency Department) setting reported they had practiced for more than 25 years, while twenty eight percent of those who practiced in the Hospital (Inpatient) setting exceeded 25 years of practice. Forty percent of respondents that indicated the Hospital (Outpatient) setting had practiced for more than 25 years. Sixty one percent of respondents who indicated ‘Not currently practicing’ had practiced for more than 25 years. Sixty nine percent of respondents who reported ‘Do not practice Medicine’, indicated that they had practiced for less than one year. Lastly, 59% of those who reported ‘other’ as their medical practice setting, had practiced for more than 25 years (figure 2.4C).

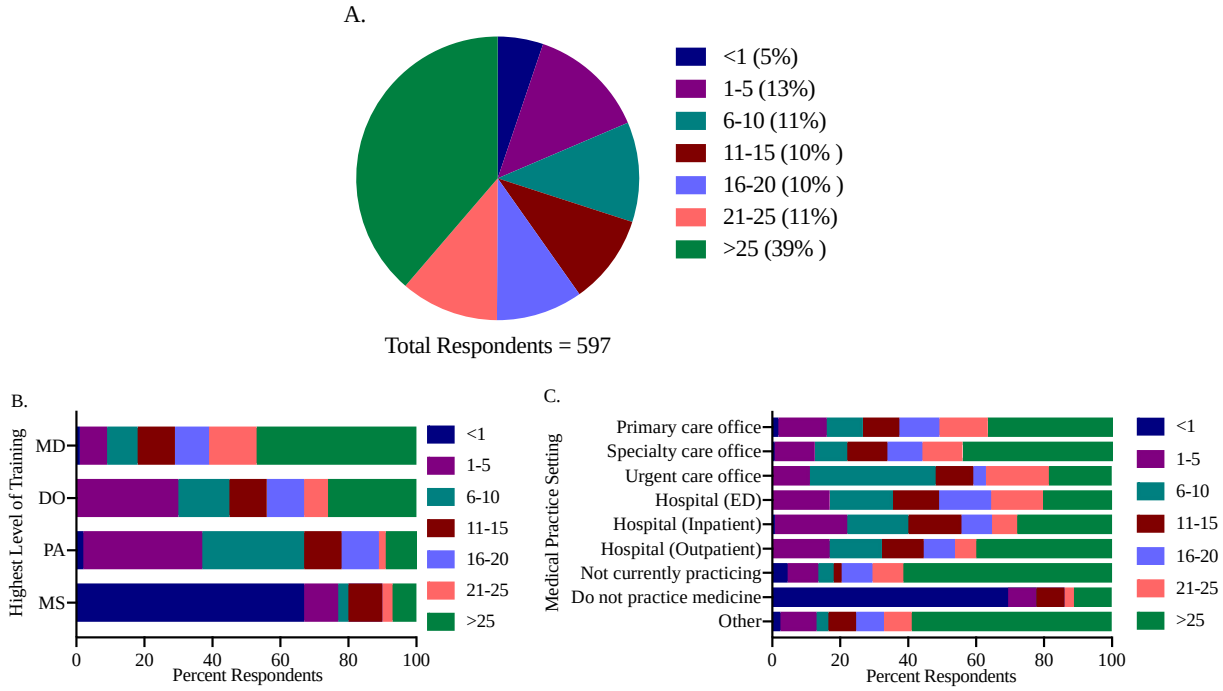


Figure 2.4. Number of years practiced in healthcare reported by survey respondents. A: Number of years practiced in healthcare and showing percentage of respondents (in parentheses) who reported practicing <1 year, 1-5 years, 6-10 years, 11-15 years, 16-20 years, 21-25 years, and >25 years. B: Number of years practiced by highest level of training, expressed as percentage of highest level of training. C: Number of years practiced by medical practice setting, expressed as a percentage of medical practice setting. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science, ED, Emergency Department.

Service to Rural and Urban communities: In total, 597 responses were received for Q5. Sixty two percent of respondents served both Rural and Urban communities, 21% served Urban communities only, and 17% served Rural communities only (Figure 2.5A).

Among MDs, 63% served both Rural and Urban communities, 22% served only Urban communities and 15% served only Rural communities. Among DOs, 50% served Rural and Urban communities, 33% only Rural communities and 17% only Urban communities. Among PAs, 53% served Rural and Urban communities, 35% only Urban communities and 12% only Rural communities. Sixty three percent of respondents who held an MS degree as the highest level of qualification served both Rural and Urban communities, 33% served only Rural communities and 3% served only Urban communities (Figure 2.5B).

Of those who reported Primary care office as their medical practice setting, 48% indicated that they served both Rural and Urban communities, while 28% indicated only Rural and 24% indicated only Urban (Figure 2.5C). Seventy three percent of respondents who practiced in a Specialty care office served both, 21% indicated only Urban, 7 % indicated only Rural. Sixty seven percent of those who practiced in an Urgent care office served both, 22% indicated only Urban, and 11% indicated only Rural. Sixty six percent of those who practiced in the Hospital (Emergency Department) served both communities, 20% indicated that they served only Urban, and 14% indicated only Rural. Sixty three percent of those who practiced in Hospital (Inpatient) served both communities, 25% indicated that they served only Urban, and 11% indicated only Rural. Sixty nine percent of those who practiced in the Hospital (outpatient), indicated that they served both communities, 22% served only Urban, and 9% served only Rural. Sixty six percent of those who reported 'Not currently practicing', served both communities, 23% indicated that they served only Urban, and 11% indicated only Rural. Sixty four percent of those who reported 'Do not practice medicine', served both communities, 33% served only Rural, and 3 % served only Urban. Fifty nine percent of those who reported 'other' as their medical practice setting, served both communities, 21% indicated that they only served Rural, and 20% indicated Urban (Figure 2.5C).

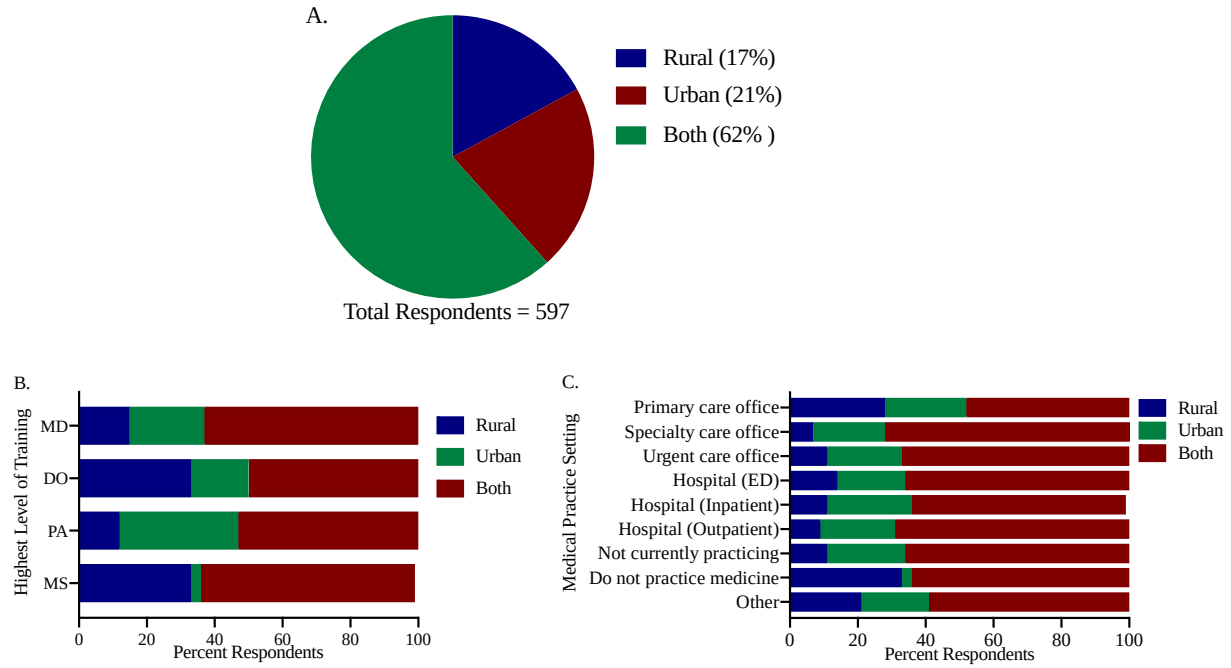


Figure 2.5. Service to Rural and Urban communities. A: Number of respondents who reported service to Rural and Urban communities where numbers in parentheses show number of respondents expressed as a percentage of the total number of respondents. B: Rural and Urban community service by highest level of training expressed as a percentage of highest level of training. C Rural and Urban community service by medical practice setting expressed as percentage of medical practice setting. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science, ED, Emergency Department.

Number of patients presenting with a suspected or confirmed TBD in a typical year: In total 597 responses were received for Q6. Fifty seven percent of the respondents selected 1-25 patients with a suspected or confirmed TBD, 19% selected 'zero' patients, 18% selected 'Not Applicable', 4% selected 26-50 patients, 1% selected 51-75 patients, and less than one percent selected 76-100 or greater than 100 (Figure 2.6A).

Among MDs, 58% reported 1-25 patients with a suspected or confirmed TBD, 21% reported zero patients, 14% selected "Not Applicable" and 5% reported 26-50 patients. Among DOs, 74% reported 1-25 patients, 13% selected "Not Applicable" and 9% reported zero patients with a suspected or confirmed TBD. Among PAs, 73% reported 1-25 patients with a suspected or confirmed TBD, 14% selected zero patients and 11% selected "Not Applicable". Among MS, 73% selected "Not Applicable", 20% selected zero patients and 7% reported 1-25 patients with suspected or confirmed TBD in a typical year (Figure 2.6B).

The following percentage of medical practice settings consulted 1-25 patients with suspected or confirmed TBD: Primary care office (83%), Specialty care office (55%), Urgent care office (70%), Hospital (Emergency Department) (81%), Hospital (Inpatient) (48%), Hospital (Outpatient) (38%), 'Not currently practicing' (16%), 'Do not practice Medicine' (8%), and 'other' (39%). The following percentage of medical practice settings consulted zero patients with suspected or confirmed TBD: Primary care office (7%), (29%), Urgent care office (4%), Hospital (Emergency Department) (7%), Hospital (Inpatient) (33%), Hospital (Outpatient) (40%), 'Not currently practicing' (26%), 'Do not practice Medicine' (19%), and 'other' (24%). The percentage of medical practice settings that consulted 26-50 patients with suspected or confirmed TBD were Primary care office (8%), Specialty care office (2%), Urgent care office (19%), Hospital (Emergency Department) (7%), Hospital (Inpatient) (2%), Hospital (Outpatient) (2%), and 'Not currently practicing' (2%). The percentage of medical practice settings that consulted 51-70 patients with suspected or confirmed TBD were Specialty care office (1%), Urgent care office (4%), and Hospital (Emergency Department) (5%). The following percentage of medical practice settings that consulted 76-100 patients: Specialty care office (1%), and 'other' (1%). The following medical practice settings reported 'Not Applicable': Primary care office (1%), Specialty care office (12%), Urgent care office (4%), Hospital (Inpatient) (18%), Hospital (Outpatient) (20%), 'Not currently practicing' (56%), 'Do not practice Medicine' (72%), and 'other' (35%) (Figure 2.6C).

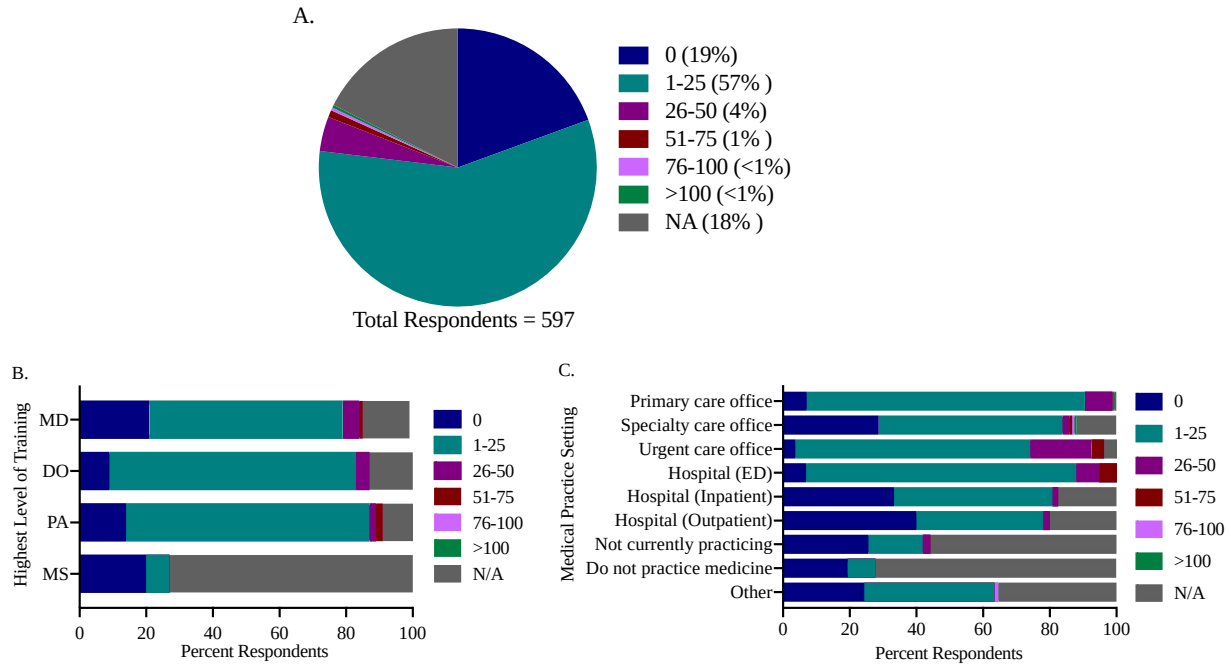


Figure 2.6. Number of patients that present with suspected or confirmed TBDs per year. A: Number of respondents who consulted with 0 patients with suspected or confirmed TBDs per year, 1-25 patients, 26-50 patients, 51-75 patients, 76-100 patients, >100 to patients or NA, Not Applicable and expressed as percentage of total respondents in parentheses, where respondents reported. B: Number of patients by highest level of training, expressed as a percentage of highest level of training. C: Number of patients by medical practice setting, expressed as a percentage of medical practice setting. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science, ED, Emergency Department.

2.4.2 Knowledge of ticks and tick-borne diseases

Section 2 of the survey collected information on provider knowledge of ticks, tick biology, TBDs endemic to the state of Indiana, diagnoses, and the signs and symptoms of TBDs.

Human TBDs identified by respondents as endemic in the state of Indiana: In total, 1435 responses were received to Q7. With regard to TBDs, the following were reported as endemic to the state of Indiana by survey respondents: Lyme disease (69% respondents), unsure (40%) Spotted Fever rickettsioses (37%), Human Ehrlichiosis (27%), Tularemia (15%), Babesiosis (14%), STARI (11%), Anaplasmosis (10%), Alpha-gal allergy (8%), Heartland virus (6%), and Powassan virus (4%) (Figure 2.7A).

Among MDs, 69% reported Lyme disease, 41% reported Spotted Fever Rickettsioses (SFR), 39% selected ‘unsure’, 30% Human Ehrlichiosis, 17% Tularemia, 15% Babesiosis, 13% Southern tick associated rash illness (STARI), 10% Anaplasmosis, 10% Alpha-gal Allergy, and 6% Heartland virus as endemic. Among DOs, 74% reported Lyme disease, 28% Human Ehrlichiosis, 28% SFR, 28% selected ‘unsure’, 13% Babesiosis, 11% Anaplasmosis, 11% Tularemia, 7% Heartland virus, 7% STARI, and 4% Alpha-gal allergy as endemic. Among PAs, 80% reported Lyme disease, 38% selected unsure, and 27% reported SFR. Among MS, 73% selected unsure, 50% reported Lyme disease, and 23% reported SFR as endemic (Figure 2.7B).

Among those in the Primary care office as medical practice setting, 29% reported Lyme disease, 17% reported SFR, 13% selected ‘unsure’, 7% reported Babesiosis, 7% reported Tularemia, 5% reported Anaplasmosis, and 5% reported STARI as endemic. In the Specialty care office setting, 29% respondents reported Lyme disease, 16% selected ‘unsure’, 14 % reported SFR, 10% reported Human Ehrlichiosis, 7 % reported STARI, 6% reported tularemia, and 5% reported Babesiosis as endemic. In the Urgent care office setting, 32% reported Lyme disease, 16% reported SFR, 13% reported Human Ehrlichiosis, 12% selected ‘Unsure’, 7% reported STARI, and 6% reported Babesiosis as endemic. In the Hospital (Emergency department) setting, 33% reported Lyme disease, 15% reported SFR, 14% selected ‘unsure’, 11% reported Human Ehrlichiosis, 6% reported babesiosis, 6% reported Alpha-gal allergy, and 5% reported Tularemia. In the Hospital (Inpatient) setting, 28% reported Lyme disease, 20% selected ‘Unsure’, 14% reported SFR, 12% reported Human Ehrlichiosis, 6% reported Babesiosis, and 5% reported Tularemia. In the Hospital (Outpatient) setting, 28% reported Lyme disease, 21% selected ‘unsure’, 13% reported SFR, 10% reported Human Ehrlichiosis, 6% reported Babesiosis, and 6% reported Tularemia. Of those respondents ‘Not currently practicing’, 29% reported Lyme disease, 19% selected ‘unsure’, 18% reported SFR, 11% reported Human Ehrlichiosis, and 8% reported Tularemia. Of those who reported ‘Do not practice Medicine’, 33% selected ‘unsure’, 31% reported Lyme disease, 14% reported SFR, and 7% reported Human Ehrlichiosis. Those who selected ‘other’ as their medical practice setting, 25% reported Lyme disease, 17% reported SFR, 16% selected ‘unsure’, 13% reported Human Ehrlichiosis, 7% reported Tularemia, 6% reported Babesiosis, and 6% reported STARI as endemic (Figure 2.7C).

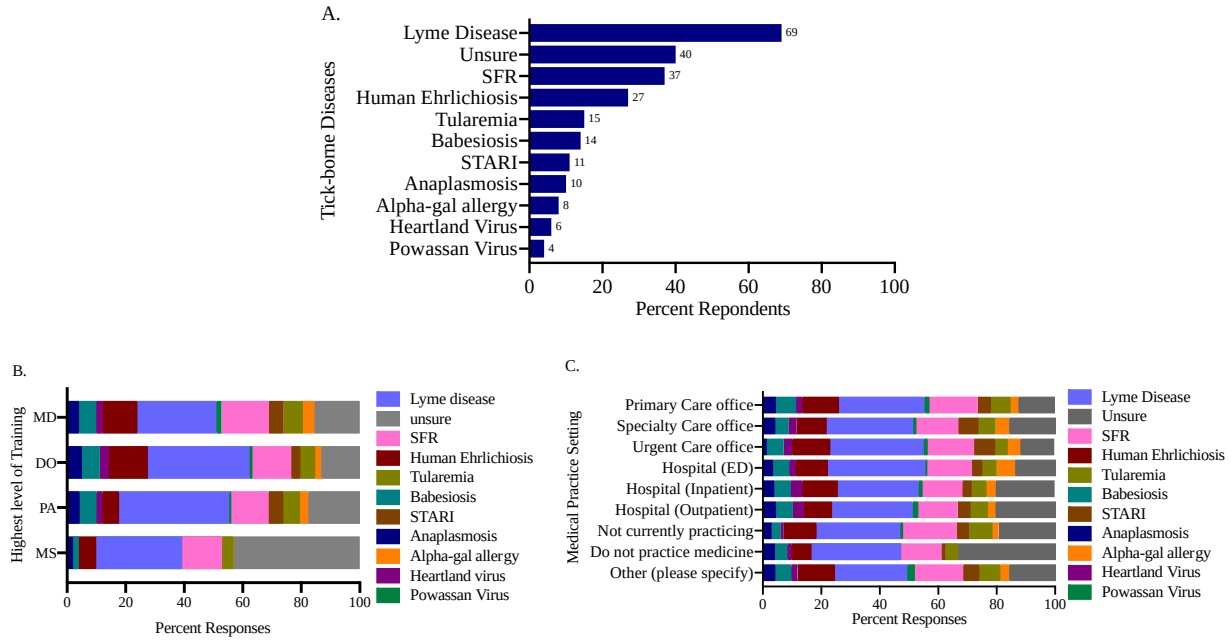


Figure 2.7. Tick-borne diseases identified as endemic in the state of Indiana by survey respondents. A: Percentage of respondents that reported Anaplasmosis, Babesiosis, Heartland virus, human Ehrlichiosis, Lyme disease, Powassan virus, spotted fever rickettsiosis, southern tick associated rash illness, tularemia, Alpha-gal allergy and unsure, expressed as a percentage of the total number of respondents (numbers to the right of the bars indicate percent respondents). B: TBDs identified as endemic by highest level of training, expressed as a percentage of highest level of training. C: TBDs identified as endemic by medical practice setting, expressed as a percentage of medical practice setting. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science; ED, Emergency Department; SFR, spotted fever rickettsiosis; STARI, southern tick associated rash illness.

Human TBDs diagnosed in the state of Indiana: In total, 807 responses were received to Q8, as respondents had the option to select more than one response for this question. Fifty two percent of respondents indicated that the diagnosis of TBDs was 'Not Applicable', 44% reported diagnosis of human Lyme disease cases, 16% SFR, 8% Human Ehrlichiosis, and 5% or less reported diagnosis of Alpha-gal allergy, Babesiosis, Tularemia, Anaplasmosis, STARI, Heartland virus and Powassan virus cases (Figure 2.8A).

Among MDs, 46% reported diagnosis of Lyme disease, 49% reported 'Not Applicable', and 18% reported SFR cases. Among DOs, 50% reported diagnosis of Lyme disease cases, 48% percent selected 'Not Applicable', and 13% reported SFR cases. Among PAs, 56% reported diagnosis of Lyme disease cases, 44% selected 'Not Applicable' and 14% reported SFR cases. Ninety seven percent of those with an MS selected 'Not Applicable'(Figure 2.8B).

Forty six percent of those who practiced in the Primary care office setting reported diagnosis of Lyme disease cases, 21% selected 'Not Applicable', 16% reported SFR and 8% reported Human Ehrlichiosis cases. Forty three percent of those that practiced in the Specialty care office setting selected 'Not Applicable', 26% reported diagnosis of Lyme disease cases, 8% reported SFR, and 7% reported Human Ehrlichiosis cases. Fifty eight percent of respondents that practiced in the Urgent care office setting reported diagnosis of Lyme disease cases, 20% reported SFR, 10% reported Human Ehrlichiosis cases, and 10% selected 'Not Applicable'. Forty five percent of those that practiced in the Hospital (Emergency Department) reported diagnosis of Lyme disease, 30% selected 'Not Applicable', 13% reported SFR, and 7% reported Human Ehrlichiosis. Forty seven percent of those that practiced in the Hospital (inpatient) setting selected 'Not Applicable', 23% reported diagnosis of Lyme disease, 10% reported SFR, and 6% reported Human Ehrlichiosis. Fifty three percent of that practiced in the Hospital (outpatient) setting selected 'Not Applicable', 23% reported diagnosis of Lyme disease, 8% reported SFR, and 6% reported Human Ehrlichiosis. Fifty one percent of those 'not currently practicing' also selected 'Not Applicable', 28% reported diagnosis of Lyme disease, 11% reported SFR, and 8% Human Ehrlichiosis. Eighty percent of those who 'Do not practice Medicine' also selected 'Not Applicable', and 8% reported diagnosis of Lyme disease. Fifty two percent of respondents that selected 'other' as their medical practice setting, selected 'Not Applicable', 22% percent reported diagnosis of Lyme disease and 7% reported SFR (Figure 2.8C).

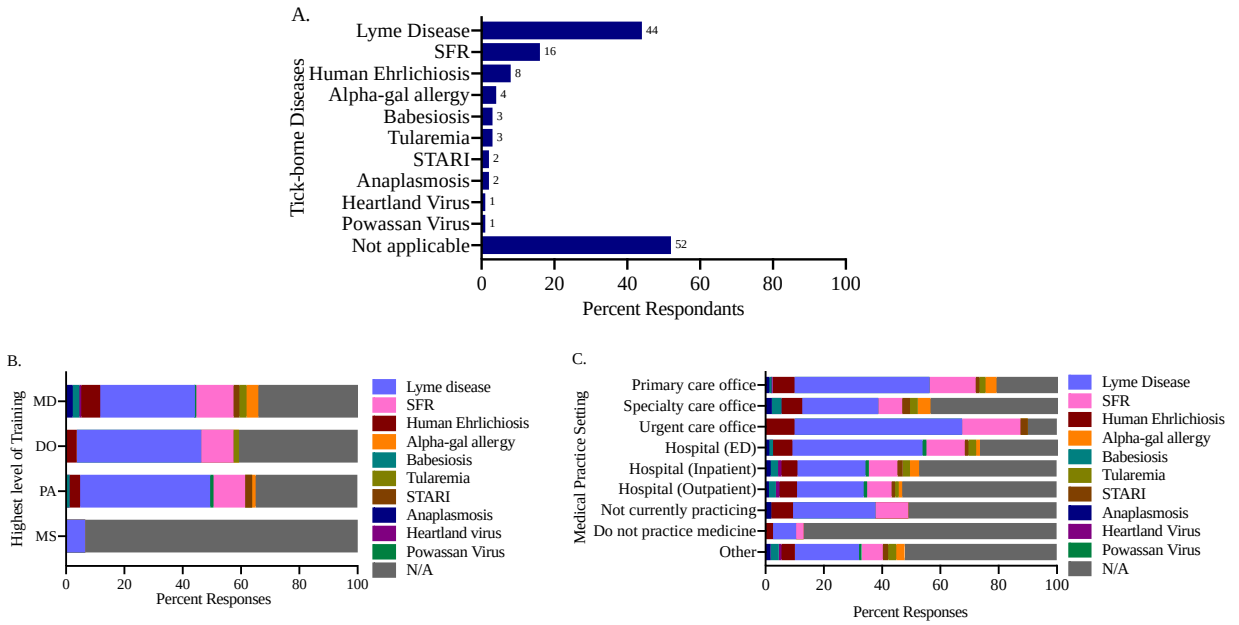


Figure 2.8. Tick-borne diseases diagnosed in the state of Indiana. A: TBDs diagnosed in the state of Indiana indicated by respondents expressed as a percentage of total respondents (number to the right of the bar indicate percent respondents). B: TBDs diagnosed in the state of Indiana by highest level of training expressed as a percentage of highest level of training. C: TBDs diagnosed in the state of Indiana by medical practice setting expressed as a percentage of medical practice setting. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science; ED, Emergency Department; SFR, spotted fever rickettsiosis; STARI, southern tick associated rash illness.

Ticks capable of transmitting diseases to humans in the state of Indiana: 858 responses were received to Q9, as respondents had the option to select more than one response for this question. Forty seven percent of respondents asked to identify four species of ticks considered important vectors of disease and established in Indiana selected 'unsure', 31% reported *I. scapularis*, 27% selected 'all the above', 20% reported *A. americanum*, 13% reported *D. variabilis*, and 7% reported *R. sanguineus* (Figure 2.9A).

Among MDs, 30% of responses were 'unsure', 23% were *I. scapularis*, 19% 'all of the above', 15% *A. americanum*, 9% *D. variabilis*, and 4% *R. sanguineus*. Among DOs, 35% of were 'unsure', 23% were *I. scapularis*, 18% were 'all of the above', 6% were *D. variabilis*, and 3% were *R. sanguineus*. Among PAs, 34% of the responses were 'unsure', 24% were *I. scapularis*, 14% were 'all of the above', 10% were *D. variabilis*, 9% were *R. sanguineus* and 8% were *A. americanum*. Among MS, 51% of the responses were 'unsure', 24% were 'all of the above', 8%

were *I. scapularis,* 8% were *A. americanum,* 5% were *D. variabilis,* and 3% were *R. sanguineus* (Figure 2.9B).

Twenty six percent of the responses by those who practice in a primary care office were *A. americanum,* 24% were *I. scapularis*, 23% were 'unsure', 14% were 'all the above', 7% were *D. variabilis,* and 7% were *R. sanguineus*. Twenty six percent of the responses by those who practice in a Specialty care office were 'unsure', 22% were *A. americanum*, 22% were 'all of the above', 18% were *I. scapularis,* 10% were *R. sanguineus,* and 3% were *D. variabilis*. Thirty percent of the responses by those who practice in Urgent care office were 'unsure', 20% were 'all of the above', 18% were *I. scapularis,* 15% were *A. americanum,* 14% were *D. variabilis,* and 3% were *R. sanguineus*. Twenty six percent of the responses by those who practice in a Hospital (Emergency department) were 'unsure', 24% were *I. scapularis,* 24% were *A. americanum,* 16% were 'all of the above', and 8% were *R. sanguineus*. Thirty three percent of the responses by those who practice in Hospital (inpatient) were 'unsure', 19% were *I. scapularis*, 19% were 'All of the above', 14% were *A. americanum,* 9% were *D. variabilis,* and 6% were *R. sanguineus*. Thirty five percent of the responses by those who practice in Hospital (outpatient) were 'unsure', 21% were *I. scapularis*, 21% were 'all of the above', 9% were *D. variabilis,* 9% were *A. americanum,* and 6% were *R. sanguineus*. Thirty nine percent of the responses by those who are not currently practicing were *I. scapularis,* 18% were *A. americanum*, 18% were 'unsure', 9% were *R. sanguineus*, 9% were 'all of the above', and 7% *D. variabilis*. Forty one percent of the responses by those who do not practice Medicine were 'unsure', 22% were 'all of the above', 18% were *I. scapularis,* 11% were *D. variabilis,* 5% were *A. Americanum,* and 2% were *R. sanguineus*. Thirty three percent of the responses by those who selected 'other' medical practice setting were 'unsure', 24% were *I. scapularis*, 18% were 'All of the above', 12% were *D. variabilis,* 11% were *A. americanum,* and 2% were *R. sanguineus*. (Figure 2.9C).

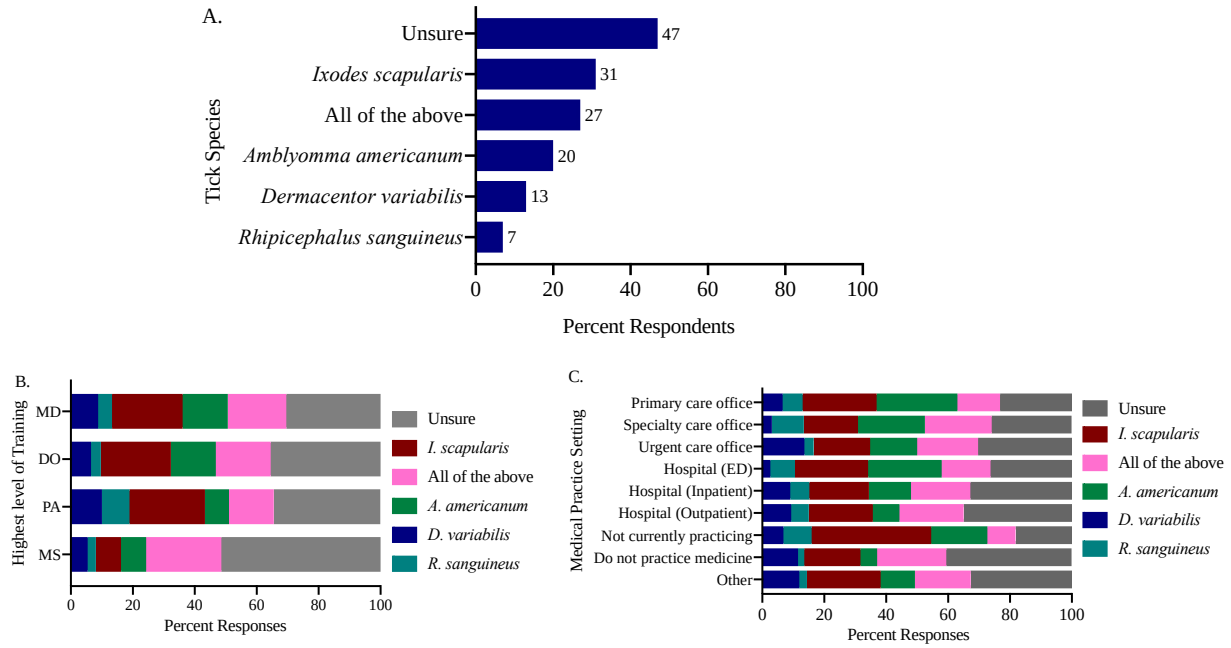


Figure 2.9. Ticks capable of diseases transmission to humans in the state of Indiana. A: ticks capable of transmitting diseases to humans in the state of Indiana indicated by respondents expressed as a percentage of total respondents (number to the right of the bar indicate percent respondents). B: ticks capable of transmitting diseases to humans in the state of Indiana by highest level of training expressed as a percentage of highest level of training. C: ticks capable of transmitting diseases to humans in the state of Indiana by medical practice setting expressed as a percentage of medical practice setting. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science; ED, Emergency Department.

Documentation of Ixodes scapularis ticks in most Indiana counties: In total, 597 responses were received. Fifty six percent of the total respondents reported they were 'unsure' whether *I. scapularis* had been documented in most Indiana counties. 40% of the respondents reported 'true', and 4% reported 'false' (Figure 2.10A).

Among MDs, 54% selected 'unsure', 42% reported 'true', and 4% reported 'false'. Among DOs 61% selected 'unsure', 37% reported 'true', and 2% reported 'false'. Among PAs, 55% selected 'unsure', 39% reported 'true' and 6% reported 'false'. Among MS, 67% selected 'unsure', 30% reported 'true', and 3% reported 'false'(Figure 2.10B).

Fifty percent of the respondents in Primary care office reported 'true', 47% selected 'unsure', and 3% reported 'false'. Sixty percent of the respondents in Specialty care office selected 'unsure', 36% reported 'true', and 4% reported 'false'. Forty eight percent of the respondents in Urgent care office selected 'unsure', 41% reported 'true', and 11% reported 'false'. Fifty four

percent of the respondents in Hospital (Emergency department) selected ‘unsure’, 42% reported ‘true’, and 3% reported ‘false’. Sixty two percent of the respondents in Hospital (inpatient) selected ‘unsure’, 34% reported ‘true’, and 4% reported ‘false’. Sixty eight percent of the respondents in Hospital (outpatient) selected ‘unsure’, 29% reported ‘true’, and 3% reported ‘false’. Sixty one percent of those who are not currently practicing selected ‘unsure’, 34% reported ‘true’, and 5% reported ‘false’. Sixty four percent of the respondents who do not practice Medicine selected ‘unsure’, 33% reported ‘true’, and 3% reported ‘false’. Forty nine percent of the respondents who selected ‘other’ for their medical practice setting reported ‘true’, 48% selected ‘unsure’ and 2% reported ‘false’(Figure 2.10C).

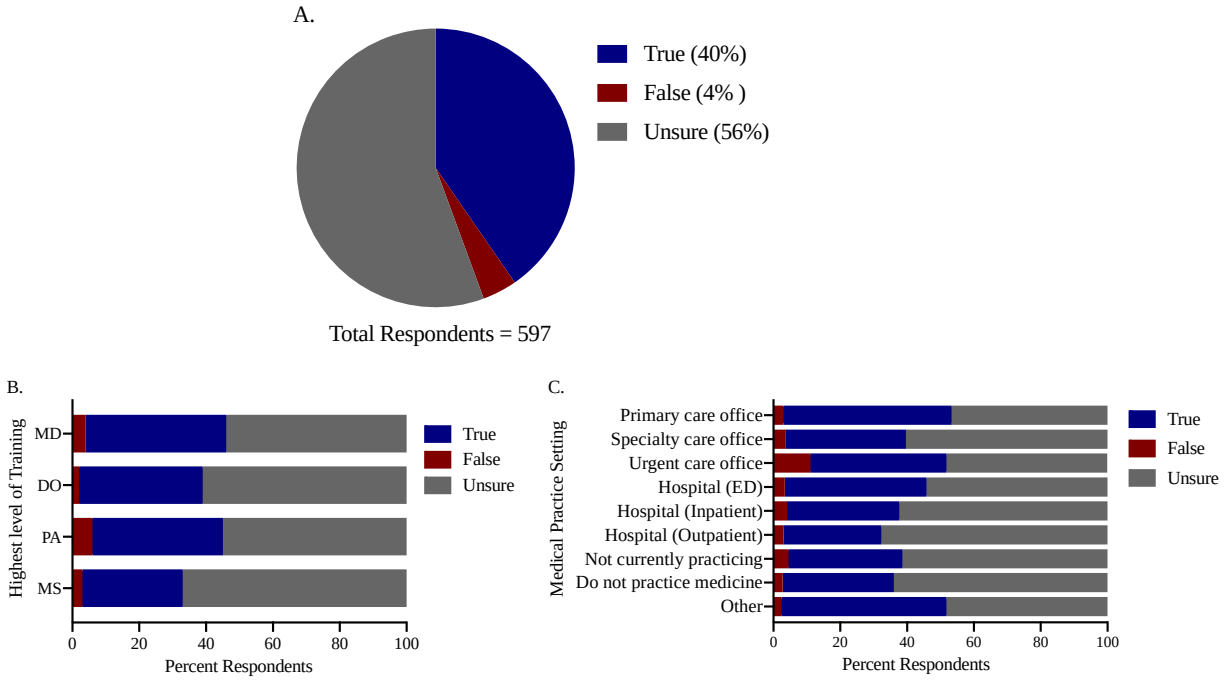


Figure 2.10. Documentation of *I. scapularis* in most counties of Indiana. A: documentation of *I. scapularis* in most counties of Indiana indicated by respondents expressed as a percentage of total respondents (number to the right of the bar indicate percent respondents). B: documentation of *I. scapularis* in most counties of Indiana by highest level of training expressed as a percentage of highest level of training. C: documentation of *I. scapularis* in most counties of Indiana by medical practice setting expressed as a percentage of medical practice setting. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science; ED, Emergency Department

Highest risk of Lyme disease transmission in northwest Indiana: In total, 597 responses were received for Q11 (While the risk of Lyme disease transmission is present throughout the state of Indiana, it is highest in the northwest part of the state?). Forty eight percent of the respondents

selected ‘unsure’ for risk of Lyme disease transmission being highest in the northwest part of Indiana, 29% reported ‘true’, and 22% reported ‘false’(Figure 2.11A).

Among MDs, 49% selected ‘unsure’, 32% reported ‘true’, and 20% reported ‘false’. Among DOs, 41% selected ‘unsure’, 30% reported ‘false’ and 28% reported ‘true’. Among PAs, 39% selected ‘unsure’, 39% reported ‘false’ and 21% reported ‘true’. Among MS, 70% selected ‘unsure’, 23% reported ‘true’, and 7% reported ‘false’(Figure 2.11B).

Forty percent of those who practice in primary care office selected ‘unsure’, 30% reported ‘true’, and 30% reported ‘false’. Fifty percent of the respondents who practice in Specialty care office selected ‘unsure’, 27% reported ‘true’, and 23% reported ‘false’. Forty eight percent of those who practice in Urgent care office selected ‘unsure’, 26% reported ‘true’, and 26% reported ‘false’. Forty six percent of those who practice in Hospital (Emergency Department) selected ‘unsure’, 34% reported ‘true’, and 20% reported ‘false’. Forty eight percent of those who practice in Hospital (inpatient) selected ‘unsure’, 29% reported ‘true’, and 23% reported ‘false’. Forty eight percent of those who practice in Hospital (outpatient) selected ‘unsure’, 26% reported ‘true’, and 26% reported ‘false’. Fifty nine percent of those who are not currently practicing selected ‘unsure’, 34% reported ‘true’, and 7% reported ‘false’. Sixty percent of those who do not practice Medicine selected ‘unsure’, 28% reported ‘true’, and 11% reported ‘false’. Forty six percent of those who selected ‘other’ for their medical practice setting selected ‘unsure’, 30% reported true, and 23% reported false (Figure 2.11C).

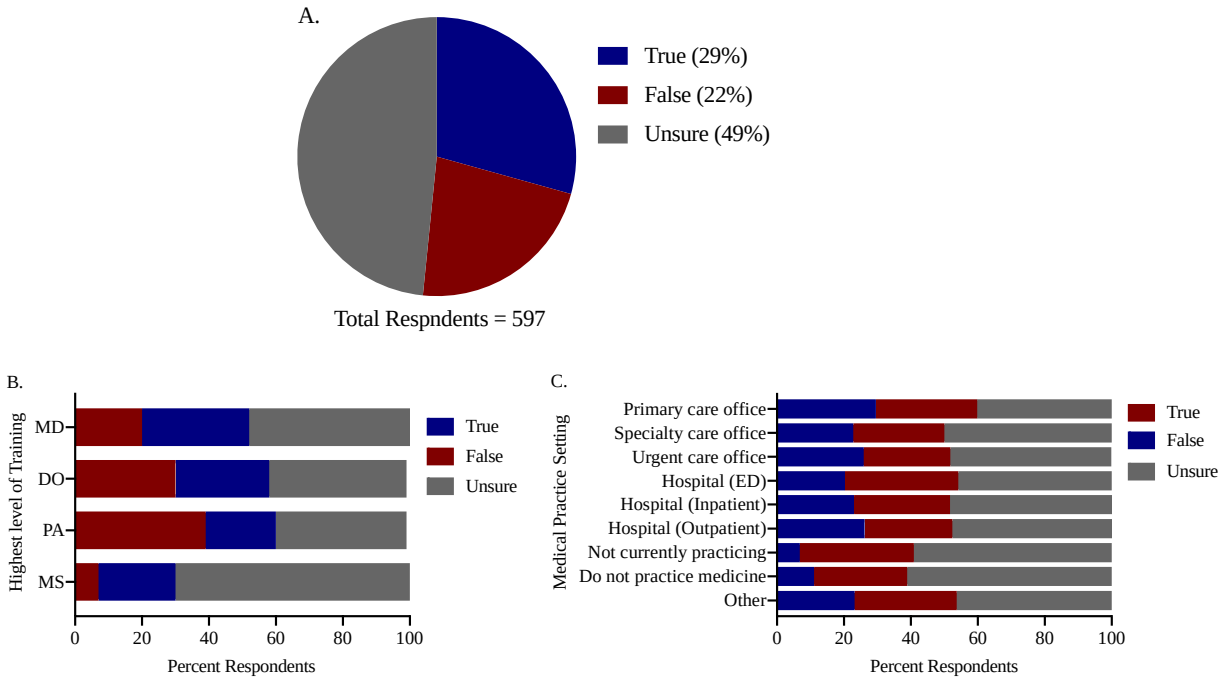


Figure 2.11. Highest risk of LD transmission in northwest part of Indiana. A: highest risk of LD transmission in northwest part of Indiana indicated by respondents expressed as a percentage of the total number of respondents. B highest risk of LD transmission in northwest part of Indiana by highest level of training expressed as a percentage of highest level of training. C: highest risk of LD transmission in northwest part of Indiana by medical practice setting expressed as a percentage of medical practice setting. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science; ED, Emergency Department

Months considered highest risk for transmission of TBDs in the state of Indiana: In total, 597 responses were received for Q12**.** Fifty two percent of all respondents reported 'May-July', 26% reported 'August-October', 19% selected 'unsure', and 3% reported 'February-April'. None of the respondents reported 'November-January'(Figure 2.12A).

Among MDs, 53% reported May-July, 27% reported August-October, and 17% selected 'unsure'. Among DOs, 65% reported May-July, 20% reported August-October, and 15% selected unsure. Among PAs, 48% reported May-July, 36% reported August-October, and 14% selected 'unsure'. Among MS, 47% reported May-July, 40% selected 'unsure', and 10% reported August-October (Figure 2.12B).

Fifty six percent of those who practice in Primary care office reported May-July, 30% reported August-October, and 13% selected 'unsure'. Fifty one percent of those who practice in Specialty care office reported May-July, 25% reported August-October, and 20% selected unsure.

Fifty nine percent of those who practice in Urgent care office reported May-July, 33% reported August-October, and 7% selected ‘unsure’. Fifty six percent of those who practice in Hospital (Emergency Department) reported ‘May-July’, 36% reported August-October, and 8% selected ‘unsure’. Forty seven percent of those who practice in Hospital (Inpatient) reported May-July, 25% reported August-October, and 25% selected unsure. Fifty one percent of those who practice in Hospital (Outpatient) reported May-July, 25% reported August-October, and 23% selected ‘unsure’. Thirty nine percent of those who are not currently practicing reported May-July, 32% selected unsure, and 23% reported August-October. Forty seven percent of those who do not practice Medicine selected ‘unsure’, 44% reported May-July, and 6% reported August-October. Fifty nine percent of those who selected ‘other’ as their medical practice setting reported May-July, 22% reported August-October, and 18% selected unsure (Figure 2.12C).

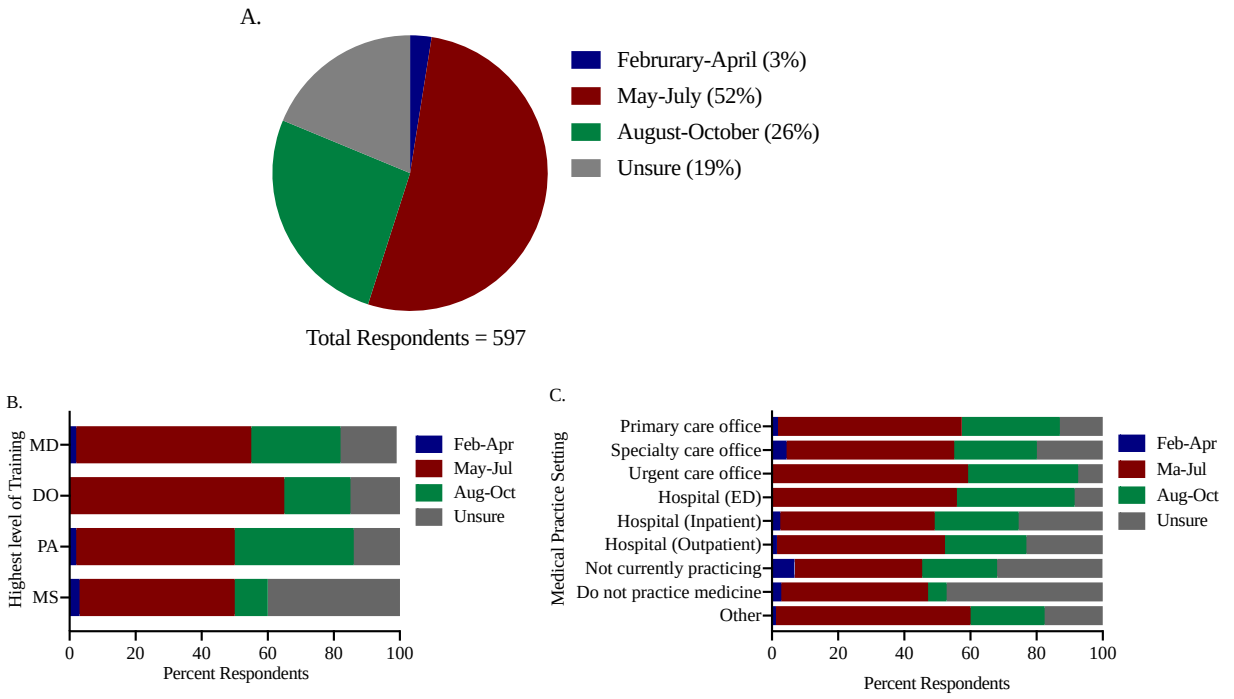


Figure 2.12. Months considered highest risk of transmission of TBDs in the State of Indiana. A: months considered highest risk of transmission of TBDs in the State of Indiana indicated by respondents expressed as a percentage of the total number of respondents. B: months considered highest risk of transmission of TBDs in the State of Indiana by highest level of training expressed as a percentage of respondents in highest level of training. C: months considered highest risk of transmission of TBDs in the State of Indiana by medical practice setting expressed as a percentage of respondents in medical practice setting. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science; ED, Emergency Department

Signs and symptoms associated with TBDs in the state of Indiana: In total, 3,026 responses were received for Q13, as the respondents had the option to select more than one response for this question. Eighty percent or more of respondents reported "arthritis", "fever/chills", "headache", "rash" and "muscle ache" as signs and symptoms associated with TBDs. Seventy two percent of respondents reported/selected "inflammation". Seven percent of the respondents selected 'unsure', and 3% 'other'(see Table 2.5). Among those who selected 'other' for signs and symptoms, most common listed were 'fatigue' (26%), and 'Neuropathy' (11%) (Figure 2.13A).

Among MDs, 74% or more selected all of the options listed as potential signs and symptoms under this question. Among DOs, 74% or higher of all the respondents reported arthritis, fever/chills, headache, rash and muscle ache, and 57% reported inflammation. Among PAs 77% or higher reported all the signs and symptoms listed under question. Among MSs, 67% reported Fever/chills, 57% reported inflammation and muscle ache, 50% reported headache, 43% reported rash, 37% selected 'unsure', and 27% reported arthritis (Figure 2.13B).

Eighteen percent of the responses by those who practice in Primary care office were 'rash', 17% were 'arthritis', 'fever/chills' and 'headache', 16% were 'muscle ache', and 13% were 'inflammation'. Eighteen percent of the responses by those who practice in Specialty care office were 'rash', 17% were 'fever/chills', 16% were 'arthritis', 'headache' and 'muscle ache', and 14% were 'inflammation'. Eighteen percent of the responses by those who practice in Urgent care office were 'arthritis', 'headache' and 'rash', 17% were 'fever/chills', 16% were 'muscle ache', and 14% were 'inflammation'. Eighteen percent of the responses by those who practice in hospital (emergency department) were 'fever/chills', 17% were 'arthritis', 'headache', 'rash' and 'muscle ache', and 14% were 'inflammation'. Eighteen percent of the responses by those who practice in Hospital (inpatient) were 'fever/chills' and 'rash', 17% were 'arthritis', 16% were 'headache' and 'muscle ache', and 14% were 'inflammation'. Eighteen percent of the responses by those who practice in Hospital (outpatient) were 'rash', 17% were 'arthritis' and 'fever/chills', 16% were 'headache' and 'muscle ache', and 15% were 'inflammation'. Eighteen percent of the responses by those who are not currently practicing were 'rash', 17% were 'muscle ache', 16% were 'fever/chills', 'headache' and 'inflammation', and 15% were 'arthritis'. Eighteen percent of the responses by those who do not practice Medicine were 'fever/chills' and 'inflammation', 17% were 'muscle ache', 15% were 'rash', 14% were 'headache', and 9% were 'arthritis' and 'unsure'. Eighteen percent of the responses by those who selected 'other' for their medical practice setting

were ‘rash’, 17% were ‘arthritis’ and ‘fever/chills’, 15% were ‘headache’ and ‘muscle ache’, and 14% were ‘inflammation’ (Figure 2.13C).

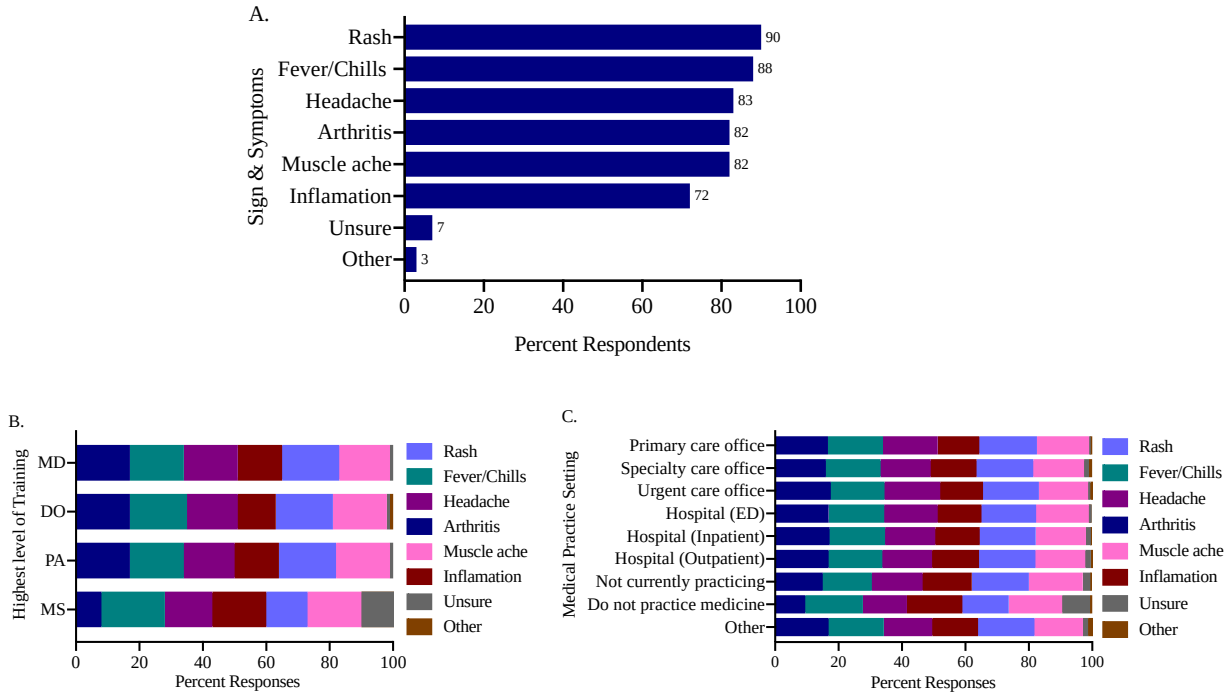


Figure 2.13. Signs and symptoms associated with TBDs in the state of Indiana. A: signs and symptoms associated with TBDs in the state of Indiana indicated by respondents expressed as a percentage of the total number of respondents (number to the right of the bar indicate percent respondents). B: signs and symptoms associated with TBDs in the state of Indiana by highest level of training expressed as a percentage of respondents in highest level of training. C: graphs about signs and symptoms associated with TBDs in the state of Indiana by medical practice setting expressed as a percentage of responses in medical practice setting. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science; ED, Emergency Department

Table 2.5: ‘Other’ TBD signs and symptoms as reported by respondents.

Sign & Symptoms: "other"	**Total Number of Respondents (% respondents)**
Fatigue	5 (0.8%)
Neuropathy	2 (0.3%)
Bell's Palsy, chronic fatigue	1 (0.2%)
Carditis	1 (0.2%)
Death, Neurologic syndromes	1 (0.2%)
Emesis, Nausea, Paresthesia, Facial palsy, Brain fog	1 (0.2%)
encephalitis, neurological symptoms	1 (0.2%)
Erythema migrans	1 (0.2%)

Table 2.5 continued

high white count, very low white count-ehrlichiosis	1 (0.2%)
Nausea vomiting diarrhea confusion	1 (0.2%)
Neuro and cardiac issues	1 (0.2%)
Numbness, weakness	1 (0.2%)
too many to list	1 (0.2%)
VII palsy, Carditis, CNS involvement, Radiculomyelopathy	1 (0.2%)

Note: CNS, central nervous system; VII palsy, seventh nerve palsy

Detection of erythema migrans (EM) in all individuals positive for Lyme disease: In total, 597 responses were received for Q14 (All patients with Lyme disease develop an erythema migrans (bulls-eye rash)?)**.** Eighty eight percent of respondents reported 'false', 9% selected 'unsure', and 4% reported 'true'(Figure 2.14A).

Among MDs, 91% reported 'false', 5% selected 'unsure' and 4% reported 'true'. Among, DOs, 96% reported 'false', and 4% selected 'unsure'. Among PAs, 94% selected 'false', 5% selected 'unsure', and 2% reported 'true'. Among MS, 57% selected 'unsure', 40% reported false, and 3% reported 'true'(Figure 2.14B).

Ninety percent of the respondents who practice in Primary care office reported 'false', 3% reported 'true' and 3% selected 'unsure'. Ninety one percent of the respondents who practice in Specialty care office reported 'false', 7% selected 'unsure', and 2% reported 'true'. Eighty nine percent of the respondents who practice in Urgent care office reported 'false', 7% selected 'unsure' and 4% reported 'true'. Ninety seven percent of the respondents who practice in Hospital (emergency department) reported 'false', and 3% selected 'unsure'. Eighty seven percent of the respondents who practice in Hospital (inpatient) reported 'false', 7% reported 'true', and 6% selected 'unsure'. Ninety two percent of the respondents who practice in Hospital (outpatient) reported 'false', 5% selected 'unsure', and 3% reported 'true'. Eighty two percent of the respondents who are not currently practicing reported 'false', 11% selected 'unsure', and 7% reported 'true'. Forty seven percent of the respondents who do not practice medicine reported 'false', 47% selected 'unsure', and 6% reported 'true'. Eighty four percent of the respondents who selected 'other' as their medical practice setting reported 'false', 11% selected 'unsure', and 6% reported 'true' (Figure 2.14C).

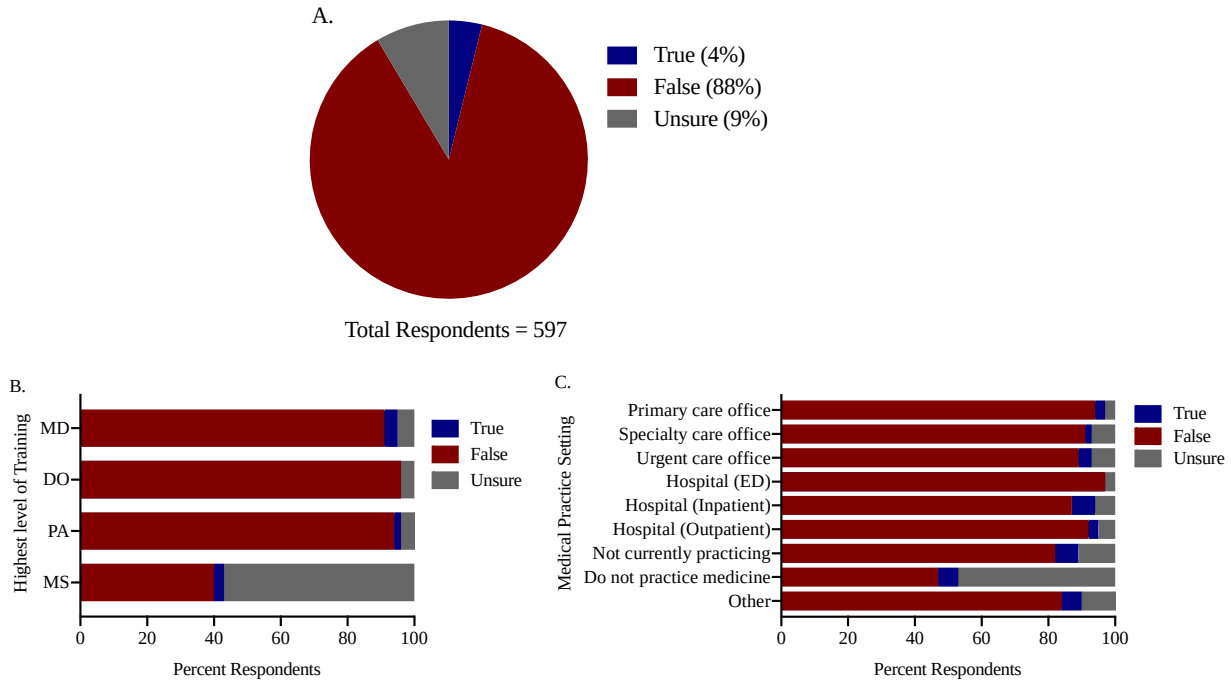


Figure 2.14. Detection of erythema migrans (EM) in all individuals positive for LD. A: detection of EM in all individuals positive for LD indicated by respondents expressed as a percentage of the total number of respondents. B: highest level of training by detection of EM in all individuals positive for LD expressed as a percentage of respondents reporting true, false and unsure. C: medical practice setting by detection of EM in all individuals positive for LD expressed as a percentage of respondents reporting true, false and unsure. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science; ED, Emergency Department

2.4.3 Prevention and diagnosis

Section 3 of the survey collected information about methods used to remove an attached tick, whether early removal of an attached tick can reduce risk of some TBDs, and test requested when evaluating a patient with suspected TBDs.

Methods used to remove an attached tick: In total, 896 responses were received for Q15. Seventy five percent of the total respondents selected ‘pull the tick with fine-tipped tweezers’, 28% selected ‘pull the tick with a commercial tick removal tool’, 11% selected ‘Not Applicable’, 9% selected ‘touch the tick with a hot match’ and ‘cover the tick with petroleum jelly’, 7% selected ‘pull the tick with fingers or fingernails’, 4% selected ‘cover the tick with nail polish’, and 3% selected

‘freeze the tick with liquid nitrogen/dry ice’ and ‘other’. Among those who selected ‘other’, most common listed were ‘Alcohol’ (11%) and ‘no idea’ (11%) (Figure 2.15A, Table 2.6).

Among MDs, 51% of the responses were ‘pull the tick with fine-tipped tweezers’, 20% were ‘pull the tick with a commercial tick removal tool’, 7% ‘cover the tick with petroleum jelly’, and 7% were ‘Not Applicable’. Among DOs, 45% of the responses were ‘pull the tick with fine-tipped tweezers’, 22% were ‘pull the tick with a commercial tick removal tool’, 11% ‘Not Applicable’, and 10% were ‘touch the tick with hot match’. Among PAs, 59% of the responses were ‘pull the tick with fine-tipped tweezers’, 20% were ‘pull the tick with a commercial tick removal tool’, and 7% were ‘touch the tick with a hot match’ and ‘Not Applicable’. Among MS, 45% of the responses were ‘pull the tick with fine-tipped tweezers’, 17% were ‘pull the tick with fingers or fingernails’, 15% were ‘touch the tick with a hot match’, 11% were ‘Not Applicable’, and 9% were ‘pull the tick with a commercial tick removal tool’(Figure 2.15B).

Fifty six percent of the responses by those who practice in primary care office were ‘pull the tick with fine-tipped tweezers’, 20% were ‘pull the tick with a commercial tick removal tool’, 5% were ‘cover the tick with petroleum jelly’, 4% were ‘pull the tick with fingers or fingernails’ and ‘other’, 3% were ‘touch the tick with a hot match’ and ‘Not Applicable’, and 2% were ‘cover the tick with nail polish’ and ‘freeze the tick with nitrogen/dry ice’. Forty two percent of the responses of those who practice in Specialty care office were ‘pull the tick with fine-tipped tweezers’ 19% were ‘pull the tick with a commercial tick removal tool’, 10% were ‘Not Applicable’, 9% were ‘cover the tick with petroleum jelly, 8% were ‘touch the tick with a hot match’ 6% were ‘cover the tick with nail polish’, and 3% were ‘pull the tick with fingers or fingernails’ and ‘freeze the tick with nitrogen/dry ice’. Seventy three percent of the responses by those who practice in Urgent care office were ‘pull the tick with fine-tipped tweezers’, 18% were ‘pull the tick with a commercial tick removal tool’, 6% were ‘pull the tick with fingers or fingernails’, and 3% were ‘cover the tick with petroleum jelly’. Fifty five percent of those who practice in hospital (Emergency department) were ‘pull the tick with fine-tipped tweezers’, 18% were ‘pull the tick with a commercial tick removal tool’, 9% were ‘cover the tick petroleum jelly’, 6% were ‘touch the tick with a hot match’, 4% were ‘other’, 3% were ‘pull the tick with fingers or fingernails’, 2% were ‘cover the tick with nail polish’, and 1% were ‘freeze the tick with nitrogen/dry ice’ and ‘Not Applicable’. Forty seven percent of the responses from those who practice in Hospital (inpatient) were ‘pull the tick with fine-tipped tweezers’, 23% were ‘pull the

tick with a commercial tick removal tool', 10% were 'Not Applicable', 9% were 'touch the tick with a hot match', 5% were 'cover the tick with petroleum jelly', and 2% were 'pull the tick with fingers or fingernails', 'cover the tick nail polish' and 'other'. Forty two percent of the responses of those who practice in Hospital (outpatient) were 'pull the tick with fine-tipped tweezers', 26% were 'pull the tick with a commercial tick removal tool', 13% were 'Not Applicable', 8% were 'touch the tick with a hot match', 4% were 'cover the tick with petroleum jelly', 3% were 'pull the tick with fingers or fingernails' and 'cover the tick with nail polish', and 1% were 'freeze the tick with nitrogen/dry ice'. Forty seven percent of the responses by those who are not currently practicing were 'pull the tick with fine-tipped tweezers', 20% were 'pull the tick with commercial tick removal tool', 10% were 'Not Applicable', 7% were 'cover the tick with petroleum jelly', 5% were 'pull the tick with fingers or fingernails', 'touch the tick with a hot match' and 'cover the tick with nail polish', and 2% were 'other'. Forty three percent of the responses by those who do not practice medicine were 'pull the tick with fine-tipped tweezers', 16% were 'pull the tick fingers or fingernails' and 'touch the tick with a hot match', 12% were 'pull the tick with a commercial tick removal tool', 10% were 'Not Applicable', and 2% were 'cover the tick with petroleum jelly' and 'freeze the tick with nitrogen/dry ice'. Among 'other' medical practice setting, 48% of the responses were 'pull the tick with fine-tipped tweezers', 17% were 'pull the tick a commercial tick removal tool', 11% were 'Not Applicable', 8% were 'cover the tick with petroleum jelly', 5% were 'pull the tick with fingers or fingernails', 4% were 'touch the tick with a hot match', 3% were 'cover the tick nail polish', and 2% were 'freeze the tick nitrogen/dry ice' and 'other'(Figure 2.15C).

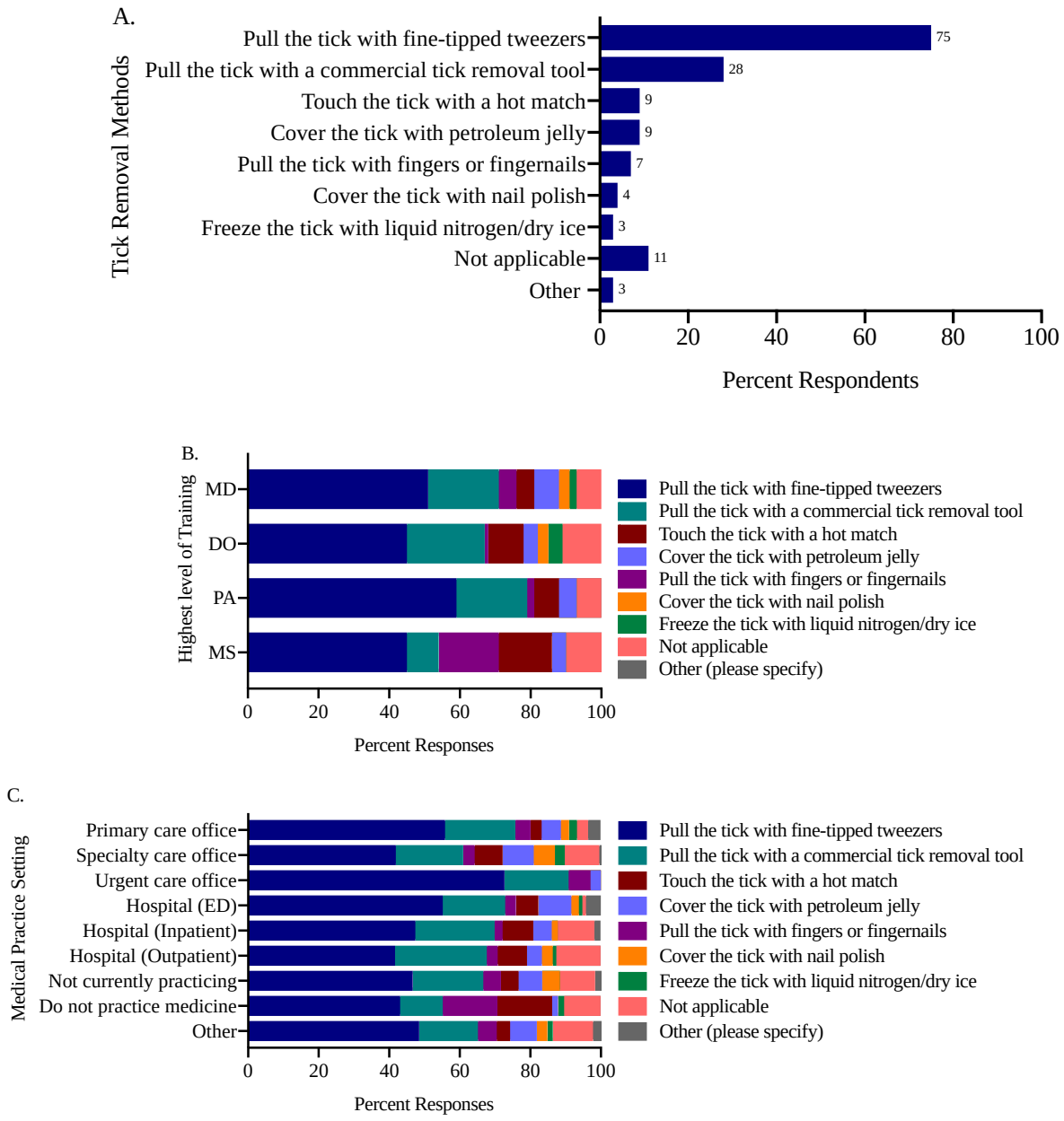


Figure 2.15. Methods used to remove an attached tick. A: methods used to remove an attached tick reported indicated by respondents expressed as a percentage of the total number of respondents (number to the right of the bar indicate percent respondents). B: methods used to remove an attached tick expressed by highest level of training as a percentage of highest level of training. C: methods used to remove an attached tick by medical practice setting expressed as a percentage of medical practice setting. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science; ED, Emergency Department

Table 2.6: 'Other' methods used for tick removal as reported by respondents

Methods used for tick removal: "other"	Total Number of Respondents (% respondents)
Alcohol	2 (0.3%)
no idea	2 (0.3%)
Cotton ball soaked with soap, apply for 30 seconds and then remove to see if tick has attached to cotton ball	1 (0.2%)
Cover tic with lidocaine jelly 2% for 30 minutes	1 (0.2%)
Cover with alcohol pad for five minutes then remove easily with tweezers.	1 (0.2%)
cover with gauze or tissue and apply gentle steady traction until removed	1 (0.2%)
Excise	1 (0.2%)
I remove any tissue at the bite-site in case mandible fragments remain	1 (0.2%)
Pinch the mouth-piece when removing to prevent regurgitation	1 (0.2%)
Pull the tick with tweezers by the head not the body	1 (0.2%)
Punch biopsy excision	1 (0.2%)
punch biopsy when embedded	1 (0.2%)
scrape off with card	1 (0.2%)
Slow traction with Forceps in the office, Needle nosed pliers or fingers in woods	1 (0.2%)
Twist and pull with fine-tipped tweezers with care to dislodge mouth parts	1 (0.2%)
use permethazine lotion	1 (0.2%)
Use Tea tree oil on Tick before removal	1 (0.2%)

Early removal of an attached tick can reduce risk of some TBDs: In total, 597 responses were received to Q16. Eighty eight percent of all the respondents reported 'true' when asked if early removal of an attached tick can reduce risk of some TBDs, 9% selected 'unsure', and 3% reported 'false'(Figure 2.16A).

Among MDs, 88% reported 'true', 8% selected 'unsure', and '4% selected 'false'. Among DOs, 93% reported 'true', and 7% selected 'unsure'. Among PAs, 91% reported 'true', and 9% selected 'unsure'. Among MS, 77% reported 'true' and 23% reported 'unsure'(Figure 2.16B).

Ninety three percent of the respondents in primary care office reported 'true', 4% selected 'unsure', and 3% reported 'false'. Eighty three percent of the respondents in Specialty care office reported 'true', 12% selected 'unsure', and 4% reported 'false'. One hundred percent of the respondents in Urgent care office reported 'true'. Ninety five percent of the respondents in Hospital (emergency department) reported 'true', and 5% selected 'unsure'. Eighty four percent of the respondents in Hospital (inpatient) reported 'true', 11% selected unsure, and 6% reported 'false'. Eighty percent of the respondents in Hospital (outpatient) reported 'true', 14% selected 'unsure', and 6% reported 'false'. Eighty percent of the respondents who are not currently practicing

reported ‘true’, 16% selected ‘unsure’, and 4% reported ‘false’. Sixty seven percent of the respondents who do not practice medicine reported ‘true’, 33% selected unsure. Among other, 89% reported ‘true’, 7% selected ‘unsure’, and 4% reported false (Figure 2.16C).

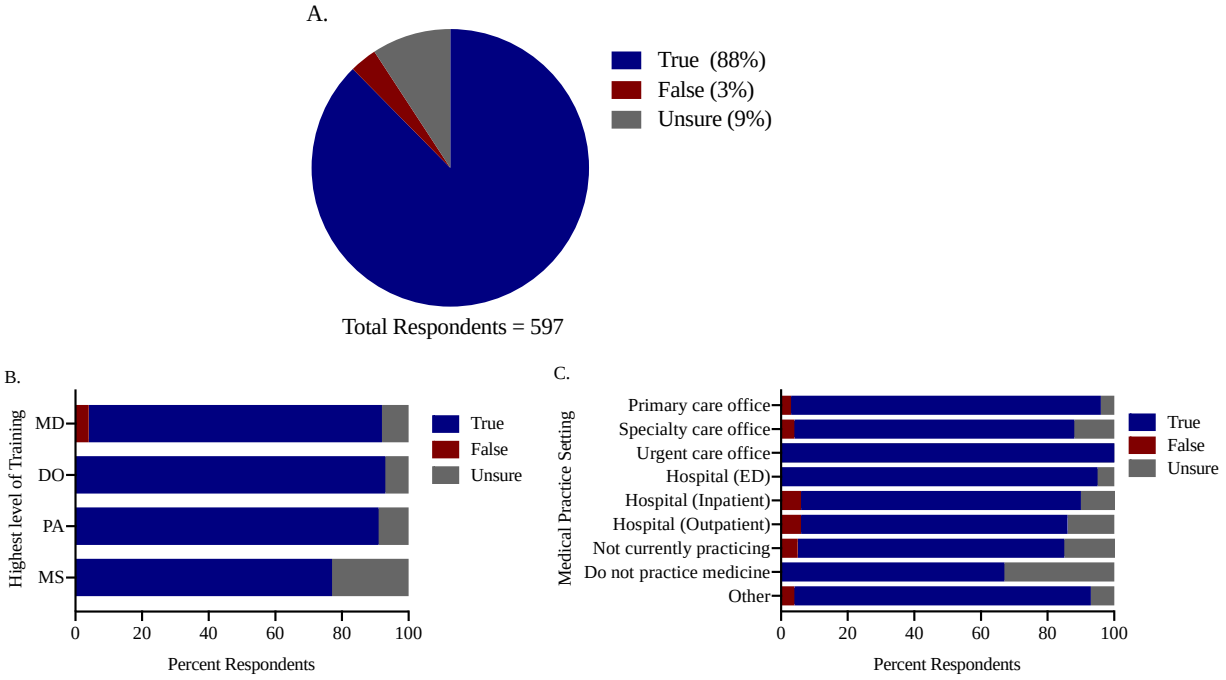


Figure 2.16. Early removal of an attached tick can reduce risk of some TBDs. A: early removal of an attached tick can reduce risk of some TBDs indicated by respondents expressed as a percentage of the total number of respondents. B: early removal of an attached tick can reduce risk of some TBDs by highest level of training expressed as a percentage of highest level of training. C: early removal of an attached tick can reduce risk of some TBDs by medical practice setting expressed as a percentage of medical practice setting. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science; ED, Emergency Department

Test requested when evaluating a patient with suspected TBDs: In total, 696 responses were received for Q17**.** Fifty eight percent of all the respondents reported ‘serological testing’, 22% selected ‘unsure’, 20% reported ‘nucleic acid amplification testing’, 14% selected ‘Not Applicable’, and 3% selected ‘other’ (see Figure 2.17A; Table 2.7).

Among MDs, 53% of the responses were ‘serological testing’, 18% were ‘nucleic acid amplification testing’ and ‘unsure’, and 8% were ‘Not Applicable’. Among Dos, 51% of the responses were ‘serological testing’, 25% were ‘nucleic acid amplification testing’, 13 were ‘unsure’, 8% were ‘Not Applicable’, and 4% were ‘other’. Among PAs, 54% of the responses were ‘serological testing’, 20% were ‘unsure’, 13% were ‘nucleic acid amplification testing’, 9% were

‘Not Applicable’, and 4% were ‘other’. Among MS, 68% of the responses were ‘Not Applicable’, 26% were ‘unsure, and 3% were ‘serological testing’ and ‘nucleic acid amplification testing’ (Figure 2.17B).

Fifty nine percent of the responses by those who practice in primary care office were ‘serological testing’, 20% were ‘nucleic acid amplification’, 17% were ‘unsure’, 4% were ‘other’, and 2% were ‘Not Applicable’. Fifty percent of the responses by those who practice in Specialty care office were ‘serological testing’, 19% were ‘unsure’, 14% were ‘nucleic acid amplification’, 13% were ‘Not Applicable’, and 4% were ‘other’. Sixty four percent of the responses by those who practice in Urgent care office were ‘serological testing’, 18% were ‘nucleic acid amplification’, 12% were ‘unsure’, and 6% were ‘Not Applicable’. Fifty three percent of the responses by those who practice in Hospital (emergency department) were ‘serological testing’, 31% were ‘nucleic acid amplification’, 11% were ‘unsure’, and 3% were ‘Not Applicable’ and ‘other’. Forty eight percent of the responses by those who practice in Hospital (inpatient) were ‘serological testing’, 21% were ‘unsure’, 18% were ‘nucleic acid amplification’, 13% were ‘Not Applicable’, and 1% were ‘other’. Thirty five percent of the responses by those who practice in hospital (outpatient) were ‘serological testing’, 26% were ‘nucleic acid amplification’, 22% were ‘unsure’, 16% were ‘Not Applicable’, and 1% were ‘other’. Fifty percent of the response by those who are not currently practicing were ‘serological testing’, 30% were ‘unsure’, 12% were ‘nucleic acid amplification’, 6% were ‘Not Applicable’, and 2% were ‘other’. Fifty five percent of the responses by those who do not practice medicine were ‘Not Applicable’, 29% were ‘unsure’, 11% were ‘serological testing’, and 5% were ‘nucleic acid amplification’. Among ‘other’ medical practice setting, 40% were ‘serological testing’, 23% were ‘Not Applicable’, 18% were ‘unsure’, 16% were ‘nucleic acid amplification’, and 3% were ‘other’ (Figure 2.17C).

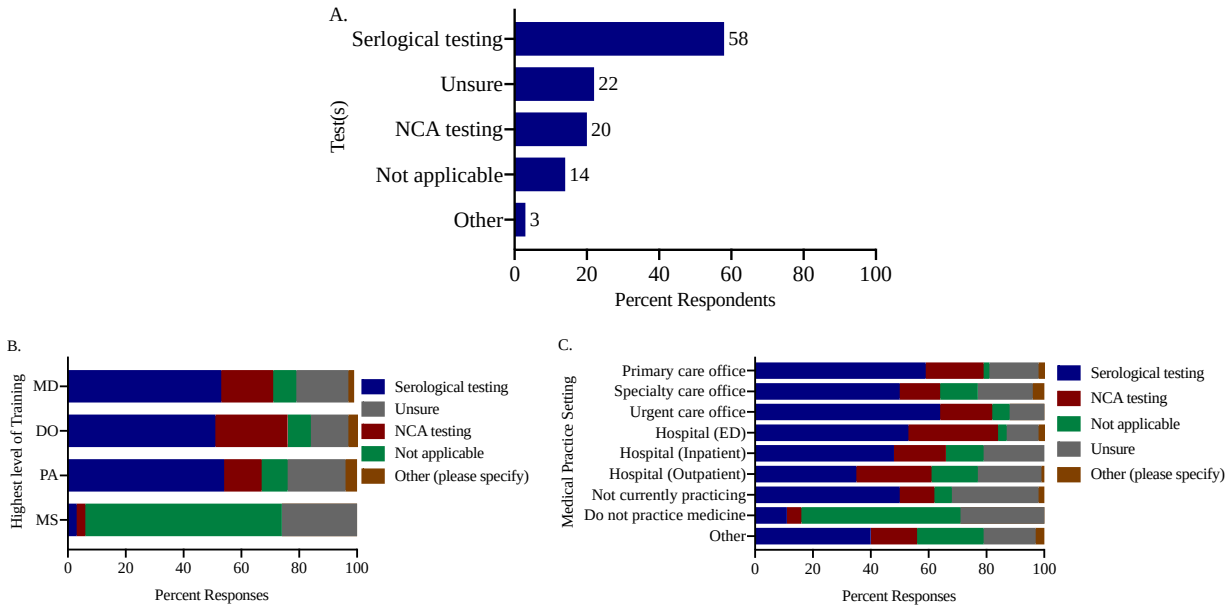


Figure 2.17. Test requested when evaluating a patient with suspected TBDs. A: test requested when evaluating a patient with suspected TBDs reported indicated by respondents expressed as a percentage of the total number of respondents (number to the right of the bar indicate percent respondents). B: test requested when evaluating a patient with suspected TBDs by highest level of training expressed as a percentage highest level of training. C test requested when evaluating a patient with suspected TBDs by medical practice setting expressed as a percentage of medical practice setting. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science; ED, Emergency Department; NCA, Nucleic acid amplification.

Table 2.7: 'Other' test requested for suspected TBDs as reported by respondents

Test requested for suspected Tick-borne diseases: "other"	**Total Number of Respondents (% respondents)**
Refer	2 (0.3 %)
alpha gal antibodies	1 (0.2 %)
blood smear	1 (0.2 %)
clinical diagnosis is appropriate to start treatment	1 (0.2 %)
completely variable, depending on WHO is the provider with whom I am working!	1 (0.2 %)
Don't treat these patients	1 (0.2 %)
FISH testing/ Immunoblot	1 (0.2 %)
history and physical exam	1 (0.2 %)
If Lyme is suspected due to finding of erythema migrans, usually just treat without testing	1 (0.2 %)
None	1 (0.2 %)
Sometimes serology.	1 (0.2 %)
Specialty labs including IGenex	1 (0.2 %)
Test can be negative fir weeks so it is not applicable in acute illness	1 (0.2 %)

Table 2.7 continued

Tick panel	1 (0.2 %)
Varies by presentation	1 (0.2 %)
We have a tick borne pane with titers and immunoglobulins	1 (0.2 %)

Note: WHO: World Health Organization, FISH: Fluorescent in situ hybridization

2.4.4 Information and resources

Section 4 of the survey collected information about online resources used to obtain information and guidelines on tick-borne disease in Indiana, most helpful media in obtaining information on TBDs, most helpful training formats in obtaining information on TBDs, and whether respondent described themselves as Lyme disease specialist, TBD specialist, and/ Lyme-literate healthcare provider/MD.

Online resources used to obtain information on tick-borne disease in Indiana: In total, 595 responses were received for Q 18. Sixty two percent of the respondents selected 'yes', and 38% selected 'no' (Figure 2.18).

Q18a. Among those who selected 'yes', 821 responses were received. Of these, 45% reported 'CDC' with an average rating of 4.4 on the scale of 1-5, 33% reported 'ISDH' (Avg. rating: 4.1), 30% reported 'scientific literature' (Avg. rating: 4.4), 16% selected 'other' (Avg. rating: 4.5), 14% reported 'ISDA' (Avg. rating: 3.7), 13% reported 'PUES' (Avg. rating: 3.4), 12% reported 'ALDF' (Avg. rating: 2.9), 'AMA' (Avg. rating: 2.5) and 'professional specialty associations' (4.3), 9% reported 'ILC' (Avg. rating: 2.7), 8% reported 'ILADS' (Avg. rating: 2.4) and 'LDA' (Avg. rating: 2.2), 7% reported 'Lymedisease.org/The Lyme Times' (Avg. rating: 2.0), and 4% reported 'Professional conference' (Avg. rating: 3.4). Among those who selected 'other', the most common listed term was 'up to date' (74%) (Figure 2.18B, Table 2.8).

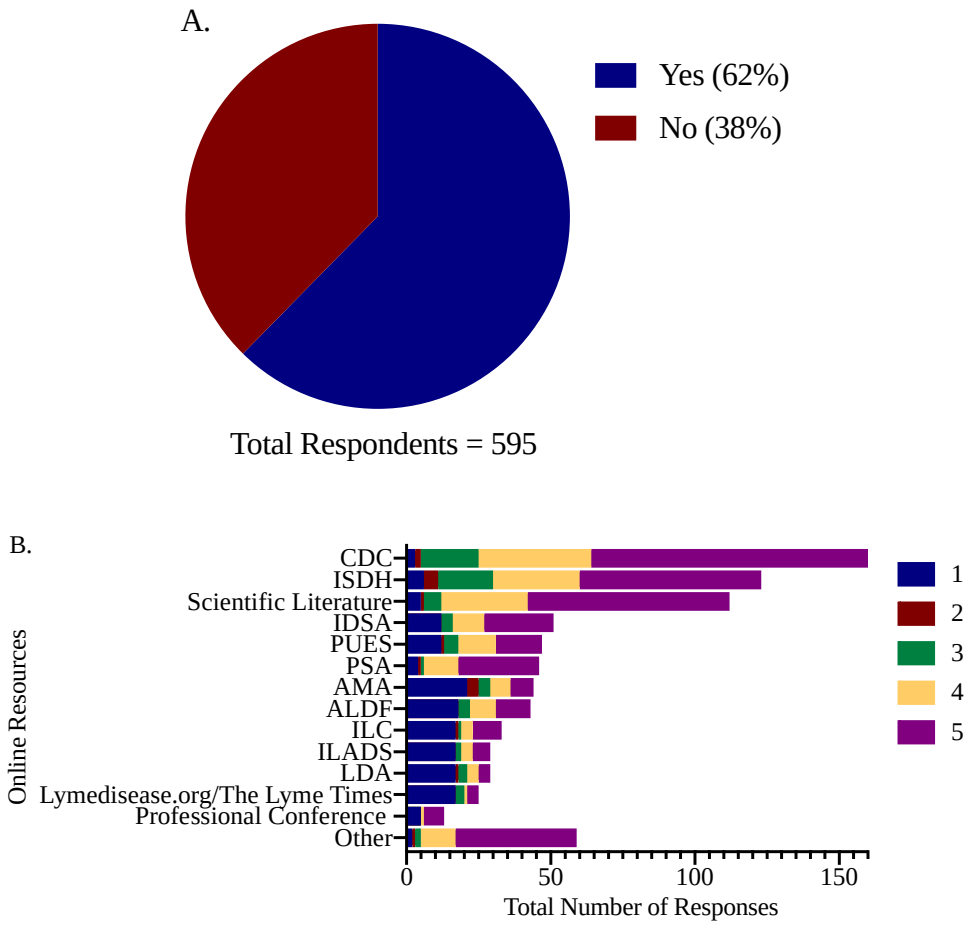


Figure 2.18. Online resources used to obtain information on the epidemiology of TBDs in the state of Indiana. A: whether online resources were used to obtain information on the epidemiology of TBDs in the state of Indiana indicated by respondents expressed as a percentage of the total number of respondents. B: utility of online resources used to obtain information on TBDs expressed as a number of respondents reporting utility on a scale of 1 (low utility) to 5 (high utility). ALDF, American Lyme Disease Foundation; AMA, American Medical Association; CDC, Centers for Disease Control and Prevention; ILC, Indiana Lyme Connect; ISDH, Indiana State Department of Health; ILADS, International Lyme and Associated Disease Society; LDA, Lyme Disease Association; PUES, Purdue University Extension Services; PSA, Professional Society Associations.

Table 2.8: 'Other' resources used to obtain information on the epidemiology of TBDs as reported by respondents

Resource to obtain info: "Other"	**Total Number of Respondents (% respondents)**
up to date	54 (9%)
Epocrates	2 (0.3%)
Medscape	2 (0.3%)
AAFP	1 (0.2%)

Table 2.8 continued

AAP	1 (0.2%)
ACEP	1 (0.2%)
emedicine.com	1 (0.2%)
Epocrates; Up To Date	1 (0.2%)
Google and searching *.edu	1 (0.2%)
LDA	1 (0.2%)
Local ID specialist	1 (0.2%)
Medscape, UpToDate	1 (0.2%)
Minnesota DNR	1 (0.2%)
MMWR	1 (0.2%)
Other university resources	1 (0.2%)
Personal reading	1 (0.2%)
UpToDate; Epocrates	1 (0.2%)
WebMD	1 (0.2%)

Online resources used to obtain guidelines for diagnosis and treatment of TBDs: In total, 589 responses were received for Q19. Sixty five percent of the respondents reported 'yes', and 35% reported 'no' (Figure 2.19A).

Q19a. Among those who selected 'yes', 590 responses were received. Of these, 35% reported 'CDC' with an average rating of 4.6, 25% reported 'scientific literature' (avg. rating: 4.5), 23% reported 'ISDH' (avg. rating: 4.2), 19% selected 'other' (avg. rating: 4.7), 11% reported 'ISDA' (avg. rating: 4.2), 7% reported 'AMA' (avg. rating: 3.3) and 'professional specialty associations' (avg. rating: 4.1), 6% reported 'PUES' (avg. rating: 3.4), 5% reported 'ALDF' (avg. rating: 3.3), 4% reported 'ILC' (avg. rating: 3.3) and 'ILADS' (avg. rating: 3.2), 3% reported 'LDA' (avg. rating: 2.7) and 'Lymedisease.org/The Lyme times' (avg. rating: 2.5), and 2% reported 'professional conference' (avg. rating: 3.4). Of those who selected 'other', the most common listed term was 'up to date' (88%) (Figure 2.19B; Table 2.9).

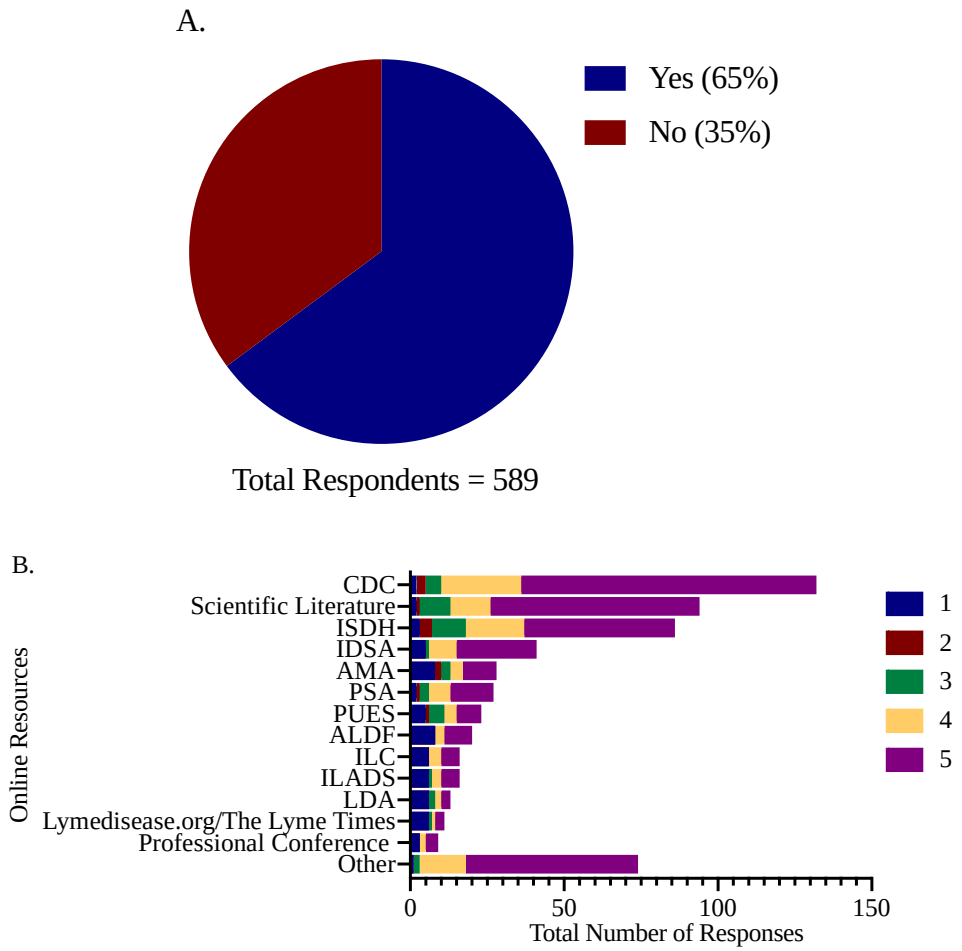


Figure 2.19. Online resources used to obtain guidelines for diagnosis and treatment of TBDs. A: whether online resources used to obtain guidelines for diagnosis and treatment of TBDs indicated by respondents expressed as a percentage of the total number of respondents. B: utility of online resources used to obtain guidelines for diagnosis and treatment of TBDs expressed as a number of respondents reporting utility on a scale of 1 (low utility) to 5 (high utility). ALDF, American Lyme Disease Foundation; AMA, American Medical Association; CDC, Centers for Disease Control and Prevention; ILC, Indiana Lyme Connect; ISDH, Indiana State Department of Health; ILADS, International Lyme and Associated Disease Society; LDA, Lyme Disease Association; PUES, Purdue University Extension Services; PSA, Professional Society Associations

Table 2.9: 'Other' resources to obtain guidelines as reported by respondents

Resources to obtain guidelines: "other"	**Total Number of Respondents (% respondents)**
Up to date	76 (12.7%)
Epocrates	2 (0.3%)
MedScape	2 (0.3%)
AAP Redbook	1 (0.2%)
ACEP	1 (0.2%)

Table 2.9 continued

emedicine.com	1 (0.2%)
Local county health dept	1 (0.2%)
Red book	1 (0.2%)
Sanford Guide to Infectious disease	1 (0.2%)

Most helpful media in obtaining information on TBDs: In total, 1149 responses were received for Q20, as the respondents had the option to select more than one response for this question. Eighty five percent of the respondents selected 'website', 31% selected 'Electronic newsletter', 29% selected 'Printed material', 20% selected 'webinar', 18% selected 'Podcast', 7% selected 'social media', and 3% selected 'other'. Among those who selected 'other', the most common listed term was 'up to date' (29%) (Figure 2.20A; Table 2.10).

Among MDs, 46% of the responses were 'website', 17% were 'e-newsletter', 14% were 'printed material', 10% were 'podcast' and 'webinar', 2% were 'social media', and 1% were 'other'. Among DOs, 43% were 'website', 16% were 'e-newsletter', 13% were 'webinar', 12% were 'printed material', 9% were 'podcast', 4% were 'other', and 2% were 'social media'. Among PAs, 45% were 'website', 16% were 'e-newsletter', 13% were 'printed material', 11% were 'podcast' and 'webinar', 3% were 'social media', and 1% were 'other'. Among MSs, 34% were 'website', 23% were 'printed material', 14% were 'social media', 12% were 'e-newsletter', 10% were 'webinar', 5% were 'podcast', and 1% were 'other' (Figure 2.20B).

Thirty eight percent of the responses by those who practice in primary care office were 'website', 19% were 'printed material', 17% were 'e-newsletter', 12% were 'podcast' and 'webinar', 2% were 'social media' and 'other'. Forty eight percent of the responses by those who practice in Specialty care office were 'website', 16% were 'e-newsletter', 14% were 'printed material', 9% were 'podcast' and 'webinar', and 2% were 'social media' and 'other'. Thirty nine percent of those who practice in urgent care office were 'website', 20% were 'e-newsletter' and 'printed material', 8% were 'podcast', 7% were 'webinar', 3% were 'other', and 2% were 'social media'. Forty three percent of the responses by those who practice in hospital (emergency department) were 'website', 17% were 'e-newsletter', 12% were 'podcast', 11% were 'e-newsletter' and 'printed material', 4% were 'social media', and 2% were 'other'. Fifty two percent of the responses by those who practice in hospital (inpatient) were 'website', 15% were 'e-newsletter', 11% were 'podcast' and 'webinar', 7% were 'printed material', 3% were 'social

media', and 1% were 'other'. Fifty two percent of the responses by those who practice in hospital (outpatient) were 'website', 18% were 'e-newsletter', 14% were 'printed material', 9% were 'webinar', 6% were 'podcast', and 1% were 'social media' and 'other'. Forty three percent of the responses by those who are not currently practicing were 'website', 21% were 'e-newsletter', 15% were 'printed material', 7% were 'webinar', 5% were 'podcast' and 'social media', and 4% were 'other'. Forty one percent of the responses by those who do not practice medicine were 'website', 22% were 'printed material', 15% were 'social media', 14% were 'webinar', 4% were 'podcast' and 'e-newsletter', and 1% were 'other'. Forty three percent of the responses by those who selected 'other' as their medical practice setting were 'website', 16% were 'e-newsletter' and 'printed material', 13% were 'webinar', 8% were 'podcast', 3% were 'social media', and 2% were 'other' (Figure 2.20C).

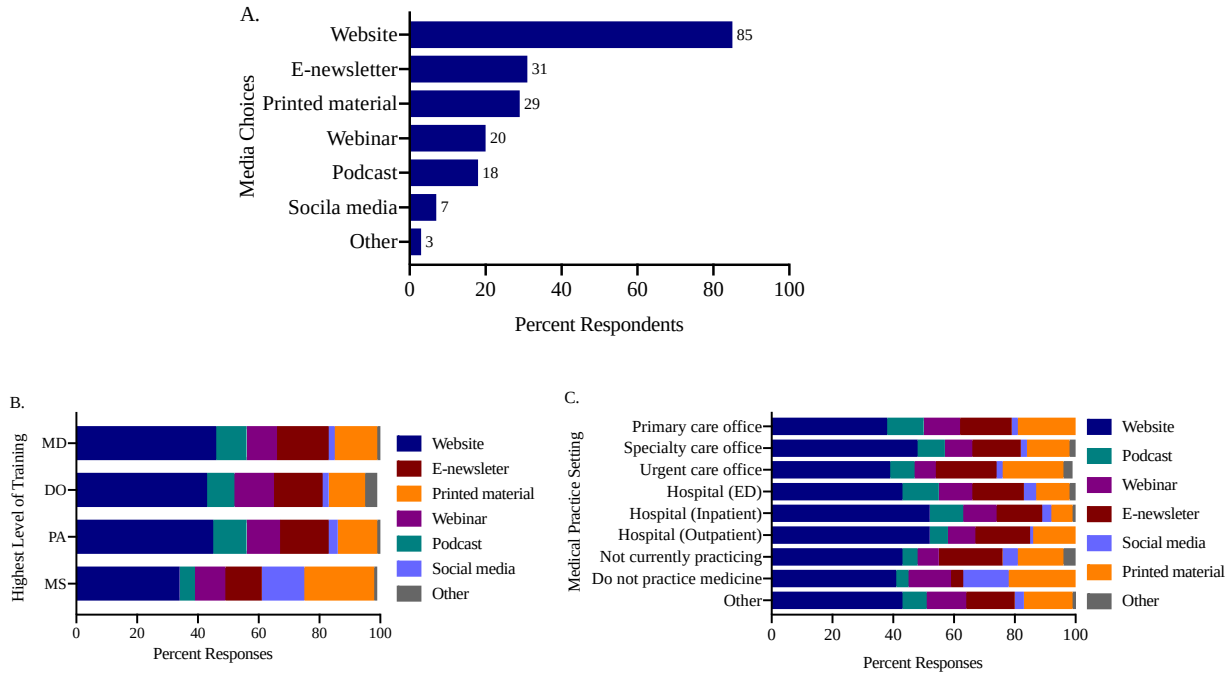


Figure 2.20. Most helpful media in obtaining information on TBDs. A: most helpful media in obtaining information on TBDs indicated by respondents expressed as a percentage of the total number of respondents (number to the right of the bar indicate percent respondents). B most helpful media in obtaining information on TBDs by highest level of training expressed as a percentage of highest level of training. C: most helpful media in obtaining information on TBDs by medical practice setting expressed as a percentage of medical practice setting. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science; ED, Emergency Department

Table 2.10: 'Other' helpful media in obtaining information on TBDs as reported by respondents.

Helpful media: "other"	Total Number of Respondents (% respondents)
Up to date	5 (0.8%)
An electronic newsletter automatically sent to my inbox would be greatly useful	1 (0.2%)
Don't treat this	1 (0.2%)
Dr Norwalk	1 (0.2%)
Every 3- or 6-month update on electronic media possibly tied to season rather than ongoing information overload. Needs jury on what goes in at least for parts of it	1 (0.2%)
Guest speaker at professional society meetings (Indiana Soc of American Foresters, The Wildlife Society, others and Indiana Forestry & Woodland Owners Assoc.	1 (0.2%)
Linked to Update	1 (0.2%)
Medical websites	1 (0.2%)
On demand info through website including algorithms for diagnosis and treatment	1 (0.2%)
paper mail Net CE Sacramento California	1 (0.2%)
PEPID app	1 (0.2%)
post card in the mail at beginning of tick season	1 (0.2%)
Regional meetings	1 (0.2%)

Helpful training formats in obtaining information on TBDs: In total, 981 responses were received for Q21. Seventy nine percent of the respondents reported 'online training', 51% reported 'continuing medical education (CME) event', 19% reported 'seminar', 13% were 'in-person training', and 3% selected 'other'. Among those who selected 'other', the most common terms listed were 'online CME' (17%), and 'na' (11%) (Figure 2.21A; Table 2.11).

Among MDs, 47% of the responses were 'online training', 36% were 'CME event', 8% were 'seminar', 7% were 'in-person training', and 2% were 'other'. Among DOs, 51% of the responses were 'online training', 39% were 'CME event', 4% were 'seminar' and 'other', and 1% were 'in-person training'. Among PAs, 51% of the responses were 'online training', 39% were 'CME event', 6% were 'in-person training', and 4% were 'seminar'. Among MSs, 56% of the responses were 'online training', 22% were 'in-person training', 14% were 'seminar', and 4% were 'CME event' and 'other' (Figure 2.21B).

Forty four percent of the responses by those who practice in primary care office were 'online training', 38% were 'CME event', 9% were 'seminar', 7% were 'in-person', and 1% were 'other'. Forty four percent of the responses by those who practice in Specialty care office were 'online', 39% were 'CME event', 7% were 'in-person', 6% were 'seminar', and 3% were 'other'. Forty seven percent of the responses by those who practice in urgent care office were 'online training', 35% were 'CME event', and 9% were 'in-person training' and 'seminar'. Fifty one

percent of the responses by those who practice in hospital (emergency department) were ‘in-person training’ and ‘seminar’, and 3% were ‘other’ (Figure 2.21C).

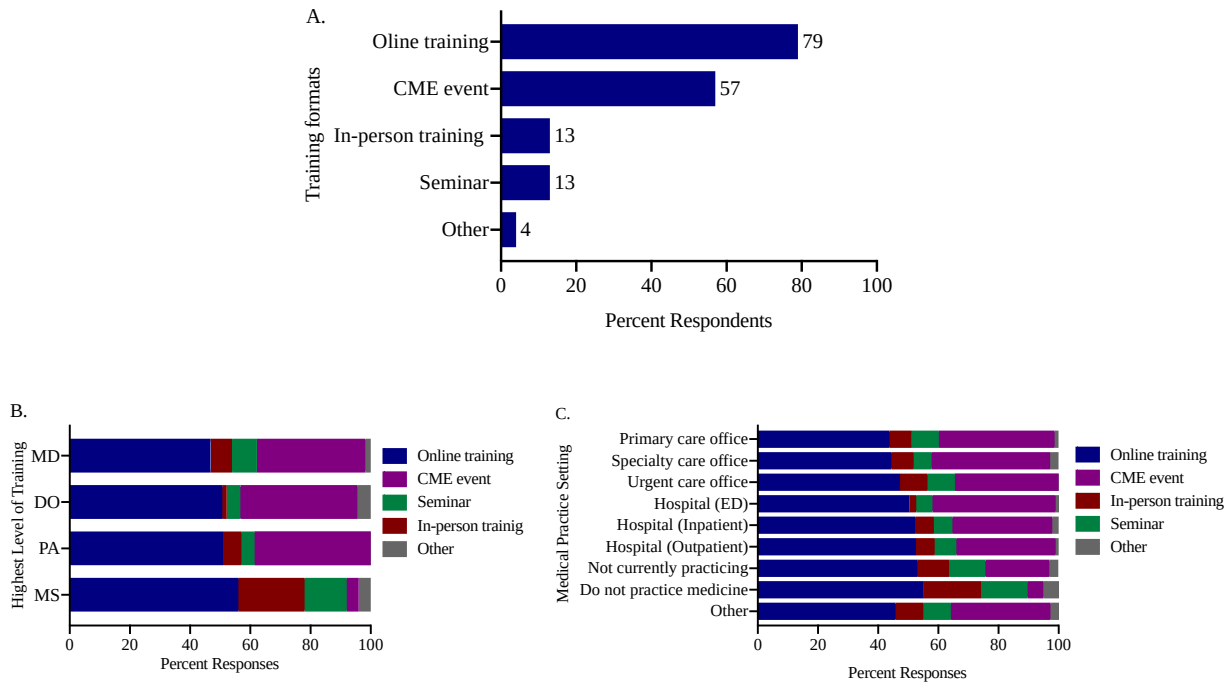


Figure 2.21. Helpful training formats in obtaining information on TBDs. A: helpful training formats in obtaining information on TBDs indicated by respondents expressed as a percentage of the total number of respondents (number to the right of the bar indicate percent respondents). B: helpful training formats in obtaining information on TBDs by highest level of training expressed as percentage of highest level of training. C: helpful training formats in obtaining information on TBDs by medical practice setting expressed as percentage of medical practice setting. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science; ED, Emergency Department; CME; continuing medical education

Table 2.11: ‘Other’ training format as reported by respondents

Training formats “other”	**Total Number of Respondents (% respondents)**
ONLINE CME	3 (0.5%)
Na	2 (0.3%)
Ability to search at time of diagnosis as everything in medicine is constantly changing	1 (0.2%)
archived recordings of any of the above	1 (0.2%)
Articles on Medscape	1 (0.2%)
Don’t treat these	1 (0.2%)
I do not need training to find resources	1 (0.2%)
I do not typically treat	1 (0.2%)

Table 2.11 continued

Journal article	1 (0.2%)
Look up on web as needed	1 (0.2%)
paper mail NetCE Sacramento, CA	1 (0.2%)
PEPID app or email document	1 (0.2%)
Scientific literature	1 (0.2%)
See 20. Other	1 (0.2%)
website	1 (0.2%)

Describe as Lyme disease specialist, TBD specialist, and/ Lyme-literate healthcare provider/MD: In total, 597 responses were received for Q22. Eighty nine percent of the respondents reported 'no', 5% reported 'yes', and 6% selected 'Not Applicable' (Figure 2.22A).

Among MDs, 91% reported 'no', 6% reported 'yes', and 3% selected 'Not Applicable'. Among DOs, 89% reported 'no', 4% reported 'yes', and 7% selected 'Not Applicable'. Among PAs, 95% reported 'no', and 5% selected 'Not Applicable'. Among MSs, 63% reported 'no', and 37% selected 'Not Applicable' (Figure 2.22B).

Ninety one percent of the respondent in primary care office reported 'no', 7% reported 'yes', and 2% selected 'Not Applicable'. Eighty one percent of the respondents in Specialty care office reported 'no', 10% reported 'yes', and 10% selected 'Not Applicable'. Eighty nine percent of the respondents reported 'no', 7% reported 'yes', and 4% selected 'Not Applicable'. Ninety five percent of the respondents in hospital (emergency department) reported 'no', 3% reported 'yes', and 2% selected 'Not Applicable'. Ninety three percent of the respondents in hospital (inpatient) reported 'no', 4% reported 'yes' and 3% selected 'Not Applicable'. Eighty nine percent of the respondents in hospital (outpatient) reported 'no', 6% reported 'yes', and 5% selected 'Not Applicable'. Eighty nine percent of the respondents who are not currently practicing reported 'no', and 11% selected 'Not Applicable'. Fifty eight percent of the respondents who do not practice medicine reported 'no', and 42% selected 'Not Applicable'. Eighty seven percent of the respondent who selected 'other' as their medical practice setting reported 'no', 6% reported 'yes', and 7% selected 'Not Applicable' (Figure 2.22C).

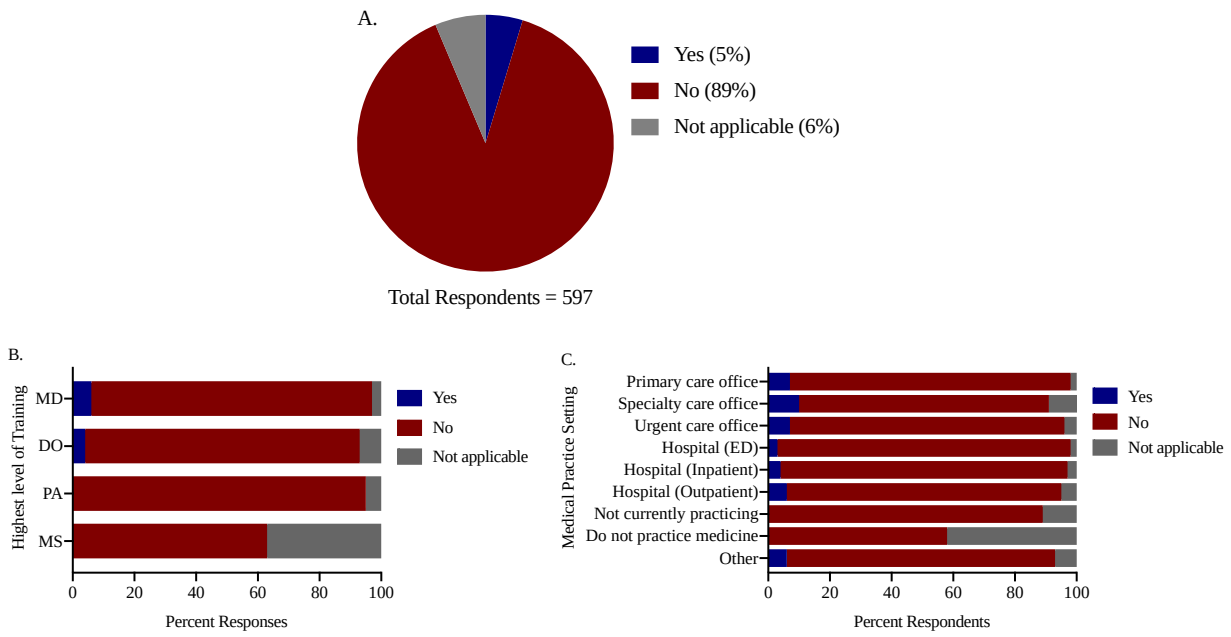


Figure 2.22. Description as a LD specialist, TBD specialist, and/or Lyme-literate healthcare provider/MD. A: whether respondent described themselves as LD specialist, TBD specialist, and/or Lyme-literate healthcare provider/MD indicated by respondents expressed as a percentage of the total number of respondents. B respondent described themselves as LD specialist, TBD Specialist, and/or Lyme-literate healthcare provider/MD by highest level of training expressed as a percentage of respondent's highest level of training. C: respondent described themselves as LD specialist, TBD Specialist, and/or Lyme-literate healthcare provider/MD expressed by medical practice setting as a percentage of respondent's medical practice setting. MD, Doctor of Medicine; DO, Doctor of Osteopathic Medicine; PA, Physician Assistant; MS, Master of Science; ED, Emergency Department

Major issues faced in diagnosing and treating tick-borne diseases in Indiana: a code book was developed to analyze Q23, "What are the major issues you have faced in diagnosis and treatment of TBDs in Indiana?", which was an open-ended question. The codebook had six major themes and 15 subcategories (Figure 2.24 and Table 2.12). The majority of the responses were categorized into two major themes; Health care provider (38.4%) and Not applicable (36.9%), followed by Health care system (12.9%), Patient (9.5%), Disagreement (8.5%), and Education (7.4%). The Health care provider category was further subcategorized into 'knowledge: ticks and TBDs' (21.4%), 'experience' (13.7%), 'suspicion' (1.5%), 'tick identification' (1.2%), and 'risk of medical practice' (0.5%). The Not applicable category was subcategorized into 'not applicable' (27.1%) and 'not categorized' (9.7%). The Patient category was subcategorized into 'knowledge' (3.0%) and 'patient reporting' (6.5%). The Disagreement category was subcategorized into

'provider/patient request' (4.2%) and 'provider/provider' (4.4%). The Education category was subcategorized into 'resources' (7.4%).

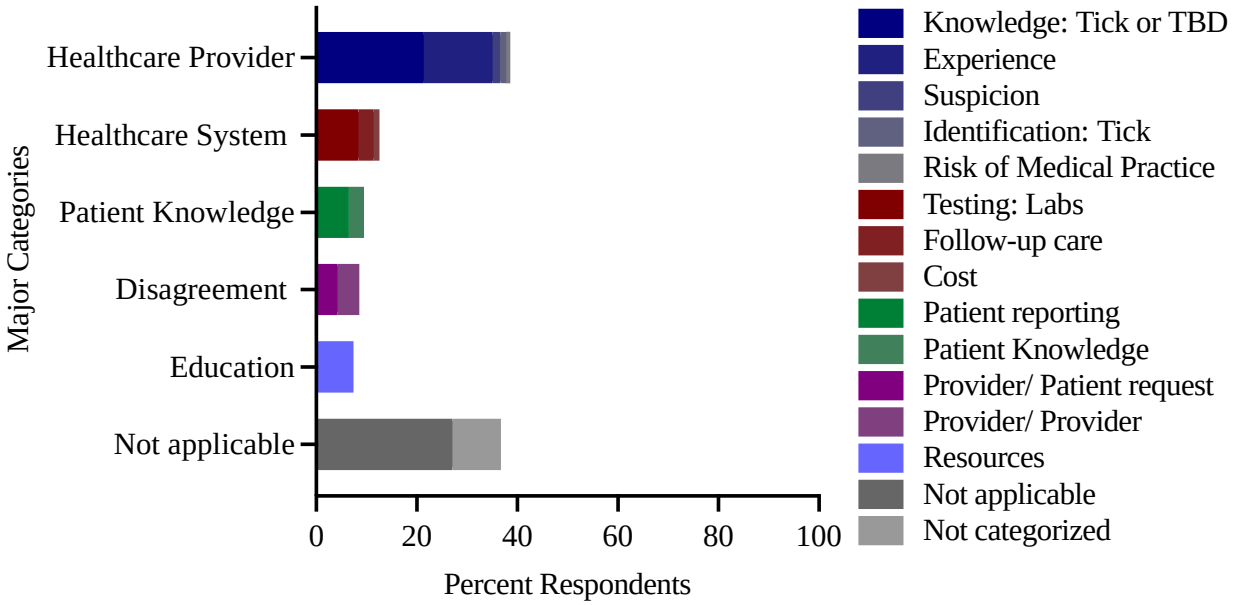


Figure 2.23. Major issues faced in diagnosis and treatment of tick-borne diseases in Indiana by associated sub categories. TBD, Tick borne disease.

Table 2.12: Codebook developed to code responses to Question 23: “What are the major issues you have faced in diagnosis and treatment of TBDs in Indiana?”. The first and second columns show the six categories and sub-categories. The total percent respondents are shown in parentheses. The third column shows the definition for each category and sub-category, and the last column lists examples of typical responses assigned to the code.

Category	Subcategory	Definition	Example
Health Care Provider (38.4%)	Knowledge: Tick or TBD (21.4%)	• Respondent reported ‘lack of knowledge’ by itself or ‘lack of knowledge about ticks, TBDs, testing and diagnosis’. • Respondent unsure what test(s) to request based on patient symptoms • Respondent reported that the respondent is unsure about ticks and TBDs in Indiana • Respondent reported diagnosis complicated by vague symptoms or symptoms that overlap with other diseases • Respondents reported lack of understanding regarding tests associated with TBDs • Respondent reported issue with prevention of tick bite or TBDs via improper tick removal technique	1. "Lack of understanding from family physicians and infectious disease trained physicians that these infectious diseases exist in Indiana" 2. "Lack of knowledge", "lack of awarenes" 3."I am not sure." 4."I don't know." 5. "Early intervention and removing the tick gently by the head without traumatizing it to cause it to regurgitate back into my patients"
	Experience (13.7%)	• Respondent reported lack of experience with ticks and TBDs in general or lack experience in Indiana • Respondent reported low incidence of tick bites/TBDs in respondent’s medical practice setting or geographical area of practice. • Respondents used the words such as 'usually' or 'typically' when descrbing their experieve with ticks or TBDs	1. "Lack of experience" 2. "This is rarely an issue in my practice- low frequency of need to update my knowledge" 3. "See too infrequent" 4. "low incidence decreases awareness of change in diagnosis"
	Suspicion (1.5%)	• Respondent reported they do not suspect TBDs due to low incidence of TBD cases.	1. "Low level of suspicion for tick borne diseases" 2. "Having a high index of suspicion."
	Identification: Tick (1.2%)	• Respondent reported that the respondent is unable to ID tick or tick bite	1. "Identification of the offending tick" 2. "Tick life cycle identification"
	Risk of Medical Practice (0.5%)	• Respondent reported risk(s) associated with medical practice; malpractice	1." I practice in ""fear"" that one of my colleagues will accuse me of malpractice and take action against me."

Table 2.12. Continued

Health Care System (12.9%)	Testing: Labs (8.4%)	• Respondent reported issues obtaining lab tests, esp. in timely manner • Respondent reported issues obtaining lab tests from reliable, trusted or FDA approved labs • Respondent reported issues with identification fo ticks througth a lab	1. "Reliability of testing." 2. "Lab testing" 3. "Delay in results" 4. "Tick identification in the laboratory"
	Follow-up care (3.4%)	• Respondent reported issues with follow-up post consultation • Respondent reported provider unable to follow up with patient • Respondent reported patient does not follow up with provider • Respondent reported lack of mechanisms for patient-provider follow up	1. "Treatment follow through" 2. "In urgent care, I don't tend to get follow up to find out if they in fact had a tick-borne illness or how they do throughout the course of treatment." 3. "Follow up with Primary doctor" 4. "Not seeing the presentation first hand."
	Cost (1.2%)	• Respondent reported issues with cost of diagnosis, testing or treatment • Respondent reported Issues with insurance coverage	1. "Patients not coming to the doctor; cost of testing; inappropriate testing by EDs, ICC, etc" 2. "The biggest problem is getting insurance providers to approve testing and cover its cost for patients." 3. "Cost of testing"
Patient (9.5%)	Patient reporting (6.5%)	• Respondent reported lack of information provided by patient about history of tick bite, exposure to tick habitat: 1. If they were exposed to ticks or tick habitat 2. If they had a tick-bite in the past	1. "Patient history knowledge and ability to provide to primary care provider." 2. "Most patients I see do not know when they were bit and how long tick was attached" 3. "Getting hx from patiends" 4. "Unknown exposures." "unknown history"
	Knowledge (3.0%)	• Respondent reported patient's lack of knowledge about ticks, TBDs, methods for tick removal, symptoms of TBDs, appearance of symptoms, avoidance of tick habitat, or a tick check after exposure to tick habitat	1. "Patient education about avoidance." 2. "Lack of patient understanding on management of tick bite" 3. "Patient education"
Disagreement (8.5%)	Provider/ Patient request (4.2%)	• Respondent reported unwarranted request from patients for tests or treatment • Respondent reported public/patient have misconceptions/misinformation regarding ticks, TBDs, diagnosis, treatment.	1. "People wanting treatment for chronic Lyme disease" 2. "Public misinformation" 3. "Patients want treatment for lyme disease even when they don't meet criteria." 4. "Patient's finding false information on the internet, quack cures, etc."

Table 2.12. Continued

	Provider/ Provider (4.4%)	• Respondents reported disagreement with healthcare provided by other providers • Respondent reported over/under diagnosis of TBDs	1. "The most common issue I deal with is not actually treating tick-borne illness per se, but rather with misinformation spread by health care practitioners who are diagnosing and "treating" chronic Lyme, which is not a real medical entity." 2. "Dr. not prescribing treatment early in the process." 3. "Overdiagnosis of Lyme Disease by holistic physicians."
Education (7.4%)	Resources (7.4%)	• Respondent reported lack of resources or issue with access to resources, such as clinical guidelinse, websites, alerts etc., for diagnosis/treatment of TBDs in IN from CDC, ISDH, or other professional bodies • Respondent reported resources, such as: websites, are available, but are not backed by federal or state guidelines. • Respondent reported that source of information may not be from a high-quality source, or the information may be from an untrustworthy source	1. "Lack of resources specific to Indiana" 2. "State specific UpToDate guidelines for Assessment and testing, treatment and follow-up for the endemic zoonotic pathogens." 3. "lack of inforamtion" 4. "Early intervention and removing the tick gently by the head without traumatizing it to cause it to regurgitate back into my patients"
Not Applicable (36.9%)	Not applicable (27.1%)	• Respondent reported that question does not apply to the respondent • Respondent reported that respondent does not practice, diagnose or treat TBDs in Indiana, but they may hold an existing medical license to pratice in Indiana or another state • Respondent has clearly stated that they are not an MD, NP or PA • Respondent may be an MD, but may practice in an area of specialty that doesn't deal with TBDs or see patients with TBDs	1. "N/A", "not applicable" or "this does not apply to me" 2. "I don't diagnose or treat anyone" or "I don't dagnose" 3. "I am not a medical professional." "I am not typically asked to diagnosed these diseases." 4. "I don't practice in Indiana." 5. "none", 'No'
	Not categorized (9.7%)	• Respondent reported an ambiguous response which was too short, i.e. limited to one to five words, or signs. • Respondent reported a response which could not be categorize • Respondent reported a response without a subject	1. "Opportunity" 2. "Don’t look for it" 3. "Apathy", "identification", "Access", "Prevention", "awareness" 4. "Thinking about tick borne disease." 5. "Low motivation" 6. " ?, !!!, ., …"

2.5 Discussion

2.5.1 Survey respondents:

The Indiana Public Health Providers: Ticks and Tick-Borne diseases survey provided insights into respondents. The data indicated that respondents were trained in healthcare and practiced in medical settings; 92% of the respondents reported MD (71%), PA (12%), DO (8%), or RN (1%) as their highest level of training. Primary care office (28%), specialty care office (23%), Hospital (Inpatient) (20%), Hospital (ED) (10%), Hospital (Outpatient) (11%) and Urgent care offices (5%) were the most common practice settings. The survey revealed diverse areas of medical specialty among respondents. The most commonly were: Family medicine (22%), Internal medicine (11%), Emergency Medicine (11%) and Pediatrics (10%). Moreover, 40% of the respondents reported "other", with 'anesthesiologist and pain management' (12% total respondents) the most common response in this category. Importantly, the survey included groups of professionals that were not represented in similar studies. For example, the present study included PA and emergency medicine physicians, a need that was noted in the study of Brett et al., 2014. Further, it included practice settings that were not covered by the study by Magri et al (2002) which was limited to an assessment of Family practice, Internal Medicine and Pediatrics.

The survey revealed that the highest number of healthcare providers in this study were experienced MDs (47%) who consult on a modest number of TBD cases (1-25) per year. The reported case load of TBD cases reported by respondents in the present study was consistent with an expected case load based on the relatively low incidence of TBDs in Indiana relative to other regions of the US. It is also consistent with the study by Brett et al., 2014 who reported that 51% of providers consult at least one TBD case per year. Self-diagnosis of TBD cases have been reported in both rural and urban settings (Omodior et al. 2020). Omodior et al. (2019) reported that clusters of self-reported TBD diagnosis considered high-risk for tick exposure were in areas of Indiana where 80% of the community is rural. Therefore, Indiana providers require knowledge of ticks and TBD diagnosis regardless of where they practice, and particularly in rural areas where risk of exposer to ticks is higher.

2.5.2 Provider knowledge of clinical aspects of TBDs:

The survey respondents reported diagnosis of TBDs, including LD (44%), SFR (16%) and Human Ehrlichiosis (8%), which corresponded with endemic TBDs in the state. As expected, based on epidemiological data from ISDH and CDC, LD was the most common TBD encountered. This finding is consistent with that of, Brett et al., 2014 who reported 46.8% of practitioners encountered LD. More than 70% of the respondents correctly answered question regarding signs and symptoms of TBDs. Eighty eight percent recognized EM as a diagnostic feature for LD and the importance of early removal of an attached tick to reduce risk of TBDs. An earlier study by Magri et al. (2002) reported that less than half the respondents were aware of EM as a diagnostic feature for LD, suggesting that awareness among providers about clinical signs and symptoms of TBDs may have increased in the past two decades. Brett et al (2014) suggests that reliance on EM as a diagnostic feature may lead to increase in prophylaxis, suggesting that this possibility should be considered in Indiana.

Seventy five percent of respondents correctly answered Q15 regarding method for removal of a tick and selected "pull the tick with fine-tip tweezers", and 28% of respondents reported using a commercial tick removal tool, both of which are considered acceptable tick removal practices (Roupakias et al. 2011). The early and proper removal of an embedded tick can reduce risk of disease transmission (Glatz et al. 2017). The current recommended practice for removal of a tick is to place a pair of fine tip tweezers around the mouthparts of the tick (not the abdomen), close to the skin, with the application of firm, upward pressure until detachment of the tick (CDC, 2020). Therefore, the study shows that most Indiana healthcare providers know the proper technique for the removal of a tick, which may be a lower priority for training.

The majority of the respondents (58%) requested a serological test (e.g., ELISA, IFA, Western blot) when evaluating a patient with suspected TBDs, which is consistent with the study of Eppes et al. (1994), who reported that the majority of the physicians ordered serum ELISA tests. However, a modest number of respondents (22%) were unsure about which test to order, and this may reflect the fact that some respondents are not qualified to practice due to their highest level of training, (e.g., MS), or do not engage in direct patient care due to their medical practice setting, (e.g., 'not currently practicing'). On the other hand, this may reflect knowledge gaps regarding guidelines specific to tests for diagnosis of TBDs and presents an opportunity to develop educational materials.

2.5.3 Provider Knowledge of Ticks and TBDs:

A substantial percentage of respondents (19-56%) selected unsure for questions regarding species and distribution of tick vectors, epidemiology of TBDs, or tick bite prevention and tick removal. For example, more than 40% of the respondents reported "unsure" or answered Q9-12 incorrectly. These questions pertained to species of ticks capable of transmitting diseases to humans, geographic range of *I. scapularis***,** recognition of northwest Indiana as the region where there is highest risk for LD transmission and May-July as the months considered highest risk for transmission of TBDs in Indiana. While a percentage of respondents correctly identified LD (69%), SFR (37%) and ehrlichiosis (27%) as endemic in Indiana and recognized by the Indiana Health Alert Network (IHAN-IN) as the most prevalent TBDs in the state in IHAN-IN (2019), 40% of respondents reported that they were "unsure" about TBDs endemic to Indiana.

In the present study, 47% of respondents indicated that they were unsure about the species of ticks capable of disease transmission to humans in Indiana. This is consistent with a study by Butler et al. (2016) in which 47.4% of the participants could not identify adult female *I. scapularis*, 59.2% of the participants could not identify an engorged adult female *I. scapularis* and 30.3% could not identify a tick, which could translate to failure to prescribe tick bite prophylaxis which are based on clinical symptoms and tick-bite history, as per CDC guidelines.

Unique findings from the present study include the fact that the majority of respondents were unsure or incorrectly answered questions regarding recognition of (1) documentation of *I. scapularis*, the vector of LD, anaplasmosis, babesiosis and Powassan virus in most Indiana counties (56% were unsure, 4% were incorrect), (2) Northwest Indiana as the region of the state where there is highest risk of LD transmission (49% were unsure and 22% were incorrect), and (3) May-July as the months considered highest risk in Indiana for TBDs transmission (19% were unsure and 29% were incorrect). These findings suggest that many Indiana health care providers may fail to diagnose LD and possibly other TBDs in Indiana. Also, patients seeking prophylaxis, diagnosis, or treatment of TBDs in Indiana may not receive appropriate medical intervention. As a result, they may progress to develop acute and chronic TBDs. Therefore, provider knowledge of tick biology and TBDs epidemiology identifies as a high priority for training.

2.5.4 Differences in knowledge between those w/medical training versus other qualifications:

The survey analyses revealed discrepancies in overall knowledge of ticks and TBDs in Indiana among respondents by highest level of training. Those with an MS degree as their highest qualification were more likely to respond "unsure" to survey questions than MDs, DOs and PAs which likely reflects lack of medical knowledge among those with an MS degree. More than 40% of MS respondents reported they were "unsure" about TBDs recognized as endemic in Indiana, compared to less than 20% of respondents who identified as MDs, DOs and PAs. Among those with an MS degree, 51% were unsure of the species of ticks capable of disease transmission in Indiana compared to MDs (30%), DOs (34%), and PAs (35%). Similarly, those with an MS degree (57%) reported "unsure" for Q14 (detection of EM in all patients positive for LD), but this question was answered correctly by 90% of MDs, DOs, and PAs. Although 70% of those with an MS reported "unsure" for Q11 (highest risk of LD transmission in northwest Indiana), MDs (20%), DOs (30%), and PAs (39%) had reported it incorrectly compared to MS (7%). Lastly, 17% of the responses by those with a MS reported 'pull the tick with fingers/fingernails' compared to 5% by MDs, 1% by DOs and 2% by Pas, and 15% of the responses by MS and 10% by DOs were 'touch the tick with a hot match. Neither of these practices are recommended as they may lead to regurgitation by the tick into the feeding wound and introduction of pathogens to the host (Roupakias et al. 2011). The discrepancy in knowledge between those with the highest level of medical training (MD, DO, and PA) and those with a MS degree suggests an opportunity for educational training on TBDs for Master's level public health and extension educators.

The present study revealed that only five percent of the respondents identify as either a LD specialist, TBD specialist and/or Lyme literate healthcare professional. This is in contrast to the national survey by Brett el al. (2014) which found nearly 70% of the respondents in their study were confident about their knowledge of TBD management, but this finding varied by practitioner type and number of TBDs encountered. This study suggests that the respondents who consider themselves as Lyme literate healthcare professionals is substantially lower in Indiana than the national average and further supports the findings regarding gaps in knowledge about tick and TBDs.

2.5.5 Coding and qualitative data analysis:

The development and inclusion of a qualitative assessment is a feature that distinguishes this study from the survey described above which have concentrated on assessment of quantitative data. The codebook (Table 2.11) was developed here to quantify qualitative data from the open-ended question (Q23) which explored major issues faced in diagnosis and treatment of TBDs by Indiana healthcare providers. In all, six major categories emerged including healthcare provider, healthcare system, patient, disagreement, education, and not applicable. The findings from the qualitative assessment provided further evidence to support the hypothesis that while healthcare providers have knowledge gaps regarding ticks and TBD risk in Indiana, they are aware of these shortcomings.

The most prominent category to emerge from the analysis was the healthcare provider category which explained 38% of the data. Five subcategories were coded with *knowledge of ticks and TBDs* (21.4%) and *experience* (13.7%) were the most common subcategories identified by healthcare providers. The *knowledge: ticks and TBD* subcategory included concerns by the providers that they may have "lack of knowledge", "lack of awareness" regarding diagnosis of TBDs. Similarly, the *experience* subcategory included comments such as "lack of experience" or "This [TBD] is rarely an issue in my practice- [reflecting a] low frequency of need to update my knowledge". This reported lack of provider knowledge and experience regarding ticks and TBDs identified by the present survey suggests a potential risk for poor patient-consultation and treatment outcomes in Indiana and is particularly concerning because the state is considered a low incidence state for TBDs.

The second major category identified in the qualitative analysis (Q23) by percentage was the *Not Applicable* (36.9%) category, in which comments such us "not applicable", "this does not apply to me" or "I don't practice in Indiana" were categorized and included vague comments which were impossible to categorize such as "opportunity" or "…". The results are not unexpected as Q23 focused on ticks and TBDs in Indiana, and while a percentage of respondents may be licensed, they may not practice in the state, or they may not encounter TBD issues in their practice, which explains that 40% of the respondents reported 'other' as their area of specialty (Q3).

The third major category that emerged from the analysis was *Healthcare system* which explained 12.9% of the open-ended responses and included subcategories of *testing: labs* (8.4%), *follow-up care* (3.4%) and *cost* (1.2%). Combined these subcategories highlighted issues regarding

reliable and timely test results and were notable and concerning. Brett et al. (2014) had found that healthcare providers (75%) often ordered concurrent testing for patients with EM rash, despite it being a clinical diagnosis for Lyme disease. Once EM rash has been detected, further testing is not recommended (Halperin et al. 2013).

The *Patient* category was the fourth major category identified (9.5%) and provided insights to issues associated with patient knowledge about ticks and TBDs, and issues related to reporting of tick bite or exposure to tick habitat. The *Patient* category included subcategories of *patient reporting* (6.5%) and *knowledge* (3.0%). As revealed by comments such as "patient education about avoidance" and "Most patients I see do not know when they were bit and how long tick was attached." These findings are of concern because guidelines for TBD diagnosis utilize patient history (CDC, 2020).

The fifth category to emerge from the data included the *Disagreement* category (8.5%) which included subcategories of *provider-patient request* (4.2%) and *provider-provider* (4.4%). The subcategoried revealed issues regarding unjustified requests by patients to treat or test for TBDs, as well as issues regarding public misconception of TBDs. Some examples included "people wanting treatment for chronic Lyme disease" and "public misinformation". In the "Provider-Provider Disagreement" category, conflict with care provided by other healthcare providers was evident in comments such as; "Dr. not prescribing treatment early in the process" and "Overdiagnosis of Lyme Disease by holistic physicians." The 'patient' and 'disagreement' categories brought up a need to target educational resources towards both healthcare providers and patients, and to design resources which can help with successful physician-patient consultations regarding TBDs and exposure to tick bites.

The final category from the qualitative analyses was *Education* (7.4%), in which the only subcategory of *resources* (7.4%) was focused on lack of resources about ticks and TBDs and reliable sources of information were identified. A representative example of this category included one provider identifying, "Lack of resources specific to Indiana." This category provided insights to multiple needs regarding online resources. Specifically, providers requested 1.) that the resource are regularly updated with state-specific information about ticks and TBDs, and 2.) these resources include references from reliable sources.

2.5.6 Educational resources used by practitioners:

Sixty two percent of the respondents reported using online resources to obtain information on epidemiology of TBDs in the State of Indiana. The online resources identified by respondents included: CDC (45%), ISDH (33%) and scientific literature (30%). Similarly, 65% of the respondents reported using online resources to obtain guidelines on diagnosis and treatment of TBDs; CDC (35%), scientific literature (25%), ISDH (23%) were again among the online resources with high utility. An 'other' option was included in the questionnaire (e.g. Q18 (16%) and Q19 (19%)) to account for additional resources that practitioners may use to find information on TBDs. These open-ended responses also had high utility rating, in which the database UpToDate was commonly reported (Q18: 9%, Q19: 13%). UpToDate is an online resource for evidence-based clinical decision support for healthcare providers. These findings suggest that those using online resources to obtain information about epidemiology and guidelines on diagnosis and treatment of TBDs use federal and state government sites and sites sponsored by scientific and professional societies. The most helpful media reported in obtaining information on TBDs was a Website. Online trainings and continuing medical education (CME) events were reported as the most helpful training formats in obtaining information on TBDs. These findings are consistent with Brett et al (2014), who reported that websites were most frequently used to obtain information about ticks and TBDS.

Consultations with public health counterparts led to the hypothesis that a subpopulation of primary health care providers who self-identify as either a Lyme disease (LD) specialist or Lyme literate healthcare professional, obtain information on the epidemiology of TBDs and the guidelines to diagnose and treat TBDs from online sources such as ILADS, LDA or lymedisease.org. Our findings did not support this hypothesis. While a subpopulation reported the use of these online sources, the utility rating was modest (2.5-3.2 avg. utility rating).

2.5.7 Study Strengths and Limitations:

The survey was circulated between February and April 2020 when many Indiana public health professionals were likely engaged in response to the coronavirus disease (COVID-19) pandemic. The survey response rate suggests that the survey is unlikely to represent all professional groups that comprise the collective Indiana healthcare system. The survey response

rate and outcomes could have been different had the survey been performed at a different time and had we sampled different demographics. We acknowledge/recognize that the survey may have been completed by respondents who have interest in TBDs, particularly as the majority of the respondents reported seeing a patient with suspected or confirmed TBD. Notably, the total number of respondents (597 individuals) in the present study was considerably higher than that obtained in similar studies by Eppes et al. (1994); 124 respondents, Murray and Feder (2001); 320 respondents, Magri et al. (2002); 328 respondents, and Mader et al. (2017); 137 respondents, suggesting a reasonably deep sampling. Of note, the preceding studies were conducted in the northeast United States, where the incidence of some tick vectors and TBDs is recognized as substantially higher than the Midwest (Eisen et al. 2017). Thus, the present study provides an essential tool for comparing healthcare provider knowledge between the US's low and high TBD incidence regions. Study results revealed that Indiana healthcare providers have knowledge gaps regarding ticks capable of disease transmission, the geographic range of *I. scapularis,* the area with the highest risk for LD transmission in Indiana, and the months considered the highest risk for TBD transmission in Indiana. Therefore, it provided evidence to support the central hypothesis that Indiana healthcare providers may have less understanding of tick vectors and TBD risks relative to those who practice in high incidence states.

As far as the author is aware, the present study is one of only a handful of surveys regarding ticks and TBDs in the Midwest, and the only study to date of public health providers in the Indiana. The survey provides much-needed insights to provider knowledge and needs in Indiana and the Midwest. Lastly, the survey results were strengthened by qualitative analysis of issues faced by survey respondents regarding diagnosis and treatment of TBDs in Indiana.

2.5.8 Implications and next steps in addressing providers needs re TBDs:

Findings from the Indiana ticks and TBD survey can be used to prioritize and address the needs of public healthcare providers and facilitate the diagnosis of TBDs or develop frameworks for provider-patient consultation with improved outcomes. Educational materials can be developed to address knowledge gaps about tick biology such as tick species and distribution, and risk of exposure to TBD by months and geographic location (i.e., country level). Additionally, these educational materials could be targeted by region or area of practice for current and future

healthcare providers, especially in rural areas where risk of TBD has been reported as higher (Omodior et al. 2019). Furthermore, findings from the current study may be used to develop guidelines to frame successful physician-patient consultations regarding TBDs and exposure to tick bites. This survey also has implications for future researchers in Indiana and nationally, because ticks and TBDs are of concern for public health. An important distinguishing feature of this study is the codebook which concluded that Indiana healthcare providers are aware of their knowledge gaps about ticks and TBDs, and that they are receptive to solutions. This suggests that educational material delivered online will be well received. Overall, our study found evidence to support the central hypothesis that Indiana healthcare providers have less understanding of tick vectors and TBD risks to adequately diagnose or treat TBDs in Indiana, but further investigation is needed to understand significant differences in healthcare providers' knowledge about ticks and TBDs between high and low incidence states.

APPENDIX A. INDIANA PUBLIC HEALTH PROFESSIONALS TICKS AND TICK-BORNE DISEASES NEEDS ASSESSMENT SURVEY

Indiana Public Health Professionals Ticks and Tick-borne Diseases Needs Assessment Survey
Purdue University, Department of Entomology

Scientists at Purdue University in coordination with the Indiana State Department of Health (ISDH) are conducting a survey to develop improved educational resources for Indiana health care professionals (like yourself) to assess knowledge of ticks and tick-borne diseases. By assessing what medical professionals know – and may still need to learn - we will be better able to design an efficient brief on recommended practices for tick-borne diseases affecting Indiana.

Your answers will be kept confidential and anonymous. If you have questions or concerns, please contact: Dr. Catherine A. Hill; Professor of Entomology; hillca@purdue.edu.

Thank you very much for your participation. Your help is greatly appreciated.

Catherine Hill
Professor and Showalter Faculty Scholar
President's Fellow for the Life Sciences
Purdue University

Section 1. Professional qualifications, training and nature of practice

1. Which of the following credentials do you have? Select all that apply.
    a. Doctor of Medicine (MD)
    b. Doctor of Osteopathic Medicine (DO)
    c. Registered Nurse (RN)
    d. Registered Nurse Practitioner (RNP)
    e. Physician Assistant (PA)
    f. Doctor of Philosophy (Ph.D.)
    g. Doctor of Veterinary Medicine (DVM)
    h. Masters of Science (MS)
    i. Masters of Public Health (MPH)
    j. Bachelors degree
    k. Other (please specify)

2. Which of the following best describes your practice setting? Select all that apply.
    a. Primary Care office
    b. Specialty Care office
    c. Urgent Care office
    d. Hospital (Emergency Department)
    e. Hospital (Impatient)
    f. Hospital (Outpatient)
    g. Other (please specify)

3. Which of the following best describes your area of specialty? Select all that apply.
    a. General practice
    b. Family medicine
    c. Pediatrics
    d. Internal medicine
    e. Infectious disease
    f. Urgent care
    g. Emergency medicine
    h. Public health
    i. Purdue Cooperative Extension Service
    j. Other (please specify)

4. What is the total number of years you have practiced in health care?
    a. <1-5
    b. 6-10
    c. 11-15
    d. 16-20
    e. 20-25
    f. >25

5. Do you serve:
    a. Rural communities
    b. Urban communities
    c. Both

6. Approximately how many patients present to you with a suspected or confirmed tick-borne disease in a typical year?
    a. 0
    b. 1-25
    c. 26-50
    d. 51-75
    e. 76-100
    f. >100

Section 2. Knowledge of ticks and tick-borne diseases

7. Which of the following are endemic in the state of Indiana? Select all that apply.
    a. Anaplasmosis
    b. Babesiosis
    c. Heartland Virus
    d. Human Ehrlichiosis
    e. Lyme Disease
    f. Powassan Virus
    g. Spotted Fever Rickettsioses, *e.g.,* Rocky Mountain Spotted Fever
    h. Southern Tick-Associated Rash Illness (STARI)
    i. Tularemia

j. Alpha-gal allergy

8. Which of the following have you diagnosed in Indiana residents? Select all that apply.
    a. Anaplasmosis
    b. Babesiosis
    c. Heartland Virus
    d. Human Ehrlichiosis
    e. Lyme Disease
    f. Powassan Virus
    g. Spotted Fever Rickettsioses, e.g., Rocky Mountain Spotted Fever
    h. Southern Tick-Associated Rash Illness (STARI)
    i. Tularemia
    j. Alpha-gal allergy

9. Which of the following are capable of transmitting diseases to humans in the state of Indiana? Select all that apply.
    a. *Dermacentor variabilis* (American dog tick)
    b. *Rhipicephalus sanguineus* (Brown dog tick)
    c. *Ixodes scapularis* (black-legged tick)
    d. *Amblyomma americanum* (Lone star tick)
    e. All of the above

10. True/False: *Ixodes scapularis* ticks (black-legged ticks) have been documented in most Indiana counties?

11. True/False: While the risk of Lyme disease transmission is present throughout the state of Indiana, it is highest in the northwest part of the state?

12. Which months are considered highest risk for transmission of tick-borne diseases in the state of Indiana?
    a. February through April
    b. May through July
    c. August through October
    d. November through January

13. Which of the following signs and symptoms are associated with tick-borne diseases in Indiana? Select all that apply
    a. Arthritis
    b. Fever/chills
    c. Headache
    d. Inflammation
    e. Rash
    f. Muscle ache
    g. Other (please specify)

14. True/False: All patients with Lyme disease develop an erythema migrans (bulls-eye rash)?

Section 3. Prevention and diagnosis

15. What method(s) do you use for removal of an attached tick? Select all that apply.
    a. Pull the tick with fine-tipped tweezers
    b. Pull the tick with a commercial tick removal tool
    c. Pull the tick with fingers or fingernails
    d. Touch the tick with a hot match
    e. Cover the tick with petroleum jelly
    f. Cover the tick with nail polish
    g. Freeze the tick with liquid nitrogen/dry ice
    h. Other (please specify)

16. True/False: Early removal of an attached tick can reduce risk of transmission of some tick-borne diseases (*e.g.*, Lyme disease)?

17. Which of the following do you request when evaluating a patient with suspected tick-borne disease? Select all that apply.
    a. Serological testing (*e.g.*, ELISA, IFA, Western blot)
    b. Nucleic acid amplification testing (*e.g.*, PCR)
    c. Other (please specify)

Section 4. Information and resources

18. Which of the following online sources do you use to obtain information on the epidemiology of tick-borne diseases in Indiana? Select all that apply.
    a. American Lyme Disease Foundation (ALDF)
    b. American Medical Association (AMA)
    c. Centers for Disease Control and Prevention (CDC)
    d. Indiana Lyme Connect (ILC)
    e. Indiana State Department of Health (ISDH)
    f. Infectious Disease Society of America (IDSA)
    g. International Lyme and Associated Disease Society (ILADS)
    h. Lyme Disease Association (LDA)
    i. Lymedisease.org/The Lyme Times
    j. Professional conferences (please specify)
    k. Professional specialty associations e.g., American Academy of Family Practitioners, American Academy of Pediatrics, etc. (please specify)
    l. Purdue University Extension Service
    m. Scientific literature
    n. Other (please specify)

19. Which of the following sources do you use to obtain guidelines for diagnosis and treatment of tick-borne diseases? Select all that apply.

a. American Lyme Disease Foundation (ALDF)
b. American Medical Association (AMA)
c. Centers for Disease Control and Prevention (CDC)
d. Indiana Lyme Connect (ILC)
e. Indiana State Department of Health (ISDH)
f. Infectious Disease Society of America (IDSA)
g. International Lyme and Associated Disease Society (ILADS)
h. Lyme Disease Association (LDA)
i. Lymedisease.org/The Lyme Times
j. Professional conferences. Please specify
k. Professional specialty associations *e.g.,* American Academy of Family Practitioners, American Society for Microbiology, etc. (please specify)
l. Purdue University Extension Service
m. Scientific literature
n. Other (please specify)

20. On a scale of 1 to 5 rate the utility of the following in terms of information on tick-borne diseases, where 1 indicates low utility and 5 indicates high utility:
    a. American Lyme Disease Foundation (ALDF)
        1 2 3 4 5 N/A
    b. American Medical Association (AMA)
        1 2 3 4 5 N/A
    c. Centers for Disease Control and Prevention (CDC)
        1 2 3 4 5 N/A
    d. Indiana Lyme Connect (ILC)
        1 2 3 4 5 N/A
    e. Indiana State Department of Health (ISDH)
        1 2 3 4 5 N/A
    f. Infectious Disease Society of America (IDSA)
        1 2 3 4 5 N/A
    g. International Lyme and Associated Disease Society (ILADS)
        1 2 3 4 5 N/A
    h. Lyme Disease Association (LDA)
        1 2 3 4 5 N/A
    i. Lymedisease.org/The Lyme Times
        1 2 3 4 5 N/A
    j. Professional conferences
        1 2 3 4 5 N/A
    k. Professional specialty associations
        1 2 3 4 5 N/A
    l. Purdue University Extension Service
        1 2 3 4 5 N/A
    m. Scientific literature
        1 2 3 4 5 N/A

21. Which of the following media would be most helpful to you in obtaining additional information on tick-borne diseases in the state of Indiana? Select all that apply.
    a. Website
    b. Podcast
    c. Webinar
    d. Electronic newsletter via email
    e. Twitter/social media feed
    f. Printed material
    g. Other (please specify)

22. Which of the following training formats would be helpful to you in obtaining information on tick-borne diseases? Select all that apply.
    a. Online training
    b. In-person training (*e.g.*, workshops)
    c. Seminar(s)
    d. Continuing Medical Education (CME) event

23. Would you describe yourself as a Lyme disease specialist, tick-borne disease specialist, and/or Lyme-literate healthcare provider/MD?
    a. Yes
    b. No

24. What are the major issues you face in diagnosing and treating tick-borne diseases in Indiana?

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