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Primary Care Physicians’ Knowledge, Attitudes, and Practices Regarding Lyme Disease in High- Versus Low-Incidence Lyme Disease Midwestern States

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Walden University

College of Health Sciences and Public Policy

This is to certify that the doctoral dissertation by

Alexander Karnga

has been found to be complete and satisfactory in all respects,
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Walden University
2022

Abstract

Primary Care Physicians’ Knowledge, Attitudes, and Practices Regarding Lyme Disease in High- Versus Low-Incidence Lyme Disease Midwestern States

by

Alexander E. Karnga

MPH, Walden University, 2016

BS, University of Maryland University College, 2012

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health-Epidemiology

Walden University

May 2022

Abstract

The purpose of this quantitative cross-sectional study, guided by the barriers to physician behavior change (BPBC) framework, was to address the gaps in the Lyme disease empirical literature by examining whether there were significant differences in Lyme disease knowledge, attitude, and practices between primary care physicians in Wisconsin, a high-incidence Midwestern Lyme disease state, and Michigan, a low-incidence Lyme disease Midwestern state. The study was conducted with 65 physicians (53.8% male and 46.2% female). The study hypotheses were tested by conducting a one-way multivariate analysis of covariance (MANCOVA), controlling for physicians' years of practice (the number of patients seen per week were not significantly related to Lyme disease knowledge, attitudes, and practices for either physician group). Univariate results for the first research question showed that physicians in the high-incidence state of Wisconsin had a significantly higher Lyme disease knowledge mean score (M = 82%) than did physicians in the low-incidence Lyme disease state of Michigan (M = 75%). Univariate results for the second research question were not significant: Wisconsin and Michigan physicians had similar attitudes mean scores regarding their patients' risk for Lyme disease (M = 41% and M = 43%, respectively). Univariate results for the third research question showed that physicians in the high-incidence Lyme disease state of Wisconsin had a significantly higher Lyme disease treatment practices mean score (M = 83%) than did the physicians in the low-incidence Lyme disease state of Michigan (M = 72%). The insights gained from this study can be used to inform epidemiological initiatives concerning the surveillance of Lyme disease in Wisconsin and Michigan.

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Dedication

This work is dedicated to my wife, Daboi Marie Karnga, who has been a constant source of support and encouragement during the challenges of this dissertation process and family life. I am truly thankful for having you in my life. This work is also dedicated to the memory of my father, Gbokon Gaye, whose good examples have taught me throughout the dissertation process to work hard for things I aspire to achieve. Lastly, to my mother, Yeatee Gaye, for her commitment to caring for her children has shown me what it means to support those you love.

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Nobody has been more important to me in the pursuit of this degree than the members of my family. I would like to thank my parents, whose love and guidance have been with me in whatever I pursue. They are my greatest role models. Most importantly, I wish to thank my loving and supportive wife, Daboi Marie Karnga, and my three wonderful children, Youngor, Krubo, and Alexis, who provided unending inspiration.

Finally, I want to thank the 65 primary care physicians from Michigan and Wisconsin who participated in the online survey for this research. Sharing their knowledge and experiences made this study come to life. This dissertation would not have made it through its final stage without their responses.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction to the Study

Lyme disease is the most common tick-borne bacterial disease and a significant public health issue in North America (Greig et al., 2018), with 300,000 Lyme disease cases reported annually (Centers for Disease Control and Prevention [CDC], 2017, 2020a; Pearson, 2015). Persons with Lyme disease are infected with the *Borrelia burgdorferi* bacteria introduced to their system by the *Ixodes scapularis* tick (CDC, 2020a). There are three clinical stages of Lyme disease, with symptoms typically emerging 1 week to 1 month after a tick bite (CDC, 2020a; Greig et al., 2018). The primary early-stage symptom of Lyme disease is *erythema migrans*, which is often coupled with virus-like symptoms of fever, malaise, headache, fatigue, and swollen lymph nodes (CDC, 2020b; Peretti-Watel et al., 2019). Left untreated, Lyme disease can cause severe musculoskeletal, cardiovascular, and neurological impairments, with arthritis occurring in almost 60% of patients (Greig et al., 2018; Johnson & Feder, 2010). As such, the lack of a confirmed diagnosis or, if diagnosed through clinical observation only, the inadequate or incorrect treatment of Lyme disease can have numerous, severe, and ongoing health and mental consequences for patients (Peretti-Watel et al., 2019).

Lyme disease varies in endemicity across the United States, a result of climate and geographical factors, with Lyme disease prevalence and incidence rates highest in states with ecological systems where ticks can thrive (Sharareh et al., 2019). The spatial patterns of Lyme disease infection indicate that Lyme disease incidence rates are highest in Northeastern states, where much of the Lyme disease research has focused its efforts (Sharareh et al., 2019). However, there has been less empirical examination of Lyme disease in the American Midwest, which has one of the largest discrepancies of Lyme disease endemicity (Lantos et al., 2017). Of the high incidence states reported by the CDC (2020c), Wisconsin is the only Midwestern state, having an average 3-year Lyme disease incidence rate of 25.4 cases per 100,000 persons (CDC, 2020c). In contrast, the neighboring state of Michigan has a 3-year Lyme disease incidence rate of 1.8 cases per 100,000 persons (CDC, 2020c). There has, however, been substantial geographical expansion of Lyme disease in Michigan, increasing five-fold between 2000 and 2014, which may eventually result in Lyme disease incidence rates in Michigan becoming comparable to those in Wisconsin (Lantos et al., 2017).

According to Cabana et al.'s (1999) barriers to physician behavior change (BPBC) theory, physicians may not follow recommended diagnostic and treatment protocols to treat diseases due to knowledge, attitude, and practice barriers. Moreover, environmental factors (e.g., disease endemicity, geographical factors) may hinder the use of recommended clinical practices as they influence physicians' knowledge and attitudes (Cabana et al., 1999). Studies on Lyme disease align with Cabana et al.'s (1999) postulates. Primary care physicians may be more likely to not be aware of Lyme disease or to "deviate from guideline recommendations" (Henry et al., 2012, p. e291) for the diagnosis and treatment of Lyme disease if they (a) are not knowledgeable of Lyme disease factors, such as its causative agent and symptoms; (b) believe that their patients are not at risk for contracting Lyme disease; and/or (c) if they practice in low-endemic areas of high-incidence states or in low-incidence Lyme disease states (Conant et al., 2018; Ferrouillet et al., 2015; Gasmi et al., 2017; Henry et al., 2012; Hill & Holmes, 2015). Due to these aforementioned factors, most notably the environmental factor of state endemicity, it may be that Wisconsin and Michigan primary care physicians differ in their Lyme disease knowledge, attitudes, and practices. As such, the purpose of this study was to examine whether primary care physicians in Wisconsin, a high-incidence Midwestern Lyme disease state, and Michigan, a low-incidence Lyme disease Midwestern state, significantly differ in their (a) Lyme disease knowledge of its causative agent, incubation period, and symptoms; (b) attitudes concerning patients' risk for Lyme disease; and (c) antibiotic treatment practices.

A comprehensive overview of the study, inclusive of the guiding theory and research methodology, is presented in Chapter 1. The Background section, a synthesis of the historical and empirical work pertinent to this study, provides a rationale for the study, elucidated in statement of the problem and purpose of the study sections. The chapter continues with a presentation of the research questions and hypotheses, followed by the theoretical framework that frames the study. The study research methodology and design are discussed in the Nature of the Study section, and the parameters and weaknesses of the study are delineated in the Assumptions, Scope and Delimitations section, as well as the Limitations section. Once the significance of the study is discussed, the chapter concludes with a summary.

Background

In the 40 years that have passed since the first diagnosis of Lyme disease in Old Lyme, Connecticut, in 1977 (Wolf et al., 2020), Lyme disease has since become the most common tick-borne disease in America (CDC, 2017, 2020b). The United States has a national surveillance system through the CDC of all reportable tickborne diseases, and the endemicity of Lyme disease is well understood (CDC, 2020d). The geographical uniqueness of Lyme disease has led to the extensive examination of the ecology of Lyme disease, with studies focusing on how climate and geographical factors, and wildlife hosts influence both Lyme disease prevalence and incidence rates (Fischhoff et al., 2019; Sharareh et al., 2019). Lyme disease has long been recognized as a disease with regional parameters, with rates highest in areas that have ecological systems in which the *I. scapularis* ticks thrive, areas with a large deer population, minimal humidity, high forestation density, and low human population rates (Fischhoff et al., 2019; Ginsberg et al., 2021; Lantos et al., 2017).

The American Northeast is recognized as having the highest Lyme disease incidence rates (Sharareh et al., 2019; Wolf et al., 2020). However, Lyme disease incidence rates are also high in the Upper Midwest region of America, increasing by 213% since 2009 (Sharareh et al., 2019). Lyme disease has been shown to increase in Midwestern areas that have an ecology supporting tick proliferation, namely, rich forestation adjacent to a river and low humidity (Gardner et al., 2020; Wang et al., 2019). Lyme disease incidence rates are highest in the Midwestern state of Wisconsin, which has a 3-year Lyme disease incidence rate of 25.4 per 100,000 persons, not much lower than Connecticut’s rate of 35.5 per 100,000 persons (CDC, 2020c). Although Michigan is also in the Upper Midwest, it is a low-incidence Lyme disease state: Michigan’s 3-year Lyme disease incidence rate was 1.8 per 100,000 persons in 2018 (CDC, 2020c). However, Lyme disease cases in Michigan have seen a dramatic upsurge since 2000, with the

Southwest and Upper Peninsula areas of Michigan being notably “geographically concordant” with the tick population growth (Lantos et al., 2017, p. 3). Lyme disease incidence rates are increasing in both Wisconsin and Michigan (Wolf et al., 2020).

Although there is some research concerning clinician-diagnosed Lyme disease rates in the Midwest (Nelson et al., 2015) and the geographical expansion of Lyme disease in Michigan (Lantos et al., 2017), no study to date has examined Lyme disease knowledge, attitudes, and practices among primary care physicians in either Wisconsin or Michigan. Indeed, there has been surprisingly little empirical examination of the knowledge, attitude, and practices concerning Lyme disease among primary care physicians practicing in either high-incidence (Conant et al., 2018; Ferrouillet et al., 2015; Gasmi et al., 2017) or low-incidence (Henry et al., 2012; Hill & Holmes, 2015) Lyme disease states.

Findings across studies have shown that the percentage of primary care physicians who were knowledgeable of the causative agent, incubation period, and symptoms of Lyme disease was lower in low-incidence as compared to high-incidence states (Brett et al., 2014). Primary care physicians practicing in low-incidence Lyme disease states also tended to report little risk that their patients would contract Lyme disease, which likely contributed to their lack of Lyme disease knowledge (Henry et al., 2012; Hill & Holmes, 2015). These findings suggest that primary care physicians in low-incidence Lyme disease experience familiarity, knowledge, and attitudinal barriers concerning Lyme disease (Henry et al., 2012; Hill & Holmes, 2015).

Studies have also shown that Lyme disease treatment practices greatly varied within and between groups of primary care physicians practicing in high- versus low-incidence Lyme disease states (Beck et al., 2021; Brett et al., 2014; Ferrouillet et al., 2015; Gasmi et al., 2017; Henry et al., 2012; Hill & Holmes, 2015). Physicians in both high- and low-incidence Lyme disease states have often prescribed antibiotic treatment for Lyme disease without confirming it through diagnostic testing (Beck et al., 2021; Brett et al., 2014). Diagnosis of Lyme disease has typically been limited to a single laboratory test or, more often, clinical judgment (Beck et al., 2021; Brett et al., 2014). Indeed, Brett et al. (2014) found that a large percentage of primary care physicians in both high- and low-incidence areas (91% and 88%, respectively) prescribed antibiotics to a patient bitten by a tick without waiting for diagnostic evidence. Moreover, these physicians often treated for Lyme disease but did not report it as part of public health surveillance data collection protocols (Brett et al., 2014).

It was important to determine whether primary care physicians practicing in the Midwestern states of Wisconsin and Michigan states have sound Lyme disease knowledge, attitude, and practices, as well as whether differences exist between the two physician groups. Physicians' lack of awareness and/or use of clinical guidelines to diagnosis and treat Lyme disease have numerous public health consequences (Beck et al., 2021). Patients left untreated for Lyme disease will likely progress and worsen, greatly impairing their quality of life (Brett et al., 2014; Singh et al., 2016). Antibiotic treatment without actual reason can also impart negative health consequences (Beck et al., 2021). Moreover, an overlooked Lyme disease diagnosis resulting from attitudinal biases and underreporting of Lyme disease due to lack of knowledge of symptoms and treating for suspected but not confirmed Lyme disease may limit the capturing of accurate cases, resulting in incorrect public health surveillance data for Wisconsin and Michigan.

As stated by Singh et al. (2016, p. 48), there is a need for closer collaboration between physicians, especially those in low-incidence Lyme disease states, and public health officials "to promote education and awareness as a key step to successfully reducing the burden of Lyme disease." By gaining knowledge of Wisconsin and Michigan physicians' Lyme disease knowledge, attitudes, and practices, public health officials can identify areas for educational initiatives for physicians and promote collaboration with physicians.

Problem Statement

The problem addressed in this study was that it is not known whether primary care physicians in high- versus low-incidence Lyme disease Midwestern states report significant differences in Lyme disease knowledge regarding its causative agent, incubation period, and symptoms, attitudes about patient risk for contracting Lyme disease, and practices concerning the use of antibiotic treatment. Lyme disease rates are increasing in both Wisconsin and Michigan (Lantos et al., 2017). Moreover, Michigan is on its way to become a high-incidence Lyme disease state (CDC, 2020c; Wolf et al., 2020). Yet, to date, the public health burden of Lyme disease remains unknown in Wisconsin and Michigan, in part due to the lack of understanding of primary care physicians' Lyme disease knowledge, attitudes, and practices in these states. It may have been that primary care physicians in Wisconsin and Michigan did not believe their patients were at risk for Lyme disease and thus were ill prepared to effectively diagnosis and treat patients with Lyme disease. It may have been that Wisconsin physicians, as they resided in a high-incidence Lyme disease state, perceived their patients to justifiably be at risk for Lyme disease and, as such, had sound knowledge of the disease and utilized the recommended antibiotic treatment protocols to treat it. Information gained in this study concerning the similarities and differences concerning Lyme disease knowledge, attitudes, and practices in Wisconsin and Michigan can be used to inform physician and public health educational and training initiatives, benefiting both a high-incidence (Wisconsin) and a low-incidence (Michigan) Midwestern state.

Purpose of the Study

The purpose of this quantitative study, which employed a cross-sectional design, was to examine whether primary care physicians in high- versus low-incidence Lyme disease Midwestern states significantly differed on Lyme disease Knowledge, attitude, and practices. The independent variable was nominal, with 1 = *Wisconsin, a high-incidence Lyme disease state,* and 0 = *Michigan, a low-incidence Lyme disease state*. The study had three dependent variables aligned with primary care physicians' Lyme disease knowledge, attitudes, and treatment constructs. The first dependent variable was Lyme disease knowledge, measured using the Lyme Disease Knowledge (LDK) scale, which is part of the Lyme Disease Knowledge, Attitudes, and Practices Inventory (LD-KAPI; Magri et al., 2002). The second dependent variable concerned attitudes about patients' risk for Lyme disease after a tick bite, measured using a single item from the LD-KAPI (Magri et al., 2002), "How would you rate your patients' risk of developing Lyme disease after a tick bite?” The third dependent variable pertained to use of antibiotic treatment for Lyme disease, measured using the Lyme Disease Treatment Practice LDTP scale of the LD-KAPI (Magri et al., 2002). The study had four descriptive variables: (a) the physicians’ gender, (b) primary care specialty, (c) years of practice, and (d) average weekly caseload.

Research Questions and Hypotheses

This was a quantitative study that employed a cross-sectional survey design. In alignment with quantitative methods (Moring, 2014), the scientific method was used in this study. I used a cross-sectional survey design, in which data were collected from the primary care physicians in one point in time. The design was causal comparative, appropriate to examine knowledge, attitude, and practice differences between primary care physicians practicing in the high- versus low-incidence Lyme disease Midwestern states of Wisconsin and Michigan, respectively. The study had three research questions, each having null and alternative hypotheses, as follows:

RQ1: Is there a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their knowledge of Lyme disease, controlling for their years of practice and patient caseload per week?

$H1_o$: There is not a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their knowledge of Lyme disease, controlling for their years of practice and patient caseload per week.

$H1_a$: There is a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their knowledge of Lyme disease, controlling for their years of practice and patient caseload per week.

RQ2: Is there is a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their attitudes about their patients' risk of contracting Lyme disease, controlling for their years of practice and patient caseload per week?

$H2_o$: There is not a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their attitudes about their patients' risk of contracting Lyme disease, controlling for their years of practice and patient caseload per week.

$H2_a$: There is a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their attitudes about their patients' risk of contracting Lyme disease, controlling for their years of practice and patient caseload per week.

RQ3: Is there is a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their use of Lyme disease antibiotic treatment practices, controlling for their years of practice and patient caseload per week?

$H3_o$: There is not a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their use of Lyme disease antibiotic treatment practices, controlling for their years of practice and patient caseload per week.

$H3_a$: There is a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their use of Lyme disease antibiotic treatment practices, controlling for their years of practice and patient caseload per week.

Theoretical Framework

The theoretical framework that informed this study was the BPBC model proposed by Cabana et al. (1999). The BPBC model emerged out of an empirical need to develop a framework identifying the knowledge, attitude, and practice barriers of physicians in relation to their implementation of clinical practice guidelines (Cabana et al., 1999). The authors identified barriers aligned with each knowledge, attitude, and practices element, also noting that these barriers influenced and were influenced by other barriers and elements. According to Cabana et al., physicians' lack of familiarity and awareness, which fall under the knowledge domain. These knowledge factors in turn effect attitudinal and behavioral elements concerning lack of outcome expectancy, self-efficacy, and motivation. There are also external factors that influence physician knowledge, attitude, and practices, which Cabana et al. delineated into three groups: patient factors, guideline factors, and environmental factors. In this study, a key theoretical argument is that the environmental factor of state endemicity level plays a role in shaping primary care physicians' Lyme disease knowledge, attitude, and practices.

Moreover, Magri et al. (2002) utilized Cabana et al.’s theory to inform their development of the LD-KAPI, the instrument used in this study.

Nature of the Study

This was a quantitative study that employed a cross-sectional causal comparison design. The study was quantitative as it was deductive in nature and utilized the scientific method, with numerical data collected and statistically analyzed to determine the decision to reject or fail to reject the study null hypotheses. Data were collected at one point in time, hence the cross-sectional element of the design. The causal comparative design is a type of nonexperimental design utilized to determine if there are independent variable group differences on one or more dependent variables, with both types of variables naturally occurring and thus not manipulable (Moring, 2014). The causal comparative design was an appropriate design for examining Lyme disease knowledge, attitude, and practice differences between two groups of practicing Midwestern primary care physicians.

Definitions

Disease endemicity: Disease endemicity concerns the prevalence rate of a disease in a community (CDC, 2020b).

Erythema migrans: *Erythema migrans* is a bulls-eye rash, the most common symptom of Lyme disease (CDC, 2020a).

High-incidence Lyme disease state: The CDC (2020d) defines a high-incidence Lyme disease state as a state having an average Lyme disease 3-year incidence rate of 10 cases per 100,000 persons or higher.

Ixodes scapularus: *Ixodes scapularus* is the deer tick or black-legged tick that carries the spirochete bacterium that causes Lyme disease (CDC, 2017, 2020a).

Low-incidence Lyme disease state: The CDC (2020d) defines a low-incidence Lyme disease state as a state having less than an average Lyme disease 3-year incidence rate of 10 cases per 100,000 persons.

Lyme disease: Lyme disease is a tick-borne zoonotic disease, the causative agent of which is the *Borrelia burgdorferi* spirochete, introduced into the body by bite from the *I. scapularus* tick (CDC, 2017). The most common manifestation of Lyme disease is *erythema migrans*, a bulls-eye rash; additional symptoms include lethargy, myalgia, chills, fever, and arthralgia (Mead, 2015). Left untreated, Lyme disease can result in numerous and severe cardiovascular and neurological problems (CDC, 2020a).

Assumptions

All empirical studies have assumptions, or aspects of the study taken to be true "without concrete proof" (Ellis & Levy, 2009, p. 331). This study had some assumptions related to the theory, methodology, and sample. There was a theoretical assumption that Cabana et al.'s (1999) BPBC model was a sound theoretical framework that provided pertinent information on barriers to physician knowledge, attitude, and practices. Aligned methodological assumptions were that the study research questions aligned with the BPBC model. An additional methodological assumption was that the LD-KAPI (Magri et al., 2002) scales and items, as confirmed in studies using the LD-KAPI (Conant et al., 2018; Ferrouillet et al., 2015; Henry et al., 2012), provided sound and reliable measurement of primary care physicians' Lyme disease knowledge, attitude, and practices. The sample assumptions were that the primary care physicians (a) represented the target population; (b) had some level of training regarding diagnosing, treating, and reporting cases of Lyme disease; and (c) provided honest and truthful responses on the study questionnaire.

Scope and Delimitations

The study had a scope, or an identified boundary, and associated delimitations, or constraints placed on the study due to the study scope (Moring, 2014). The scope of the study was specific to Wisconsin and Michigan primary care physicians and their Lyme disease knowledge, attitudes, and antibiotic treatment practices. As a result of the study scope, the study was delimited to primary care physicians, and not any other physicians, who were licensed and certified to practice in the states of Wisconsin and Michigan. The study was delimited to the physicians' perceptions of their Lyme disease knowledge, attitude, and practices as framed by Cabana et al.'s (1999) BPBC model. The study was also delimited to the measurement of Lyme disease knowledge, attitude, and practices, as assessed by the pertinent scales and items on the LD-KAPI (Magri et al., 2002).

Limitations

Studies have limitations, which are the opposite of delimitations in that they are outside the control of the investigator (Ellis & Levy, 2009). Study limitations can reduce both the internal (i.e., the degree to which it can be said that differences were the result of the independent variable and not any other variable) and external (i.e., generalizability) validity of a study (Nardi, 2018). The recruitment methods of this study introduced some limitations. Although I utilized simple random sampling to identify primary care physicians who would receive a study email invitation, the primary care physicians themselves made the decision to participate in the study. This recruitment method may have increased the likelihood of the self-selection bias: this bias refers to individuals choosing to participate in a study having qualitative differences on key attributes than those choosing not to participate (Nardi, 2018). For example, the primary care physicians who chose to participate in this study may have had more diagnostic, treatment, and reporting experience concerning Lyme disease and/or a higher number of patients with Lyme disease than primary care physicians who decided to not participate. An associated bias that may have occurred in this study was the social desirability bias: this bias refers to participants providing socially acceptable but not necessarily truthful responses on study questions (Nardi, 2018). Certain procedures, including requiring informed consent that outlined the steps to ensure participant confidentiality and using an online data collection method, may have helped to reduce the self-selection and social desirability biases in this study.

The study had design, theoretical, and sample limitations. The study design was nonexperimental, and as such, causality cannot be inferred in the findings. The study findings were only be discussed in relation to Cabana et al.'s (1999) BPBC theory. Although other theories may have applied to this study, the study findings could not and were not generalized to such models. The study was limited to primary care physicians in Wisconsin and Michigan. As such, study findings could not be generalized to physicians who were not primary care physicians or to primary care physicians practicing in other states.

Significance

This study had theoretical and empirical significance. This study was informed by Cabana et al.'s (1999) BPBC model. Despite its application to physician knowledge, attitude, and practices in relation to hypertension (Dash et al., 2020; Fang et al., 2018), asthma (Kaiser et al., 2020; Sharpe et al., 2020), and other chronic health issues (Goodarzi et al., 2018; Nelson et al., 2015), and despite Magri et al.'s (2002) acknowledgment regarding its applicability to Lyme disease, Cabana et al.'s BPBC model has not been utilized in studies examining primary care physicians' Lyme disease knowledge, attitude, and practices. This study provided some empirical validation as to the theoretical relevance of Cabana et al.'s BPBC theory specific to Wisconsin and Michigan primary care physicians' Lyme disease knowledge, attitude, and practices.

This study advanced the empirical understanding of Lyme disease knowledge, attitude, and practices among primary care physicians in high-incidence (i.e., Wisconsin) versus low-incidence (i.e., Michigan) Lyme disease Midwestern states. Although there has been some examination of Lyme disease knowledge, attitude, and practices among primary care physicians practicing in high-incidence states (Conant et al., 2018; Ferrouillet et al., 2015; Gasmi et al., 2017; Singh et al., 2016), results have been equivocal across studies. Despite being a high-incidence state, Wisconsin has not received empirical attention in the primary care physicians' Lyme disease knowledge, attitude, and practices literature. Moreover, primary care physicians' Lyme disease knowledge, attitude, and practices in low-incidence Lyme disease states have received minimal empirical attention (Henry et al., 2012; Hill & Holmes, 2015). While Brett et al.

(2014) found significant differences between primary care physicians practicing in high- versus low-incidence Lyme disease geographical areas in America, there has not been to date a study examining primary care physicians' Lyme disease knowledge, attitude, and practices in both high- and low-incidence states. The results of this study provided much needed understanding as to whether primary care physicians in high- versus low-incidence Lyme disease Midwest states significantly differed on perceptions of Lyme disease knowledge, attitude, and practices.

This study had applied significance as well. New knowledge regarding areas of risk in Michigan and Wisconsin was gathered on an epidemiological level. The insights gained from this study can be used to inform epidemiological initiatives concerning the surveillance of Lyme disease in Wisconsin and Michigan. Findings could help inform professional development initiatives aimed at improving Lyme disease knowledge, attitude, and the use of recommended clinical practices among primary care physicians. It is important to ensure that primary care physicians who are key stakeholders in providing healthcare to the general population know how to best diagnose, treat, and report Lyme disease cases.

Summary

In the United States, Lyme disease remains a serious disease. Over 33,000 cases of Lyme disease are reported to the CDC annually (CDC, 2020d). Lyme disease is often underreported in some parts of the United States, and the confirmed cases or incidence of Lyme disease may be underreported (Lantos, 2011). If patients who do, in fact, have Lyme disease never receive a correct diagnosis, there is a possibility that those patients will develop chronic Lyme disease and their recovery could be problematic and expensive (Pearson, 2015).

The Midwestern state of Wisconsin is recognized as a high-incidence Lyme disease state, as it has a 3-year Lyme disease incidence rate of 25.4 per 100,000 persons (CDC, 2020c). Although Michigan is considered a Midwestern low-incidence Lyme disease state, having a 3-year Lyme disease incidence rate of 1.8 per 100,000 in 2018 (CDC, 2020c), Lyme disease cases in Michigan have seen a dramatic upsurge since 2000 (Lantos et al., 2017). The reasons for the differences in Lyme disease incidence rates in Wisconsin and Michigan have not been fully explained. They may be due to factors involving Wisconsin and Michigan primary care physicians' knowledge, attitudes, and treatment practices regarding Lyme disease. This quantitative cross-sectional study addressed the gap in the empirical literature regarding potential differences between Wisconsin and Michigan primary care physicians' Lyme disease knowledge, attitudes, and practices. This concludes Chapter 1. A literature review is the topic of Chapter 2.

Chapter 2: Literature Review

The problem addressed in this study was that it was not known if primary care physicians in high- versus low-incidence Lyme disease Midwestern states reported significant differences in Lyme disease knowledge regarding its causative agent, incubation period, and symptoms, attitudes about patient risk for contracting Lyme disease, and practices concerning the use of antibiotic treatment. There has been some examination of Lyme disease knowledge, attitude, and practices among primary care physicians practicing in high- and low-endemic areas (Conant et al., 2018; Ferrouillet et al., 2015; Gasmi et al., 2017; Henry et al., 2012; Hill & Holmes, 2015). Findings from these studies showed that primary care physicians in high-incidence Lyme disease states had a sound level of knowledge of Lyme disease symptoms and showed appropriate concerns regarding their patients' risk for contracting Lyme disease; however, their treatment practices varied (Ferrouillet et al., 2015; Gasmi et al., 2017).

In contrast, primary care physicians practicing in low-incidence Lyme disease states tended to have poor knowledge of Lyme disease symptoms, and the knowledge they had often did not extend to treatment, as most considered their patients to not be at risk for contracting Lyme disease (Henry et al., 2012; Hill & Holmes, 2015). When considered as a collective, the findings on primary care physicians' Lyme disease knowledge, attitude, and practices were equivocal (Conant et al., 2018; Ferrouillet et al., 2015; Gasmi et al., 2017; Henry et al., 2012; Hill & Holmes, 2015), and they provided no enlightenment as to whether there were significant differences in Lyme disease knowledge, attitude, and practices between primary care physicians in the high-incidence

Lyme disease state of Wisconsin versus the low-incidence Lyme disease state of Michigan.

The purpose of this quantitative study, which employed a cross-sectional causal comparative design, was to examine whether primary care physicians in high- versus low-incidence Lyme disease Midwestern states significantly differed on Lyme disease knowledge, attitude, and practices. The independent variable was nominal, with 1 = *Wisconsin, a high-incidence Lyme disease state*, and 0 = *Michigan, a low-incidence Lyme disease state*. The study had three dependent variables aligned with primary care physicians' Lyme disease knowledge, attitudes, and treatment constructs. The first dependent variable was Lyme disease knowledge, measured using the LDK scale, which is part of the LD-KAPI (Magri et al., 2002). The second dependent variable concerned attitudes about patients' risk for Lyme disease after a tick bite, measured using a single item from the LD-KAPI (Magri et al., 2002), "How would you rate your patients' risk of developing Lyme disease after a tick bite?" The third dependent variable pertained to use of antibiotic treatment for Lyme disease, measured using the LDTP scale of the LD-KAPI (Magri et al., 2002). The study had four descriptive variables: the physicians' gender, primary care specialty, years of practice, and average weekly caseload.

The purpose of this chapter is to provide a comprehensive review, synthesis, and discussion of the pertinent theoretical and empirical literature. The literature search strategy is reviewed first, followed by an elaboration of Cabana et al.'s (1999) BPBC framework, inclusive of a discussion on the contemporary empirical work informed by this theory. The review of the literature comprises the bulk of this chapter, with subsections on specific topics relevant to the study. The chapter ends with a summary and conclusion.

Literature Search Strategy

The literature search for this study, conducted to find, retrieve, review, and synthesize pertinent peer-reviewed research, was performed using EBSCO databases, specifically Medline, Science Direct, Science Citation Index Expanded, CINAHL, ProQuest Health & Medical Collection, CINAHL Plus, Nursing & Allied Health, PubMed, and PubMed.gov. Google Scholar was also utilized as a search engine. I set the search parameters to research articles published in peer-reviewed journals between the years 2015 and 2021. However, after reviewing the literature for the years 2015–2021, I extended the parameters to 2012–2021 to allow for inclusion of seminal articles, such as Cabana et al. (1999), Magri et al. (2002), and Henry et al. (2012). The search terms used singly and in combination with other terms were *epidemiology*, *public health*, *medicine*; *physician*, *doctor*, *healthcare provider*; *knowledge*, *attitudes*, *practices*, *KAPs*; *Lyme disease*, *tick-borne diseases*; *geography*, *ecology*, *endemic*, *endemicity*, *prevalence*, *incidence*, *high-incidence*, *low-incidence*, *state*, *area*, *region*, *indigenous*; *differences*, and *similarities*.

Theoretical Foundation

Cabana et al.’s (1999) BPBC theoretical framework guided this study. The BPBC model was the result of Cabana et al.’s review and synthesis of 76 peer-reviewed research articles on physician knowledge, attitude, and practices in relation to their implementation of clinical practice guidelines. Noting that “the process and factors responsible for how physicians change their practice methods," especially for novel or relatively unknown diseases, Cabana et al. (1999, p. 1458), developed their BPBC framework, which identified barriers aligned with each KAP element, also noting that these barriers influenced and were influenced by other barriers and elements. Magri et al. (2002) utilized Cabana et al.'s theory to inform the development of the LD-KAPI, the instrument used in this study.

The BPBC framework provides a sequential model to understanding knowledge, attitude, and practices, and their aligned barriers, in relation to the adoption of clinical treatment guidelines (Cabana et al., 1999). According to Cabana et al.'s BPBC framework, the physicians' knowledge of a disease influences their attitudes surrounding the disease, which in turn influence behaviors concerning the treatment of the disease; moreover, the physicians experience specific barriers that impair their knowledge, attitude, and practices. The physicians' knowledge, or lack thereof, is impaired by their lack of familiarity and awareness of certain treatment guidelines, which often result from a lack of available scholarly guidelines on disease treatment practices and lack of time and resources, including accessibility of guidelines. The physicians' lack of knowledge in turn shapes their treatment attitudes, impacted by the physicians' lack of agreement with existing clinical guidelines, often due to lack familiarity with the disease and confusion surrounding the interpretation of clinical evidence, the limited applicability to the patient, and/or the impracticality of the recommended treatment (Cabana et al., 1999).

Physicians' attitudes are also shaped by lack of outcome expectancy (i.e., lack of expected benefits of treatment), lack of self-efficacy to apply recommended clinical practices, and a lack of motivation to follow the guidelines (Cabana et al., 1999). As they have direct effects on the patient, lack of outcome expectancy, self-efficacy, and motivation all have serious consequences for the physicians' adoption of clinical practices (Cabana et al., 1999). Physicians' attitudes in relation to their outcome expectancies, self-efficacy, and motivation influences and is influenced by external factors to shape physicians' adoption of clinical practices (Cabana et al., 1999). Cabana et al. (1999) delineated external barriers into three domains pertaining to (a) the patient (e.g., preferences for treatment); (b) the guidelines themselves; and (c) environmental factors, inclusive of lack of time, resources, organizational support, and related factors. In summary, physicians' knowledge and attitudes concerning the adoption of specific clinical practices is impacted by numerous internal and external factors, which can impede the physicians' adoption of clinical guidelines for the treatment of a disease (Cabana et al., 1999).

Research Informed by the BPBC Theory

Due to the numerous implications of physicians' not following clinical guidelines (Fischer et al., 2016), there has been a number of studies examining the validity of Cabana et al.'s (1999) BPBC theory as applied to physician knowledge, attitude, and practices in various domains (Lavoie et al., 2017; Liang et al., 2017). Liang et al., in their review of the empirical literature on physician knowledge, attitude, and practices, found that the BPBC theory was used in 7.1% of the reviewed studies, coming in fourth after the more commonly used theories of the theory of planned behavior, theoretical domains framework, and diffusion of innovation theory. Moreover, whereas the more established theories were used to guide empirical work on the identification of barriers and/or intervention studies, Cabana et al.'s BPBC has been used specifically for the empirical exploration of barriers to physicians' knowledge, attitude, and practices (Liang et al., 2017), which is the intent of this study.

Some of the empirical work informed by Cabana et al. (1999) included an exploration and elaboration of the theoretical postulates posed in the BPBC theory (Fischer et al., 2016; Lavoie et al., 2017). Fischer et al. conducted a systematic review of 69 research studies published between 1980 and 2015, with the authors exploring the literature in relation to the BPBC theory, identifying additional barriers in each KAP domain. Lavoie et al. also reviewed over 100 studies in the physician knowledge, attitude, and practices literature in relation to the BPBC theory. Based on their conclusions of the research on physician knowledge, attitude, and practices, Fischer et al. and Lavoie et al. recommended Cabana et al.'s BPBC as an important theory for research examining physicians' knowledge, attitude, and practices barriers concerning the treatment of chronic disease.

Both Fischer et al. (2016) and Lavoie et al. (2017) confirmed that physicians' knowledge was shaped by lack of familiarity and awareness of the disease and its treatment guidelines. Fischer et al. also confirmed Cabana et al.'s (1999) postulate that physicians' attitudes were shaped by their lack of outcome expectancies, self-efficacy, and motivation. However, Fischer et al. argued that additional attitudinal barriers exist, including lack of physician agreement and uncertainty with the guidelines, lack of skills to effectively implement the practice, and lack of a learning culture that advocates for the physicians' adoption of emerging treatment protocols (Fischer et al., 2016). Lavoie et al. also concluded that physicians' attitudes were unduly influenced by their lack of outcome expectancies, self-efficacy, motivation, and—in agreement with Fischer et al.—the physicians' uncertainty about the treatment guidelines. The work by Fischer et al. and Lavoie et al. support the theoretical arguments posed by Cabana et al. concerning the lack of familiarity and awareness as factors subsumed under the knowledge domain and extend Cabana et al.'s concept of attitude barriers to include additional factors, including physicians' lack of certainty regarding recommended practices.

A strength of both Fischer et al.'s (2016) and Lavoie et al.'s (2017) review of the literature studies was that the authors provided elaboration on the external factors that impaired physicians' adoption of treatment and practice protocols. Indeed, Fischer et al. proposed that internal and external barriers work together to influence knowledge, attitude, and practices; moreover, these internal and external barriers exist on different levels (i.e., individual, interpersonal, organizational, societal). Lavoie et al. further posited that physicians' practices can be negatively influenced by environmental factors related to time, organizational resources, access to care, and the geographical setting of the hospital or practice. As posited by Cabana et al. (1999), and as elaborated upon by Fischer et al. and Lavoie et al., there are numerous external barriers that can impede physicians' knowledge, attitude, and practices concerning the adoption of healthcare treatments and practices.

Rationale for the Use of the BPBC Theory

Cabana et al.'s (1999) BPBC theory has informed numerous studies, with researchers applying the theory to examine physicians' knowledge, attitude, and practices barriers in relation to diabetes (Saint-Pierre et al., 2019); hypertension (Dash et al., 2020; Fang et al., 2018); asthma (Kaiser et al., 2020; Sharpe et al., 2020), and numerous other mental health and health issues (Fischer et al., 2016; Goodarzi et al., 2018; Liang et al., 2017; Nelson et al., 2015). Indeed, according to Lavoie et al. (2017), most of the empirical work using the BPBC framework as a theoretical guide has most often focused on physicians' knowledge, attitude, and practices barriers concerning diabetes, hypertension, and asthma. Findings from the literature have confirmed that physicians' knowledge, attitude, and practices differ across the types and specialties of physicians as well as across healthcare organizations and settings (Fischer et al., 2016; Liang et al., 2017; Nelson et al., 2015).

Cabana et al.'s (1999) BPBC theory has not, however, been utilized as a guiding theory in research on primary care physicians' Lyme disease knowledge, attitudes, and practices, despite its recommended use by Magri et al. (2002). In their seminal study on physicians' knowledge, attitude, and practices in relation to Lyme disease, Magri et al. utilized Cabana et al.'s theory to inform their development of the LD-KAPI, the instrument used in this study. This study was the first to utilize Cabana et al.'s BPBC model as a guiding theory to explore Midwestern primary care physicians' Lyme disease knowledge, attitude, and practices. This study tested Cabana et al.'s BPBC theoretical postulate, elaborated upon by Lavoie et al. (2017), that environmental factors (in this case, the level of Lyme disease state endemicity) play a role in shaping primary care physicians’ Lyme disease knowledge, attitude, and practices.

Literature Review

Lyme disease, which infects approximately 300,000 Americans per year (CDC, 2020d), is a serious disease caused by the sprirochete *B. burgdorferi*, transmitted to humans through an infected black-legged tick (Rayment & O’Flynn, 2018).The most common early symptom of Lyme disease is *erythema migrans*, a bull’s-eye rash, which can occur from 3 days to 3 months after a tick bite (Rayment & O’Flynn, 2018); however, not all patients who contract Lyme disease developed this red rash (CDC, 2020d). Additional symptoms are those often found with the flu: fever, swollen glands, malaise, myalgia, fatigue, musculoskeletal pain, and headache (Rayment & O’Flynn, 2018). Lyme disease has long-term health consequences, affecting the body on a systemic level, with most damage seen to the neurological and cardiovascular system (CDC, 2020a, 2020b; Greig et al., 2018).

The advances in the fields of epidemiology and public health concerning the treatment of Lyme disease have been greatly informed by and have informed the immense body of literature on Lyme disease (Greig et al., 2018; Waddell et al., 2016). There remain, however, gaps in the empirical literature on Lyme disease concerning potential differences in Lyme disease knowledge, attitude, and practices among physicians in high- versus low-incidence Lyme disease states (Brett et al., 2014). This literature review section of the chapter is comprised of subsections specific to a pertinent research topic. The first topics reviewed are surveillance case definition for Lyme disease, stages of Lyme disease, and diagnostic tests for Lyme disease. The topic then turns to Lyme disease endemicity in the United States, with emphasis on high- and low-incidence states and empirical rationales for such differences. The last topic explored is physicians' Lyme disease knowledge, attitude, and practices in relation to practicing in high- versus low-incidence states in America.

Lyme Disease: Surveillance Case Definition, Stages, and Diagnostic Tests

The surveillance case definition for Lyme disease, which outlined the uniform criteria for the disease, was first established in 1995, a result of the second National Conference on Serologic Diagnosis of Lyme Disease, sponsored by the CDC, the U.S. Food and Drug Administration (FDA), the National Institutes of Health (NIH), the National Committee for Clinical Laboratory Standards, and other federal and state administrations (Waddell et al., 2016). The case definition for Lyme disease has changed since 1995 as more knowledge was gained about the disease (CDC, 2020b). In 1995, the primary clinical criterion for Lyme disease was erythema migrans, with diagnostic tests confirming the diagnosis (CDC, 2020b). The case definition has grown to include a specific clinical description by the CDC (2017), presented in Figure 1.

Figure 1

Surveillance Case Description for Lyme Disease

Clinical Description

A systemic, tick-borne disease with protean manifestations, including dermatologic, rheumatologic, neurologic, and cardiac abnormalities. The most common clinical marker for the disease is erythema migrans (EM), the initial skin lesion that occurs in 60%-80% of patients.

For purposes of surveillance, EM is defined as a skin lesion that typically begins as a red macule or papule and expands over a period of days to weeks to form a large round lesion, often with partial central clearing. A single primary lesion must reach greater than or equal to 5 cm in size across its largest diameter. Secondary lesions also may occur. Annular erythematous lesions occurring within several hours of a tick bite represent hypersensitivity reactions and do not qualify as EM. For most patients, the expanding EM lesion is accompanied by other acute symptoms, particularly fatigue, fever, headache, mildly stiff neck, arthralgia, or myalgia. These symptoms are typically intermittent. The diagnosis of EM must be made by a physician. Laboratory confirmation is recommended for persons with no known exposure.

For purposes of surveillance, late manifestations include any of the following when an alternate explanation is not found:

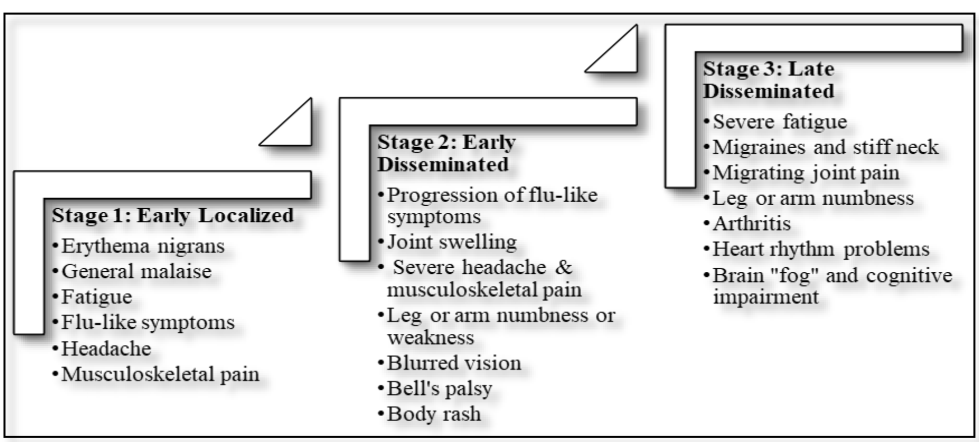
- *Musculoskeletal system* . Recurrent, brief attacks (weeks or months) of objective joint swelling in one or a few joints, sometimes followed by chronic arthritis in one or a few joints. Manifestations not considered as criteria for diagnosis include chronic progressive arthritis not preceded by brief attacks and chronic symmetrical polyarthritis. Additionally, arthralgia, myalgia, or fibromyalgia syndromes alone are not criteria for musculoskeletal involvement.
- *Nervous system* . Any of the following signs that cannot be explained by any other etiology, alone or in combination: lymphocytic meningitis; cranial neuritis, particularly facial palsy (may be bilateral); radiculoneuropathy; or, rarely, encephalomyelitis. Headache, fatigue, paresthesia, or mildly stiff neck alone, are not criteria for neurologic involvement.
- *Cardiovascular system* . Acute onset of high-grade (2nd-degree or 3rd-degree) atrioventricular conduction defects that resolve in days to weeks and are sometimes associated with myocarditis. Palpitations, bradycardia, bundle branch block, or myocarditis alone are not criteria for cardiovascular involvement.

Note. From *Lyme Disease: 2017 Case Definition*, by Centers for Disease Control and Prevention, 2017, (https://wwwn.cdc.gov/nndss/conditions/lyme-disease/case-definition/2017/). In the public domain.

There are three recognized stages of Lyme disease: (a) Stage 1, early localized; (b) Stage 2, early disseminated; and (c) Stage 3, late dissemination (see Figure 2). During Stage 1, which lasts for a few days, the patient may present with *erythema migrans*; additional flu-like symptoms may emerge at the initial stage (CDC, 2020a; Pearson, 2015). Stage 2, or early disseminated Lyme disease, lasts for several weeks to several months (CDC, 2020a; Pearson, 2015). At Stage 2, many of the flu-like symptoms, including fatigue, general malaise, fever, chills, and musculoskeletal pain, may progress and become more severe (CDC, 2020a). New symptoms may emerge at Stage 2; these include that can present as leg or arm numbness, blurred vision, joint swelling, and Bell's palsy (CDC, 2020a; Pearson, 2015). Stage 3 is called late disseminated, and this stage can last months to even years after initial infection (Johnson & Feder, 2010; Pearson, 2015). A symptomatic case of late-stage Lyme disease may include severe and chronic fatigue, stiff neck, migrating joint pain, arthritis, cognitive impairment, and/or tingling and/or numbness in the hands or feet (Johnson & Feder, 2010; Pearson, 2015).

Figure 2

Stages of Lyme Disease and Associated Symptoms



When seeking a diagnosis when a bacteria-borne disease is suspected, the gold diagnostic standard is a positive culture of a bacteria (Schutzer et al., 2019; Waddell et al., 2016). The CDC (2020b) recommends a two-tier diagnostic testing system, the Enzyme-Linked Immunosorbent Assay (ELISA) test followed by the Western Blot test. However, because it is difficult to culture *B. burgdorferi*, and as antibody tests may be conducted too early for “antibodies to be developed,” there is “no [diagnostic] gold standard” for Lyme disease (Rayment & O’Flynn, 2018, p. 1). As such, Lyme disease is often misdiagnosed and dependent on the primary care physicians’ knowledge (Schutzer et al., 2019; Waddell et al., 2016).

High- and Low-Incidence Areas of Lyme Disease

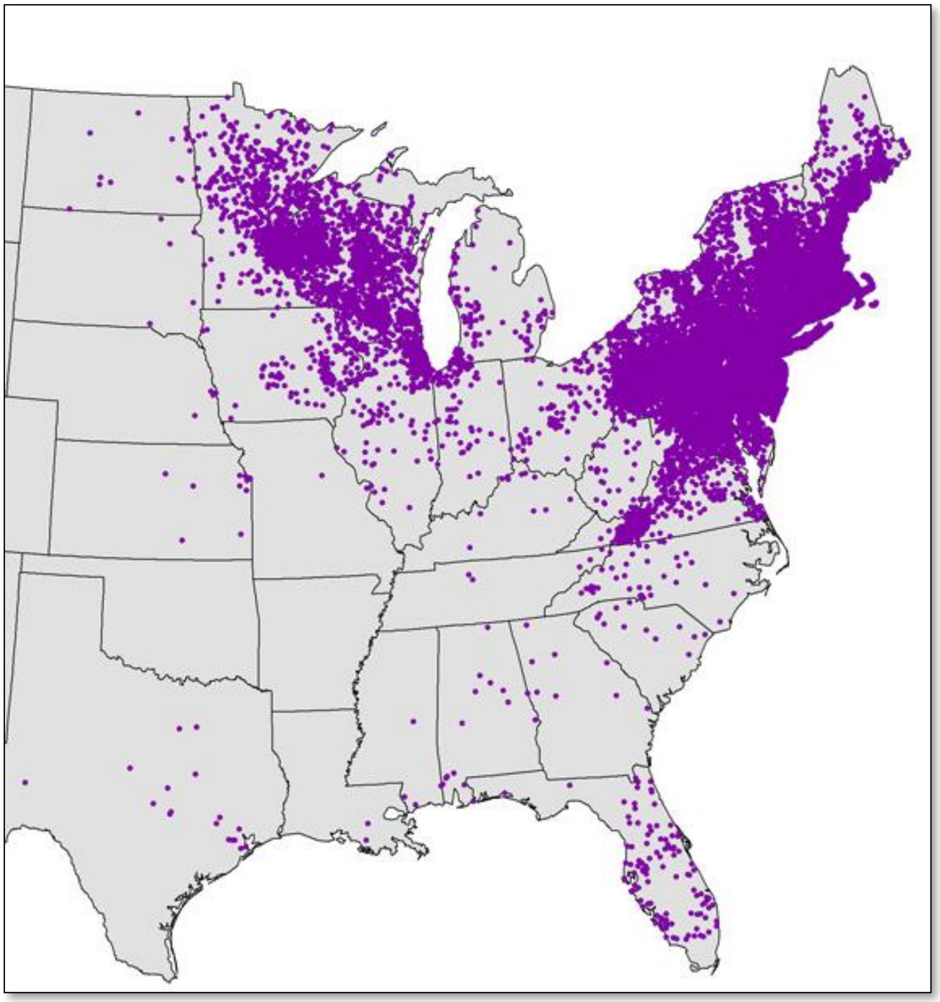
The geographical uniqueness of Lyme disease has led to the extensive examination of the ecology of Lyme disease, with studies focusing on how climate and geographical factors, wildlife hosts of Lyme disease, or both influence Lyme disease prevalence and incidence rates (Fischhoff et al., 2019: Greig et al., 2018). Lyme disease has long been recognized as a disease with regional parameters, with rates highest in areas that have ecological systems in which the *I. scapularis* ticks thrive (Ginsberg et al., 2021; Greig et al., 2018; Lantos et al., 2017). Lyme disease is prevalent in areas where there is minimal humidity, high forestation density, and low human population rates (Fischhoff et al., 2019; Greig et al., 2018). As red-tailed deer population are the hosts for *I. scapularis*, Lyme disease is high in areas with a high number of red-tailed deer (Fischhoff et al., 2019; Greig et al., 2018). Lyme disease rates may also be higher in Northern regions as both deer and small mammals are indigenous to these areas and are better hosts for *I. scapularis*; in contrast, lizards are more common hosts of *I. scapularis* in Southern states, which likely reduces transmission of the spirochete (Ginsberg et al., 2021). In summarizing the key climate and landscape factors associated with Lyme disease infection found in the Lyme disease empirical literature, Greig et al. (2018) identified temperature, rainfall, and relative humidity as the critical climate issues and a woodland landscape with heavy vegetation, rock walls, and deer population as critical landscape factors.

The American Northeast and Upper Midwest have historically been the regions with the highest Lyme disease prevalence rates (see Figure 3). Lyme disease rates have continued at a 320% increase over the past ten years in Northeastern counties and 213% in the Upper Midwest region (Sharareh et al., 2019). As of 2018, the American Northeast and Upper Midwest accounted for 93% of Lyme disease cases (Sharareh et al., 2019). As seen in Figure 3, CDC (2020c) data show that Lyme disease incidence rates are the highest in Atlantic coastal states. Connecticut has the highest Lyme disease rate in the United States, but Lyme disease rates are also notably high in the coastal states of states of Massachusetts, New Hampshire, Delaware, and New Jersey (CDC, 2020c).

The Upper Midwest has pockets of high Lyme disease rates, with rates highest in Wisconsin (CDC, 2020c). Wisconsin had a 3-year Lyme disease incidence rate of 25.4 per 100,000 in 2018, higher than rates seen in some Northeast states, including Maryland (18.6 per 100,000) and New York (14.5 per 100,000) (CDC, 2020c). While Michigan is also in the Upper Midwest, it is a low-incidence Lyme disease state. Michigan's 3-year Lyme disease incidence rate was 1.8 per 100,000 persons in 2018 (CDC, 2020c).

Figure 3

Lyme Disease Rates in Northeast and Midwest (2018)



Note. From *Lyme Disease: Tickborne Diseases of the United States*, CDC, 2020, (https://www.cdc.gov/ticks/tickbornediseases/lyme.html). In public domain.

Rates of Lyme disease have, however, increased in Michigan. In their study, Lantos et al. (2017) utilized ArcGIS software to conduct a spatial cluster analysis of Lyme disease suspected (grey) and reported (black) cases. In 2000, the number of suspected and confirmed Lyme disease cases in Michigan was less than 30, with the cases most often reported in the upper peninsula (Lantos et al., 2017). There were 108 total number of Lyme disease cases reported between 2000 and 2005, with most cases reported in concentrated areas of the upper peninsula (Lantos et al., 2017). Incidence rates of Lyme disease remained steady until 2006, when cases began to be reported in the southwest counties along Lake Michigan, and by 2016, over 180 cases of Lyme disease were reported (Lantos et al., 2017). The authors posited that Lyme disease case increases in Michigan were “geographically concordant” with the tick population growth in the southwest and upper peninsula areas of Michigan (Lantos et al., 2017, p. 3).

There is some evidence that, despite having similar Lyme disease prevalence and incidence rates, the Northeast and Upper Midwest regions may differ on ecological factors of Lyme disease. Wang et al. (2019) examined environmental correlates of Lyme disease in the Northeast and the Upper Midwest in the states of Wisconsin and Minnesota. These two regions which have seen substantial increases in Lyme disease rates since 2006. Using county-level data, the authors found that neighborhood infection level, forestation, and high average temperatures were significantly related to increase Lyme disease rates in both regions (Wang et al., 2019).

However, Dong et al. (2020) found some differences between regions. Dong et al. examined Lyme disease risk factor differences between 13 Northeast states and 6

Midwest states, utilizing land use and climate data from ArcGIS, and comparing these data to Lyme disease rates in the states. In both areas, low developed areas and areas with forestation were significantly linked to higher Lyme disease rates (Dong et al., 2020). In contrast, higher temperatures were associated with a decrease in Lyme disease rates in the Midwest but were associated with an increase in Lyme disease rates in Northeastern states (Dong et al., 2020). The differences in Lyme disease rates in association with temperature led the researchers to posit that “low humidity and high temperatures could regulate tick abundance” in Midwest states but not Northeast states (Dong et al., 2020, p. 1). There was, however, a limitation of the study in that Dong et al. included both low- and high-incidence Midwest states, while all Northeast states had high Lyme disease endemicity.

Bron et al. (2020) examined if risk factors for Lyme disease significantly differed between the high-incidence Northeast states of New York and New Jersey and the Midwest state of Wisconsin. The authors recruited 1,093 participants, 396 from New York/New Jersey and 697 from Wisconsin. Bron et al.’s findings showed that, while the percentage of participants with Lyme disease was similar in both states, 14%, risk factors differed. Participants in Wisconsin engaged in more outdoor activities, including bird watching, camping, fishing, gardening, and hiking, than did participants in New York and New Jersey. These outdoor activities placed Wisconsin participants at more risk for Lyme disease than the Northeastern participants (Bron et al., 2020). In a study like Bron et al. (2020), Ballard and Bone (2021) found that forestation was predictive of Lyme disease rates in both the Northeast and Upper Midwest; however, agricultural land use was linked to higher Lyme disease rates in the Northeast but not the Upper Midwest.

There has been less examination of the ecology of Lyme disease in just the Midwest: only a couple of studies have been conducted, one by Maestas et al. (2016), and more recently, Gardner et al. (2020). Maestas et al. found evidence of an *I. scapularis* population, the first of its kind, in South Dakota; the authors attributed the tick presence to a warmer climate and tall grass prairie located by a wooded river side. Taking the perspective that geographical distribution of Lyme disease is influenced by climate change, Gardner et al. examined predictors of increased geographical spread of Lyme disease in Midwest states between 1967 and 2018. The authors found that proximity to a high-incidence Lyme disease area, forestation, and adjacency to a river significantly predicted increased rates of Lyme disease in Midwestern counties (Gardner et al., 2020). Findings reported by Maestas et al. and Gardner et al. suggest that the Midwest region's changing climate and environmental landscape make it increasingly habitable to the *I. scapularis* tick.

Lyme Disease Knowledge, Attitudes, and Practices Among Primary Care Physicians in High- and Low-Incidence States

With the climate and environmental factors influencing changes in Lyme disease incidence rates, there is a need to examine if knowledge, attitude, and practices surrounding Lyme disease differ among primary care physicians practicing in these areas (Brett et al., 2014). There is minimal examination of primary care physicians' knowledge, attitude, and practices in relation to Lyme disease (Ferrouillet et al., 2015). However, most of the work (Brett et al., 2014; Ferrouillet et al., 2015; Henry et al., 2012; Hill & Holmes, 2015) that has been done has benefitted by the consistent use of Magri et al.'s (2002) LD-KAPI, allowing for comparisons across study findings.

Brett et al. (2014) conducted one of the earlier studies on primary care physicians' Lyme disease knowledge, attitude, and practices, utilizing a national sample of 2000 healthcare providers and assessing differences in primary care physicians' Lyme disease knowledge, attitude, and practices using Magri et al.'s (2002) LD-KAPI. Brett et al.'s study was one of the first to identify significant differences in Lyme disease knowledge, attitude, and practices between primary care physicians practicing in high- versus low-incidence areas of the United States. While 74% of primary care physicians in high-incidence areas had treated a patient with Lyme disease, only 33% of primary care physicians in low-incidence areas had treated a patient with Lyme disease. The high percentage of primary care physicians having treated patients with Lyme disease (74%) roughly corresponded to the percentage of primary care physicians in high-incidence states who agreed that they were knowledgeable of Lyme disease, including its symptoms and diagnosis. Sixty-five percent of primary care physicians in low-incidence areas agreed that they were knowledgeable of Lyme disease. Additional findings showed that a large percentage of primary care physicians in high-incidence and low-incidence areas would prescribe antibiotics to a patient bitten by a tick without waiting for diagnostic evidence, 91% and 88%, respectively. Moreover, 81% of primary care physicians consulted websites to gain information on Lyme disease; in contrast, only 21% used clinical guidelines (Brett et al., 2014). The findings from Brett et al. emphasize the similarities and differences in Lyme disease knowledge, attitude, and practices between primary care physicians practicing in high- versus low-incidence states.

There has been some exploration of primary care physicians' knowledge, attitude, and practices concerning Lyme disease, with some studies focusing on high-incidence areas (Conant et al., 2018; Ferrouillet et al., 2015; Gasmi et al., 2017; Singh et al., 2016). Two studies (Ferrouillet et al., 2015; Gasmi et al., 2017) focused on Quebec, a province having one of the highest Lyme disease incidence rates in Canada. Ferrouillet et al. utilized the LD-KAPI (Magri et al., 2002) to explore perceptions of Lyme disease knowledge, attitude, and practices among 201 primary care physicians in Quebec. Ferrouillet et al.'s study was limited in that only descriptive analyses were conducted; however, these findings provided pertinent information on Lyme disease knowledge, attitude, and practices. Only half of the primary care physicians had ever had a potential Lyme disease case. Despite this, most primary care physicians (> 80%) had sound knowledge of Lyme disease, especially its endemicity in their location and the Lyme disease symptoms of fever, myalgia, and *erythema migrans* (Ferrouillet et al., 2015). The attitudinal and treatment responses, however, varied, with some primary care physicians treating suspected but not verified cases of Lyme disease with antibiotics, likely a result of not having a patient with Lyme disease (Ferrouillet et al., 2015). Gasmi et al. (2017), in their study with Quebecois primary care physicians, reported similar findings to Ferrouillet et al., with doctors having a high degree of knowledge of Lyme disease symptoms but varying in treatment knowledge and practices.

The remaining two studies by Singh et al. (2016) and Conant et al. (2018) focused on the high-incidence Lyme disease states of West Virginia and Vermont, with both authors using Magri et al.'s (2002) LD-KAPI. West Virginia has a Lyme disease incidence rate of 30.7 cases per 100,000 persons; it is one of the few states outside of the Northeast that is a high-incidence state (CDC, 2020c). The Lyme disease knowledge score among the 297 primary care physicians in the study was 70%, indicative of relatively low knowledge; moreover, less than 50% of primary care physicians were knowledgeable of the surveillance criteria for diagnosing Lyme disease (Singh et al., 2016). Singh et al. also found that primary care physicians' knowledge of Lyme disease played no role in the treatment of Lyme disease in patients, of whom there were 83 confirmed cases.

Conant et al. (2018) explored Lyme disease serology and other diagnostic test knowledge as well as attitudes concerning patients in a sample of 147 primary care physicians in Vermont, which has a 79.1 per 100.000 persons incidence rate (CDC, 2020c). The number of correct responses varied by question topic. For example, 93% of primary care physicians reported knowing that a negative serologic test for Lyme disease did not rule out its diagnosis, but just 42% were able to interpret when a test is likely to show a false positive for Lyme disease (Conant et al., 2018). Moreover, over a third (38%) of primary care physicians stated that patient asked for non-standard serology testing for Lyme disease (Conant et al., 2018). The percentage of patients requesting difficult-to-interpret tests coupled with the primary care physicians' poor knowledge of serology testing may contribute to an incorrect diagnosis of Lyme disease (Conant et al., 2018), especially in patients of primary care physicians practicing in high-incidence Lyme disease areas (Sharareh et al., 2019).

There are two studies (Henry et al., 2012; Hill & Holmes, 2015) that have examined primary care physicians' knowledge, attitude, and practices concerning Lyme disease in low-incidence states. Henry et al. utilized Magri et al.'s (2002) LD-KAPI to explore Lyme-disease-related perceptions in a sample of 152 primary care physicians from Vancouver, British Columbia. Results showed the Lyme disease knowledge, attitude, and practices were low, lower than those reported by Ferrouillet et al. (2015). The average Lyme disease knowledge score was 76%, equivalent to a C, for primary care physicians. Specific symptom questions in which a smaller percentage of primary care physicians correctly answered were knowledge that diarrhea (67%) and heart problems (63%) can result from Lyme disease (Henry et al., 2012). Concerning Lyme disease attitudes, 83% of primary care physicians reported that their patients were at low risk for Lyme disease and 79% reported, among the patients who request a Lyme disease evaluation, their symptoms were likely attributable to another cause. Nonetheless, over a third (31%) of the primary care physicians stated that they treated for suspected Lyme disease using antibiotic treatment even when they thought the patient did not have Lyme disease. primary care physicians' knowledge of antibiotic treatment practices was also low, with between 40% and 50% of primary care physicians identifying the appropriate antibiotic treatment course (Henry et al., 2012).

Similar findings were reported by Hill and Holmes (2015), who explored Lyme disease knowledge, attitude, and practices using the LD-KAPI (Magri et al., 2002) in a sample of over 600 primary care physicians in Arkansas, a low-incidence Lyme disease state. Using the same Lyme disease scales as Henry et al. (2012), Hill and Holmes found that the average knowledge score was a failing 59% and that only 46% of primary care physicians utilized correct antibiotic treatment practices; moreover, 80% of primary care physicians reported that they felt their patients were at low risk for Lyme disease. Findings from Henry et al. and Hill and Holmes suggest that primary care physicians practicing in low-incidence Lyme disease areas may have sound knowledge of Lyme disease symptoms but are less sure about the proper antibiotic treatment for Lyme disease; moreover, most primary care physicians felt that their patients were not at risk for contracting Lyme disease.

Summary and Conclusion

Lyme disease has long been recognized as a disease with regional parameters, with rates highest in areas that have ecological systems in which the *I. scapularis* ticks thrive, areas with a large deer population, minimal humidity, high forestation density, and low human population rates (Fischhoff et al., 2019; Ginsberg et al., 2021; Lantos et al., 2017). The spatial patterns of Lyme disease surveillance data show that infection rates are highest in Northeastern and upper Midwest states (CDC, 2020d). Most Lyme disease research has focused its efforts on the Northeast (Sharareh et al., 2019); the Midwest has received considerably less empirical attention (Lantos, 2017). The lack of empirical focus on the Midwest may be a result of the varying incidence rates across the Midwest states. Wisconsin, having an average 3-year Lyme disease incidence rate of 25.4 cases per 100,000 persons, is the only Midwestern state to be identified by the CDC (2020c) as one of the top 10 high-incidence Lyme disease states in America. The neighboring state of Michigan, in contrast, is a low-incidence Lyme disease state with a 3-year Lyme disease incidence rate of 1.8 cases per 100,000 persons (CDC, 2020c). There has, however, been substantial geographical expansion of Lyme disease in Michigan, increasing five-fold between 2000 and 2014 (Lantos et al., 2017), which may eventually result in Lyme disease incidence rates in Michigan comparable to those in Wisconsin.

Despite the high rates of Lyme disease in Wisconsin (CDC, 2020c) and the increasing rates of Lyme disease infection in Michigan (Lantos et al., 2017), there had yet to be an empirical examination as to whether high- versus low-incidence Lyme disease state status played a role in influencing primary care physicians' knowledge, attitude, and practices concerning Lyme disease. This study was informed by theoretical arguments posed by Cabana et al. (1999) in their BPBC theory - which were further elaborated upon by Fischer et al. (2016), Lavoie et al. (2017), and Liang et al. (2017) - that environmental barriers could prevent primary care physicians from (a) gaining knowledge about Lyme disease; (b) perceiving that their patients were at risk for Lyme disease after a tick bite; and (c) and engaging in effective antibiotic treatment practices informed by clinical guidelines. This study specifically tested one element of the BPBC theory: that the environmental factor of state endemicity level played a role in shaping primary care physicians' Lyme disease knowledge, attitudes about their patients' risk for Lyme disease after a tick bite, and antibiotic treatment practices.

The empirical literature reviewed in this chapter provided information on the definition, symptoms, stages, and diagnostic tests for Lyme disease. I provided the rationale for this study by presenting research that focused on studies examining primary care physicians' Lyme disease knowledge, attitude, and practices in high-incidence Lyme disease states (Conant et al., 2018; Ferrouillet et al., 2015; Gasmi et al., 2017; Singh et al., 2016) versus low-incidence Lyme disease states (Henry et al., 2012; Hill & Holmes, 2015). Findings showed, that while primary care physicians overall were likely to prescribe antibiotics for suspected Lyme disease (Brett et al., 2014), primary care physicians in low-incidence states had less knowledge of Lyme disease, especially in relation to its specific symptoms and diagnostic testing, and an attitude that their patients were not at risk for Lyme disease (Henry et al., 2012; Hill & Holmes, 2015). Primary care physicians' knowledge, attitude, and practices in states with low rates of Lyme disease remain poorly understood due to the "nonspecific nature of Lyme disease symptoms coupled with the relative rarity of the disease" (Henry et al., 2012, p. e291). Indeed, the presumed low-incidence rates of Lyme disease outside of the American Northeast may have hindered the empirical work on the differences in Lyme disease knowledge, attitude, and practices between Midwestern primary care physicians working in high- versus low-incidence states (Stone et al., 2017). This study addressed the gap in the Lyme disease literature by examining if primary care physicians practicing in high- versus low-incidence Lyme disease Midwestern states (i.e., Wisconsin versus Michigan) significantly differed in their Lyme disease knowledge, attitudes about their patients' risk for Lyme disease after a tick bite, and antibiotic treatment practices. The next chapter, Chapter 3, provides a detailed overview of the study methodology.

Chapter 3: Research Method

The purpose of this study was to examine whether primary care physicians in Wisconsin, a high-incidence Midwestern Lyme disease state, and Michigan, a low-incidence Lyme disease Midwestern state, differed significantly in their (a) Lyme disease knowledge of its causative agent, incubation period, and symptoms; (b) attitudes concerning patients' risk for Lyme disease after a tick bite; and (c) antibiotic treatment practices. Lyme disease has expanded geographically to the Midwestern states, but appears to have differential geographical impact (CDC, 2020c). The states of Wisconsin and Michigan have many demographic, housing, and employment similarities (U.S. Census, 2020), but differ in Lyme disease prevalence rates (CDC, 2020c). For Wisconsin, a high-incidence Lyme disease state, the 3-year average Lyme disease prevalence rate is 25.4 confirmed cases per 100,000 persons; in contrast, Michigan, a low-incidence Lyme disease state, has a 3-year average Lyme disease prevalence rate of 1.8 confirmed cases per 100,000 persons (CDC, 2020c). It has been posited that Lyme disease state endemicity may play a role in shaping primary care physicians' knowledge, attitudes, and practices regarding Lyme disease (Henry et al., 2012).

There has been some examination of Lyme disease knowledge, attitude, and practices among primary care physicians practicing in high-incidence Lyme disease areas (Conant et al., 2018; Ferrouillet et al., 2015; Gasmi et al., 2017; Henry et al., 2012). Findings, while varied across studies (Conant et al., 2018; Ferrouillet et al., 2015; Gasmi et al., 2017; Henry et al., 2012), have suggested that primary care physicians may be more likely to "deviate from guideline recommendations" when treating patients for potential Lyme disease if they practice in high-endemic Lyme disease areas (Henry et al., 2012, p. e291). There is considerably less attention given to the examination of Lyme disease knowledge, attitude, and practices among primary care physicians practicing in low-incidence states and areas (Henry et al., 2012; Hill & Holmes, 2015). However, such studies have shown that primary care physicians in low-incidence Lyme disease states have relatively poor knowledge concerning Lyme disease symptoms and diagnostic testing (Henry et al., 2012; Hill & Holmes, 2015). A review of the literature revealed no studies that examined the effects of practicing in a high- versus low-incidence Lyme disease state on Lyme disease knowledge, attitude, and practices among a sample of Midwestern primary care physicians.

This chapter presents an overview of the study methodology. The research questions are restated, and a rationale for the study research design, a cross-sectional survey design, is provided. The chapter continues with the Methodology section, which presents information on the (a) study population, sampling plan, and sample; (b) participant recruitment and data collection process; (c) study instruments and operationalization of variables; and (d) data analysis plan. The remaining sections concern study validity, inclusive of its internal, external, and statistical conclusion validity, and the ethical procedures to be employed in the study. A summary concludes the chapter.

Research Design and Rationale

This was a quantitative study that employed a cross-sectional causal comparative design. In alignment with quantitative methods (Moring, 2014), the scientific method was utilized in this study. The design was cross-sectional, as I collected data from the primary care physicians in one point in time, and causal comparative, as I examined differences in Lyme disease knowledge, attitudes, and antibiotic treatment practices between primary care physicians working the high-incidence Lyme disease state of Wisconsin versus those working the low-incidence Lyme disease state of Michigan. The study had three research questions, each having aligned null and alternative hypotheses. The research questions and hypotheses were the following:

RQ1: Is there a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their knowledge of Lyme disease, controlling for their years of practice and patient caseload per week?

$H1_o$: There is not a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their knowledge of Lyme disease, controlling for their years of practice and patient caseload per week.

$H1_a$: There is a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their knowledge of Lyme disease, controlling for their years of practice and patient caseload per week.

RQ2: Is there is a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their attitudes about their patients' risk of contracting Lyme disease, controlling for their years of practice and patient caseload per week?

$H2_o$: There is not a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their attitudes about their patients' risk of contracting Lyme disease, controlling for their years of practice and patient caseload per week.

$H2_a$: There is a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their attitudes about their patients' risk of contracting Lyme disease, controlling for their years of practice and patient caseload per week.

RQ3: Is there is a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their use of Lyme disease antibiotic treatment practices, controlling for their years of practice and patient caseload per week?

$H3_o$: There is not a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin versus Michigan) on their use of Lyme disease antibiotic treatment practices, controlling for their years of practice and patient caseload per week.

$H3_a$: There is a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin vs. Michigan) on their use of Lyme disease antibiotic treatment practices, controlling for their years of practice and patient caseload per week.

The purpose of this quantitative cross-sectional causal comparative study was to examine whether primary care physicians in high- versus low-incidence Lyme disease Midwestern states significantly differed on Lyme disease Knowledge, attitude, and practices. The independent variable was nominal, with 1 = *Wisconsin, a high-incidence Lyme disease state*, and 0 = *Michigan, a low-incidence Lyme disease state*. The study had three dependent variables aligned with primary care physicians' Lyme disease knowledge, attitudes, and treatment constructs. The first was Lyme disease knowledge, measured using the LDK scale, which is part of the LD-KAPI (Magri et al., 2002). The second dependent variable concerned attitudes about patients' risk for Lyme disease after a tick bite, measured using a single item from the LD-KAPI (Magri et al., 2002), "How would you rate your patients' risk of developing Lyme disease after a tick bite?" The third dependent variable pertained to use of antibiotic treatment for Lyme disease, measured using the LDTP scale of the LD-KAPI (Magri et al., 2002). The study had four descriptive variables: the physicians' gender, primary care specialty, years of practice, and average weekly caseload.

Methodology

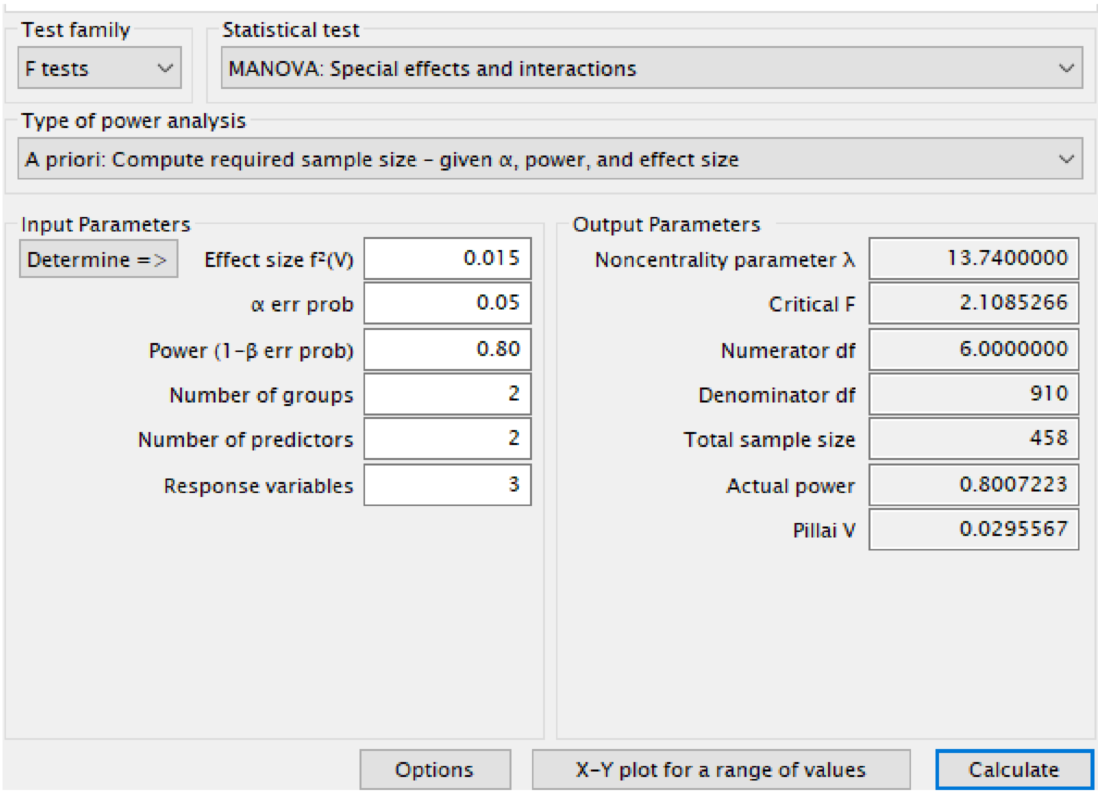
Population and Sample Size

The study target population was the approximately 15,270 licensed and currently practicing primary care physicians in two Midwestern states: Wisconsin, a high-incidence Lyme disease state, and Michigan, a low-incidence Lyme disease state. According to the American Medical Association (2022), there are 9,774 primary care physicians currently working in the state of Michigan and 5,497 primary care physicians employed in the state of Wisconsin. Per the study criteria, the physicians who participated in this study had to (a) have a license to practice medicine in the respective state, (b) be board certified, and (c) currently work as primary care physicians.

The necessary sample size needed to achieve power of .80 was established by an a priori power analysis for a multivariate analysis of covariance (MANCOVA) using the G*Power MANOVA special effects and interaction function (Faul et al., 2007). Specific parameters were set for the power analysis: (a) the effect size was set to $f^2 = 0.015$, a small effect size (Chen et al., 2010); (b) the alpha, or significance level was set to $p < .05$; (c) power was set to $1-\beta = .80$; (d) the number of independent variable groups was set to 2; (e) the number of predictors (i.e., covariates) was set to 2; and the (f) the number of response (i.e., dependent) variables was set to 3. Results from the power analysis, presented in Figure 4, showed that the necessary sample size needed to achieve power of .80 is $N = 458$, or $n = 229$ per primary care physician group. To obtain the sample size of 229 primary care physicians per state would require a response rate of 2.3% of the target population of the 9,774 Michigan primary care physicians and 4.2% of the target population of the 5,497 Wisconsin primary care physicians. As general practitioner response rates on online questionnaire range from 20% to 60% (Aitken et al., 2008; Brtnikova et al., 2018; Pit et al., 2014; Scott et al., 2011; Weaver et al., 2019), response rates of 2.3% and 4.2%, respectively, should not be difficult to achieve.

Figure 4

Power Analysis



Procedures for Recruitment, Participation, and Data Collection

Once IRB approval (# 07-22-21-0434470) was given, I initiated the proposed online recruitment and data collection procedures. I recruited and sampled primary care physicians who represented the target population of approximately 15,300 primary care physicians working in the states of Wisconsin and Michigan. The means of data collection was an online questionnaire, which I sent to the selected physicians via email. The recruitment and data collection procedures are discussed in the following sections.

Procedures for Recruitment

I initiated the process of recruiting participants by requesting a public list of primary care physicians currently practicing in the respective states and their contact information (i.e., work address, phone number, and email) from the Michigan Department of Licensing and Regulatory Affairs Bureau of Professional Licensing and the Wisconsin Department of Safety and Professional Services (Division of Professional Credential Processing). The lists were sampling frames for the study. A sampling frame is the "roll or list of sampling units," most often the members of the target population (Zhengdong, 2011, p. 15).

I employed simple random sampling, where the participants were randomly selected from the target population of primary care physicians. Using an online number generator, with its parameters set to the number of primary care physicians on the state list, I randomly selected a subgroup of primary care physicians. Although primary care physician response rates in studies have typically ranged from 30% to 60% (Aitken et al., 2008; Brtnikova et al., 2018; Pit et al., 2014), response rates lower than 20% have been reported (Scott et al., 2011; Weaver et al., 2019). To err on the side of caution, I selected a random sample of 2,500 primary care physicians per state (i.e., 45.5% of all Wisconsin primary care physicians and 25.5% of Michigan primary care physicians) from the sampling frame. With a random sample of n = 2,500 primary care physicians selected per state, a response rate of less than 10% was needed to obtain the sample size of n = 229 primary care physicians per state.

Data Collection Procedures

The means of data collection involved the physicians completing an online SurveyMonkey questionnaire. I sent the selected group of Wisconsin and Michigan primary care physicians an email that described the study purpose, the role of the participants, and the study Survey Monkey link. The participants clicked on the link, which took them to an Informed Consent statement, and on to the questionnaire.

Instrumentation and Operationalization of Constructs

I used scales and items on the LD-KAPI, an instrument developed by Magri et al. (2002) to examine physicians' Lyme disease knowledge, attitudes, and treatment practices. The LD-KAPI scales and items used in this study are discussed in the following sections.

Independent Variable: Practicing in a High- Versus Low-Incidence Lyme Disease State

The study had one independent variable, a dichotomous (nominal) variable measuring whether the primary care physician practiced in a high- versus low-incidence Lyme disease Midwestern state. The independent variable was coded as 1 = practice in high-incidence Lyme disease state (i.e., Wisconsin), and 0 = practice in low-incidence Lyme disease state (i.e., Michigan).

Dependent Variable 1: Lyme Disease Knowledge

The first dependent variable was Lyme disease knowledge, measured using the ratio coded LDKI (Magri et al., 2002). The LDKI has five dichotomous (i.e., 1 = *yes,* 0 = *no*) items assessing whether the primary care physician knows the Lyme disease causative agent, incubation period, incidence of erythema migrans, and related human granuloctic ehrlichiosis coinfection. The sixth question inquires as to whether the physician knows five key symptoms of Lyme disease (i.e., arthritis, fever, neuropathy, heart problems, and meningitis), with each sub-question having a dichotomous (i.e., 1 = *yes*, 0 = *no*) response. The LDKI composite score is treated as a ratio score from 0% to 100% based on the number of correct answers (e.g., 13/13 correct = 100%, 12/13 correct = 92%; Magri et al., 2002).

Dependent Variable 2: Attitudes About Patients' Lyme Disease Risk

The second dependent variable was the primary care physicians' attitude about patients' risk (probability) of contracting Lyme disease after a tick bite. The second dependent variable was measured using the LD-KAPI (Magri et al., 2002) single item, "How would you rate your patients' risk of developing Lyme disease after a tick bite?" The variable is ratio, ranging from 0% (i.e., no risk) to 100% (i.e., complete risk; Magri et al., 2002).

Dependent Variable 3: Lyme disease Antibiotic Treatment Practice

The third dependent variable concerned the physicians' Lyme disease antibiotic treatment practices, assessed using the LDTP scale on the LD-KAPI (Magri et al., 2002). The LDTP scale comprised of six multiple-choice questions concerning the appropriate antibiotic treatment of Lyme disease, each question having a correct answer. One question on the LDTP scale is, "Prophylaxis treatment for Lyme disease is which of the following?" Reponses are 1 = *100 mg doxycycline once a day*, 2 = *200 mg doxycycline once*, 3 = *100 mg doxycycline twice daily for seven days*, and 4 = *300 mg doxycycline* *once*, with 2 being the correct response (Magri et al., 2002). The number of correct responses is counted and divided by the total number of six questions to derive the scale score, which can range from 0% to 100% (Magri et al., 2002).

Descriptive Variable 1: Physician Gender

The first descriptive variable concerned the physicians' gender, a single item on the LD-KAPI (Magri et al., 2002). The gender variable was dichotomous (nominal), measured as 1 = *male* and 2 = *female* (Magri et al., 2002).

Descriptive Variable 2: Primary Care Physician Specialty

The second descriptive variable inquired about the physicians' primary care specialty, and it is a single item on the LD-KAPI (Magri et al., 2002). This was a nominal variable, coded where 1 = *family medicine/family practice/general practice*, 2 = *internal medicine*, 3 = *pediatrics*, and 4 = *other* (Magri et al., 2002).

Descriptive Variable 3: Years of Practice

The third descriptive variable was the primary care physicians' years of practice. This variable was measured using a single interval item from the LD-KAPI (Magri et al., 2002), "How many years have you practiced as a primary care physician?" The participants were asked to provide the number of years they have been practicing, and as such, the variable scores can range from 1 to ??? years (Magri et al., 2002).

Descriptive Variable 4: Number of Patients Seen per Week

The fourth descriptive variable was the primary care physicians' years of practice. This variable was measured using a single ordinal item from the LD-KAPI (Magri et al., 2002), "How many patients do you see each week, on average?" The participants provided the average number of patients they saw each week, with variable scores ranging from 1 to ??? years (Magri et al., 2002).

Data Analysis Plan

Once I had collected the study data using an online Survey Monkey questionnaire, the data were downloaded into an SPSS 27.0 data file. The data analysis plan was sequential, with the analyses being conducted in steps. I used SPSS 27.0 to conduct all statistical procedures.

Data Cleaning and Organization

Certain data preparation activities were performed for the first step of the data analysis. I first reviewed and adjusted data for missing data and outliers. I examined the data set for missing data by using missing value analysis functions in SPSS 27.0 (Field, 2013). Any cases that had missing not at random (MNAR) data and cases that had 75% or more missing at random (MAR) data of MCAR data were to be removed from the data set. There were no missing data at all in the data set. As such, I did not have to remove any cases (participants).

I then calculated the inter-item reliability for the LDK and LDTP scales of the LD-KAPI (Magri et al., 2002) by computing Kuder-Richardson 20 (KR20) reliability coefficients. The KR20 is used instead of the Cronbach's alpha when the scale or survey is comprised of dichotomous items (Field, 2013). Like the Cronbach's alpha, a KR20 coefficient of .70 is indicative of sound inter-item reliability (Field, 2013). The last activity I performed was the computation of the composite LDK and LDTP scale scores, which was done by counting the number of correct answers and dividing that value by the number of items in the scale.

Descriptive Statistics

In the second step of the data analysis, I computed the descriptive statistics for all study variables. I calculated the frequencies and percentages of primary care physicians practicing in a high-incidence Lyme disease state (i.e., Wisconsin) and a low-incidence Lyme disease state (i.e., Michigan), the independent variable. All three dependent variables were ratio; as such, I computed the mean, median, standard deviation, and minimum and maximum scores for these variables. The descriptive variables of physician gender and physician primary care specialty were nominal, and as such, I calculated the categorical frequencies and percentages. I then computed the mean, median, standard deviation, and minimum and maximum scores for the descriptive variables inquiring about the primary care physicians’ years of practice and number of patients seen per week.

Testing of Assumptions for a One-Way MANCOVA

The three study research questions were addressed by conducting a one-way MANCOVA. One-way MANCOVA models have assumptions of the data that must be met (Laerd Statistics, 2021). As such, the third data analysis activity was the testing of assumptions for a one-way MANCOVA.

Assumption 1. The first assumption for a one-way MANCOVA is that the “dependent variables should be measured at the interval or ratio level (i.e., they are continuous variables)” (Laerd Statistics, 2021, para. 7). The dependent variables of Lyme disease knowledge, attitudes about patients' Lyme disease risk, and Lyme disease antibiotic treatment practice were all ratio variables. The first assumption for MANCOVA was met for this study.

Assumption 2. The second assumption for a one-way MANCOVA is that there is one independent variable, and this "one independent variable should consist of two or more categorical, independent groups" (Laerd Statistics, 2021, para. 8). The study had one independent variable with two categorical independent groups: primary care physicians practicing in a high-incidence Lyme disease state (i.e., Wisconsin) or primary care physicians practicing in a low-incidence Lyme disease state (i.e., Michigan). The second assumption for MANCOVA was met for this study.

Assumption 3. The third assumption for a one-way MANCOVA is that the covariates are continuous variables (i.e., interval or ratio) (Laerd Statistics, 2021). According to Laerd Statistics (2021), "a covariate is a continuous independent variable that is added to a MANOVA model to produce a MANCOVA model" that is "used to adjust the means of the groups of the categorical independent variable" (para. 9). A continuous covariate was to be included in the analysis to provide a better assessment of the differences between the groups of the categorical independent variable on the dependent variables. The study was to have two covariates, years of practice and number of patients per week, both interval variables. The third assumption for MANCOVA was met for the study.

Assumption 4. The fourth assumption for a one-way MANCOVA, which is "more of a study design issue," is independence of observations, that is, the participants in the independent variable groups are independent and are not in both groups (Laerd Statistics, 2021, para. 10). To test for this assumption, the coding for the participants in each group of the independent variable (i.e., practice in high- versus low-incidence Lyme disease states) was reviewed and confirmed, with 1 entered for practicing in high-incidence Lyme disease states and 0 entered for practicing in low-incidence Lyme disease states to ensure that no participant is in more than one group. I confirmed that the participants were delineated into one of the two categories.

Assumption 5. The fifth assumption for a one-way MANCOVA is that there "should be a linear relationship between each pair of dependent variables within each group of the independent variable" (Laerd Statistics, 2021, para 11). This assumption was tested by splitting the SPSS data set and plotting a scatterplot matrix with loess lines of the dependent variables for each group of the independent variable. If linearity was not evident for any of the dependent variables for each independent variable group, the dependent variables was to be transformed (e.g., loglinear, square root).

Assumption 6. The sixth assumption for a one-way MANCOVA is that there should be "a linear relationship between the covariate and each dependent variable within each group of the independent variable" (Laerd Statistics, 2021, para 12). This assumption was tested by splitting the data files and "plotting a scatterplot matrix with loess lines of the covariate for each of the dependent variables, for each group of the independent variable" (Laerd Statistics, 2021, para 12).

Assumption 7. The seventh assumption for a one-way MANCOVA is that "there should be homogeneity of regression slopes" (Laerd Statistics, 2021, para. 13). This assumption was tested by computing a scatterplot matrix with loess lines, as stated in Assumption 6 above.

Assumption 8. The eighth assumption for a one-way MANCOVA is homogeneity of variances and covariances (Laerd Statistics, 2021). The dependent variables' variances and covariances should be equal for the groups of the independent variable (Laerd Statistics, 2021). This assumption was tested by computing a Box's *M* Test of Equality of Covariance Matrices.

Assumption 9. The ninth assumption for a one-way MANCOVA is that the independent variable groups should have no significant univariate outliers for each of the dependent variables (Laerd Statistics, 2021). This assumption was tested by computing and inspecting the standardized residuals for each of the three dependent variables for the two independent variable groups.

Assumption 10. The tenth assumption for a one-way MANCOVA is that there should be no significant multivariate outliers for each of the dependent variables for the independent variable groups (Laerd Statistics, 2021). This was tested by computing Mahalanobis distance values to identify any cases that is a multivariate outlier. If multivariate outliers were found in the data set, they were to be removed.

Assumption 11. The eleventh assumption for a one-way MANCOVA is that there should be multivariate normality. This assumption was tested by computing Shapiro-Wilk tests of normality, which test if the residuals for each dependent variable for the independent variable groups are normal (Laerd Statistics, 2021).

Hypothesis Testing

The statistical analysis for the study, conducted to test all three research questions, was a one-way MANCOVA. A MANCOVA provides information on the effects of independent variables on the linear combination of all dependent variables; it examines if an independent variable has a simultaneous effect of the amount of variance in the dependent variables (Tabachnick & Fidell, 2019). A MANCOVA, an extension of one-way ANOVA/ANCOVA, is used to examine if two or more independent variable groups significantly differ on two or more interval or ratio-coded dependent variables while controlling for pertinent continuous covariates (Field, 2013; Tabachnick & Fidell, 2019).

In this study, I was to examine if the two primary care physician independent variable groups differed regarding the linear combination of all the three Lyme disease knowledge, attitude, and practice dependent variables. Primary care physicians' years of practice and number of patients seen per week were to be included as covariates, as previous studies have shown that these two factors are significantly associated with Lyme disease knowledge, attitudes, and practices (Hill & Holmes, 2015; Singh et al., 2016). A MANCOVA "is an omnibus test statistic," that is, it provides results as to there are significant independent variable group differences "based on the combined dependent variables, after controlling for" covariates (Laerd Statistics, 2021, para. 2). As there were just two physician groups, a post hoc Tukey test was not necessary.

Results of the one-way MANCOVA include overall model effects and univariate effects, or the individual effects of the independent variable on each of the three dependent variables (Field, 2013; Tabachnick & Fidell, 2019). The model findings reported that were to be reported were the (a) Wilks lambda (λ); (b) the model *F*-value and the significance level, with $p < .05$; and (c) the partial eta^2 (η^2), a measure of effect size. Univariate (i.e., results for each IV/DV effect; Field, 2013) findings were to include the (a) respective *F*-value and the significance level, with $p < .05$; (b) the partial eta^2 (η^2); and (c) the means and standard deviations of the dependent variables for each independent variable group.

Validity

The quality and accuracy of quantitative study findings are contingent upon the degree to which a study has sound internal, external, and statistical conclusion validity (Baldwin, 2018). Internal validity concerns the degree to which "observed differences on the dependent variable are a direct result of the independent variable, not some other variable" (Gay & Airasian, 2000, p. 345). External validity is the degree to which study findings can be generalized and applied to other populations, contexts, and times (Baldwin, 2018). Statistical conclusion validity pertains to the degree of accuracy of the statistical findings (Frabrigar et al., 2020). There are methodological and sample threats that can minimize the study's internal, external, and statistical conclusion validity (Baldwin, 2018; Gay & Airasian, 2000). The following subsections provide information on the three types of validity and associated threats.

Internal Validity

The methodological rigor of a study improves its internal validity, or the degree of accuracy that the dependent variable is a result of the independent variable and no other variables (Baldwin, 2018). The internal validity of a study is enhanced with the use of random sampling, where individuals have an equal likelihood of (Moring, 2014). However, when simple random sampling is utilized, it is typically the researcher who ultimately selects the participants (Baldwin, 2018; Moring, 2014).

In this study, it was the primary care physicians who ultimately decided to participate, which introduced potential biases commonly seen in studies using convenience sampling, including the *self-selection* and *social desirability biases*. The self-selection bias concerns the type of persons who choose to participate or not, as participants may differ from non-participants on key attributes and qualities (Schwarz, 2014). For example, the primary care physicians who participated in this study may have differed from those who did not (e.g., concerning years of experience working with patients with Lyme disease, level of interest or specialized training in Lyme disease). This study may have been prone to the social desirability bias, in that participants could have provided socially acceptable but not necessarily truthful answers on the study questionnaire (Schwarz, 2014). The use of informed consent and participant anonymity may have helped to reduce these biases.

Excepting that I directly meet with the physicians, sit with them, and watch them complete the questionnaire in person, there was a possibility that physicians would utilize resources when answering the online (or mailed, for that matter) questionnaire. The SurveyMonkey data set included a variable that denoted the length of time the participants took to complete the online questionnaire. I reviewed this variable and found that none of the participants took an exceptionally long time (e.g., an hour or longer) to complete the questionnaire. Outside of this option, there was little else that could be done to ensure that physicians did not use outside resources.

External Validity

A study should have sound external validity, with its findings being generalizable to other participants, settings, and times (Moring, 2014). There are threats to external validity. One threat is the *threat of population validity*, where the use of a highly specific sample decreases the ability to translate study findings to other populations (Baldwin, 2018; Schwarz, 2014). This study focused on a specific target population and topic: primary care physicians in a high-incidence Lyme disease state (i.e., Wisconsin) and a low-incidence Lyme disease state (i.e., Michigan) and their knowledge, attitude, and practices associated with Lyme disease. As such, study findings could not be generalized to other primary care physician populations, such as primary care physicians working in states other than Wisconsin or Michigan or retired primary care physicians in Wisconsin and Michigan. Results could not be generalized to physicians who were not primary care physicians.

Another external validity threat is the *threat of ecological validity*, or methodological factors that limit the ability to generalize findings to other settings and situations (Baldwin, 2018; Schwarz, 2014). In this study, primary care physicians completed the study questionnaire online. As such, the findings noted in this study may be different from those reported in studies that utilized different methods (e.g., participants completed survey in person).

Statistical Conclusion Validity

Statistical conclusion validity concerns the accuracy of statistical findings, especially in relation to minimizing the likelihood of committing a Type I error or rejecting the null hypothesis when it is in fact true (Frabrigar et al., 2020). The primary threats to statistical conclusion validity are *low statistical power*, *violations of statistical assumption*, and *poor reliability of study instruments* (Frabrigar et al., 2020). I addressed the threat of low statistical power in this study by conducting a power analyses and doubling the sample size to ensure for an equal number of primary care physicians per state. The threat of statistical assumption violations was addressed by testing for data assumption and adjusting the data if assumptions were violated. The threat of poor instrument reliability was minimized in the study through the use of the LD-KAP (Magri et al., 2002), an instrument validated in prior empirical work (Conant et al., 2018; Ferrouillet et al., 2015; Gasmi et al., 2017; Henry et al., 2012; Hill & Holmes, 2015).

Ethical Procedures

All research conducted with participants must be conducted in accordance with the human subject research ethical guidelines outlined in the Belmont Report (Office for Human Research Protections [OHRP], 2019). I followed the ethical guidelines. Upon receiving committee approval to conduct this study, I completed the Walden University IRB application and submitted it to the Walden University IRB Board. The IRB application included information on the participant recruitment and informed consent processes, study variables, data collection and analysis procedures, and the storage and destruction of study materials. Data collection commenced upon Walden University IRB Board approval.

I followed additional ethical guidelines. One was the inclusion of informed consent on the study questionnaire. The informed consent form included all language required for research with human subjects, especially in relation to participating in the study, and it was approved by the Walden IRB Board. The participants had to provide informed consent to answer the study questionnaire. I also handled the study materials in an ethical manner by downloading the data and saving them in an SPSS 27.0 data file, which I kept on a password-protected and encrypted jump-drive, stored in a locked file cabinet in my home office. Related materials (e.g., printouts of results) were kept in separate cabinets in my home office. I will keep the study materials for 5 years, after which they will be destroyed.

Summary

This concludes this chapter, which provided a methodological overview of the proposed study. The purpose of this study was to determine if primary care physicians practicing in a high- versus low-incidence Midwestern Lyme disease states significantly differed in their Lyme disease knowledge, attitudes about their patients' risk for Lyme disease after a tick bit, and antibiotic treatment practices. In this chapter, I provided information on the study's cross-sectional causal comparative design and restated the study research questions, which had null and alternative hypotheses. The methodology section included information on the study target population and sample. Based on findings from power analyses, it was determined that a sample size of N = 458, or n =

229 per group, was to be sought for the study. The participant recruitment and data collection procedures were then presented, followed by information on the study instrument, the LD-KAPI (Magri et al., 2002), and the operationalization of study variables, including descriptive variable. I then summarized the steps in the data analysis plan. Study validity was then given attention, with information being presented on the definitions and associated threats of internal, external, and statistical conclusion validity. The penultimate section covered study ethical procedures. This concludes Chapter 3.

Chapter 4: Results

Lyme disease incidence rates in the Upper Midwestern region of the United States have increased by 213% since 2009 (Sharareh et al., 2019). The Midwestern state of Wisconsin is recognized as a high-incidence Lyme disease state, as it has a 3-year Lyme disease incidence rate of 25.4 per 100,000 persons (CDC, 2020c). Michigan is considered a Midwestern low-incidence Lyme disease state, having a 3-year Lyme disease incidence rate of 1.8 per 100,000 in 2018 (CDC, 2020c); however, Lyme disease cases in Michigan have seen a dramatic upsurge since 2000 (Lantos et al., 2017). There is some research concerning clinician-diagnosed Lyme disease rates in the Midwestern (Nelson et al., 2015) and the geographical expansion of Lyme disease in Michigan (Lantos et al., 2017). However, no study to date has examined Lyme disease knowledge, attitudes, and practices among primary care physicians in either Wisconsin or Michigan.

Physicians' lack of awareness and/or use of clinical guidelines to diagnosis and treat Lyme disease have numerous public health consequences (Beck et al., 2021). Patients left untreated for Lyme disease will likely progress and worsen, greatly impairing their quality of life (Brett et al., 2014; Singh et al., 2016). Antibiotic treatment without actual reason can also impart negative health consequences (Beck et al., 2021). Moreover, an overlooked Lyme disease diagnosis resulting from attitudinal biases and underreporting of Lyme disease due to lack of knowledge of symptoms and treating for suspected but not confirmed Lyme disease may limit the capturing of accurate cases, resulting in incorrect public health surveillance data for Wisconsin and Michigan.

The problem addressed in this quantitative cross-sectional causal comparative study was that it was not known whether primary care physicians in high- versus low-incidence Lyme disease states in the Midwest report significant differences in Lyme disease knowledge, attitudes about patient risk for contracting Lyme disease, and practices concerning the use of antibiotic treatment for Lyme disease. To address this public health problem, this study posed three research questions, each having associated null and alternative hypotheses, as follows:

RQ1: Is there a significant difference between Primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin versus Michigan) on their knowledge of Lyme disease, controlling for their years of practice and patient caseload per week?

$H1_o$: There is not a significant difference between Primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin versus Michigan) on their knowledge of Lyme disease, controlling for their years of practice and patient caseload per week.

$H1_a$: There is a significant difference between Primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin versus Michigan) on their knowledge of Lyme disease, controlling for their years of practice and patient caseload per week.

RQ2: Is there is a significant difference between Primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin versus Michigan) on their attitudes about their patients' risk of contracting Lyme disease, controlling for their years of practice and patient caseload per week?

$H2_o$: There is not a significant difference between Primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin versus Michigan) on their attitudes about their patients' risk of contracting Lyme disease, controlling for their years of practice and patient caseload per week.

$H2_a$: There is a significant difference between Primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin versus Michigan) on their attitudes about their patients' risk of contracting Lyme disease, controlling for their years of practice and patient caseload per week.

RQ3: Is there is a significant difference between Primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin versus Michigan) on their use of Lyme disease antibiotic treatment practices, controlling for their years of practice and patient caseload per week?

$H3_o$: There is not a significant difference between Primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin versus Michigan) on their use of Lyme disease antibiotic treatment practices, controlling for their years of practice and patient caseload per week.

$H3_a$: There is a significant difference between Primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin versus Michigan) on their use of Lyme disease antibiotic treatment practices, controlling for their years of practice and patient caseload per week.

The purpose of Chapter 4 is to comprehensively summarize the statistical findings of the study. Chapter 4 is delineated into sections, each presenting certain topics. The chapter opens with the Data Collection section, in which I discuss the time frame of the data collection, the discrepancies in the methodology as presented in Chapter 3, and the response rate of the study participants. The chapter then turns to the Results section, where I provide descriptive information on the study participants and study variables, the testing of assumptions, and the results from the one-way MANCOVA, which was conducted for hypothesis testing. The chapter concludes with a Summary section.

Data Collection

Upon receiving IRB approval, I initiated the proposed online recruitment and data collection processes of the study to recruit a sample of participants that represented that target population of approximately 15,300 primary care physicians working in the states of Wisconsin and Michigan. The recruitment process began in early August 2021. The first step of recruitment was obtaining an email list of Wisconsin and Michigan primary care physicians. I obtained a public list of contact information (e.g., phone numbers and email addresses) for primary care physicians currently practicing in Wisconsin and Michigan from the Wisconsin Department of Safety and Professional Services (Division of Professional Credential Processing) and Michigan Department of Licensing and Regulatory Affairs Bureau of Professional Licensing, respectively. The public lists had work emails from approximately 5,500 primary care physicians in the high-incidence Lyme disease state of Wisconsin and approximately 9,800 primary care physicians in the low-incidence Lyme disease state of Michigan.

Once the email information was obtained, I conducted simple random sampling to obtain the study sample. Simple random sampling entails selecting a random number of participants from the target population of individuals listed on the sampling frame (Moring, 2014). The physician email contact list was the sampling frame used in this study. As the list was numbered, I utilized an online random number generator (set from 1 to 5,000 for Wisconsin physicians and 1 to 9,800 for Michigan physicians) to randomly select 2,000 Wisconsin and 2,000 Michigan primary care physicians. I reviewed the contact information to ensure that the selected physicians met the study criteria of being certified and currently practicing in at least one of the primary care specialties, including family medicine, general practice, or internal medicine. The selected sample of 2,000 physicians per state comprised 36% of the approximately 5,500 primary care physicians in Wisconsin and 20% of the approximately 9,800 primary care physicians in Michigan and, respectively.

The online data collection period lasted between August and December 2021. In early August 2021, I emailed the 4,000 randomly selected physicians (n = 2,000 per state), with the email containing a short explanation of the email and the study and a link to the study survey on SurveyMonkey. Approximately 200 of the 2,000 Wisconsin emails and 200 of the 2000 Michigan emails bounced back to me and could not be delivered as the physician email address was obsolete or incorrect. The valid sample was reduced to n = 1,800 per state, or 3,600 total. Of the 3,600 physicians, only 36 (1%) of the physicians responded, and of these, only 15 (0.5%, n = 7 Wisconsin physicians and n = 8 Michigan physicians) completed the online questionnaire. I resent the email 2 weeks after the first and did not receive any more responses.

I met with my dissertation chair in September 2021 to discuss sample size issues. Based on chair and committee recommendations, I submitted an addendum to the IRB application that noted the low sample size and included requests to contact the physicians via their work phone and/or utilize SurveyMonkey panel recruitment services. The Walden University IRB did not allow me to contact the physicians by phone. When I examined the option of obtaining participants through SurveyMonkey, the cost was exorbitant (i.e., over $5,000 for a sample of over 400 participants). As such, I sent the study email to an additional 2,000 physicians (*n* = 1,000 per state) in November 2021. Approximately 300 (*n* = 150 per state) emails could not be delivered to physicians, lowering the number of valid emails to 1,700. The response was better on the second round, with 67 (3.9%) of physicians responding, and of those, 50 (2.9%) completing the online questionnaire. Of the 50 physicians, 25 worked in Wisconsin and 25 in Michigan. In summary, the final sample size was 65 physicians (*n* = 32 in Wisconsin and *n* = 33 in Michigan), resulting in a total response rate of 1.2%. The response rate of 1.2% was considerably lower that the response rate range of 20% to 60% found in studies using online questionnaires with physicians (Aitken et al., 2008; Brtnikova et al., 2018; Pit et al., 2014; Scott et al., 2011; Weaver et al., 2019).

Of the sample of 65 participants, 53.8% were male and 46.2% were female, percentages that were comparable to the national percentages (i.e., 54% male, 46% female) of primary care physicians reported by The American Board of Family Medicine

(2020). The percentage of 49.2% of family medicine/family practice/general practice physicians noted in this study was comparable to the national sample percentage of 42.2%, as were the internal medicine percentages, with 26.2% in this study and 34.5% reported nationally by The American Medical Association (2022). There were however no pediatricians in this study, likely due to the study focus on Lyme disease, and almost a quarter (24.6%) of physicians had other specialties, most often emergency medicine, urology, pulmonary medicine, and interventional/holistic medicine.

Results

The Results section is comprised of four subsections. In the first subsection, I present the descriptive statistics for the study participants' primary care specialty, gender, years of practice, and number of patients seen per week. Results are summarized overall and by physician grouped by high- versus low-incidence Lyme disease state. In the second subsection, I summarize the descriptive statistical findings for the independent variable of physicians grouped by low- versus high-incidence Lyme disease state and the study dependent variables of the physicians' Lyme disease knowledge, attitudes, and treatment (overall and by physician group). In the third subsection, I delineate the assumptions for the one-way MANCOVA and provide the results from the testing of the respective assumptions where needed. The fourth and last subsection presents the findings from the one-way MANCOVA conducted for hypothesis testing.

Descriptive Statistics: Participants

Table 1 provides the means and percentages for the physicians' primary care specialty and gender, with findings presented overall and by state. Almost half of the 65 physicians (*n* = 32, 49.2%) specialized in family medicine/family practice/general practice. There was a lower percentage of Wisconsin physicians (43.8%) than Michigan physicians (54.5%) who specialized in family medicine/family practice/ general practice. Almost a quarter (*n* = 17, 26.2%) of the 65 physicians were in internal medicine. A higher percentage of Wisconsin physicians (31.3%) than Michigan physicians (21.1%) specialized in internal medicine. Sixteen (24.6%) physicians reported other specialties: urology (9.2%), interventional medicine (7.7%), and pulmonary medicine (7.7%). Eight Wisconsin (25%) physicians and eight Michigan (24.2%) physicians had one of these three other specialties. Regarding gender, 35 (53.8%) of the physicians were male and 30 (46.2%) were female. The gender percentages were similar across the two states: 56.3% of Wisconsin physicians and 51.5% of Michigan physicians were male, whereas 43.8% of Wisconsin physicians and 46.2% of Michigan physicians were female.

Table 1

Descriptive Statistics: Physician Specialty Areas and Gender, Total and by State

	Total		Wisconsin (high-incidence Lyme disease state)		Michigan (low-incidence Lyme disease state)	
Demographic category	*n*	%	*n*	%	*n*	%
Primary care specialty						
Family medicine/family practice/general practice	32	49.2	14	43.8	18	54.5
Internal medicine	17	26.2	10	31.3	7	21.2
Other (i.e., interventional medicine, pulmonary medicine, or urology)	16	24.6	8	25.0	8	24.2
Total	65	100.0	32	100.0	33	100.0
Gender						
Male	35	53.8	18	56.3	17	51.5
Female	30	46.2	14	43.8	16	48.5
Total	65	100.0	32	100.0	33	100.0

Tables 2 provides the mean, standard deviation, and minimum and maximum scores for the physicians' years of practice and average number of patients seen per week (overall and by state). Overall, the physicians had a considerable level of experience, practicing for an average of 19.52 years (*SD* = 9.36 years, minimum = 3 years, maximum = 40 years). Wisconsin physicians practiced for an average of 20.22 years (*SD* = 8.81 years, minimum = 5 years, maximum = 40 years), whereas Michigan physicians practiced for an average of 18.85 years (*SD* = 9.94 years, minimum = 3 years, maximum = 39 years). Regarding number of patients, the primary care physicians as a group reported seeing an average of 88.77 patients per week (*SD* = 35.45 patients, minimum = 30 patients, maximum = 150 patients). Wisconsin physicians saw an average of 87.03 patients per week (*SD* = 36.74 patients, minimum = 35 patients, maximum = 150 patients), whereas Michigan physicians saw an average of 90.45 patients per week (*SD* = 35.65 patients, minimum = 30 patients, maximum = 150 patients).

Table 2

Descriptive Statistics: Physician Years of Practice and Patients Seen per Week, Total and by State

Physicians	*M*	*SD*	Min	Max
Total				
Years of practice	19.52	9.36	3.00	40.00
No. patients seen per week	88.77	35.45	30.00	150.00
Wisconsin [a]				
Years of practice	20.22	8.81	5.00	40.00
No. patients seen per week	87.03	35.74	35.00	150.00
Michigan [b]				
Years of practice	18.85	9.94	3.00	39.00
No. patients seen per week	90.45	35.65	30.00	150.00

[a] Wisconsin is a high-incidence Lyme disease state (*n* = 32)
[b] Michigan is a low-incidence Lyme disease state (*n* = 33)

Descriptive Statistics: Independent and Dependent Variables

The study's one independent variable concerned whether the primary care physicians practiced in a high-incidence Lyme disease Midwestern state (i.e., Wisconsin) versus a low-incidence Lyme disease Midwestern state (i.e., Michigan). Of the 65 participants, 32 (49%) practiced the high-incidence Lyme disease state of Wisconsin. Thirty-three (51%) primary care physicians practiced in the low-incidence Lyme disease state of Michigan.

Table 3 presents the descriptive statistics for the three dependent variable that assessed the primary care physicians' Lyme disease knowledge, attitudes concerning their patients' risk for contracting Lyme disease after a tick bite, and Lyme disease antibiotic treatment practices. The study participants had an average score of .78 on the 13-item measure of Lyme disease knowledge (*SD* = .13, minimum score = .46, maximum score = 1.00). The physicians' mean score regarding their attitudes about their patients' risk for Lyme disease after a tick bite was .42 (*SD* = .16, minimum score = .10, maximum score = .70). The physicians' Lyme disease antibiotic treatment practices mean score was .77 (*SD* = .15, minimum score = .50, maximum score = 1.00). In summary, the physicians' Lyme disease knowledge mean percentage score was 78%) and their antibiotic treatment practices mean percentage score was 77%; the physicians' attitude regarding their patients' risk for Lyme disease mean percentage score was 42%.

Table 3

Descriptive Statistics: Physicians' Lyme Disease Knowledge, Attitude Regarding Patients' Risk for Lyme Disease, and Lyme Disease Treatment Practices

Variable	*M*	*SD*	Min	Max
Lyme disease knowledge	.78	.13	.46	1.00
Patients' Lyme disease risk attitude	.42	.16	.10	.70
Lyme disease antibiotic treatment practices	.77	.15	.50	1.00

Testing of Assumptions for a One-Way MANCOVA

The one-way MANCOVA has certain data assumptions that must be met (Laerd Statistics, 2021). Some assumptions pertain to the scaling of the data and the data observations, requiring no statistical tests (Laerd Statistics, 2021). Some assumptions require the computation of statistical analyses to determine if the data met assumptions (Laerd Statistics, 2021). The assumptions and testing of assumptions are discussed in the following subsections.

Assumptions 1, 2, and 3: Correct Scaling of the Independent Variable, Dependent Variables, and Covariates

There are three assumptions regarding the scaling of the independent variable, dependent variables, and covariates for a MANCOVA (Laerd, 2021). The independent variable must have two - and only two - categories (Laerd, 2021). The study had one independent variable with two categorical independent groups: primary care physicians practicing in a high-incidence Lyme disease state (i.e., Wisconsin) or primary care physicians practicing in a low-incidence Lyme disease state (i.e., Michigan). There is an assumption that the "dependent variables should be measured at the interval or ratio level" (Laerd Statistics, 2021, para. 7). The dependent variables of Lyme disease knowledge, attitudes about patients' Lyme disease risk, and Lyme disease antibiotic treatment practices are all ratio variables. Finally, there is an assumption that the covariates are continuous variables (i.e., interval or ratio) (Laerd Statistics, 2021). The two covariates in this study, physicians' years of practice and number of patients seen per week, were interval. The one-way MANCOVA scaling assumptions for the independent variable, dependent variables, and covariates were met for this study.

Assumption 4: Independence of Observations

The fourth assumption for a MANCOVA, "more of a study design issue," is independence of observations. The independence of observations assumption requires that the participants in the independent variable groups are independent and are not in both groups (Laerd Statistics, 2021). There are no statistical tests for this assumption; a review of the data is instead necessary (Laerd Statistics, 2021). The coding for the participants in each group of the independent variable (i.e., practice in high- versus low-incidence Lyme disease states) was reviewed and confirmed, with 1 entered for practice in high-incidence Lyme disease states and 0 entered for practice in low-incidence Lyme disease states to ensure that no participant was in more than one group. The assumption of independence of observations was met in this study.

Assumption 5: Linear Relationship Between Dependent Variables for Each Independent Variable Group

The fifth assumption for a one-way MANCOVA was that there should be a linear relationship between each pair of dependent variables for the two independent variable groups (Laerd Statistics, 2021). The fifth assumption was tested by first splitting the SPSS data set and plotting scatterplot matrices with loess lines for the dependent variable relationships for each group of the independent variable with linear relationships examined between (a) the Lyme disease knowledge and attitudes dependent variables for the two physician groups; (b) the Lyme disease knowledge and antibiotic treatment practices dependent variables for the two physician groups; and (c) the Lyme disease attitudes knowledge and antibiotic treatment practices dependent variables for the two physician groups. The scatterplots with loess lines for the dependent variable relationships for each independent variable group are presented in Figures A1 through A3 in Appendix A. There were linear relationships between the study's dependent variables for each independent variable group. The assumption of linear relationships between dependent variables for each independent variable group was met in the study.

Assumption 6: Linear Relationship Between Covariates and Dependent Variables for Each Independent Variable Group

The sixth assumption for a one-way MANCOVA was that there should be a linear relationship between the covariates and the dependent variables for the two independent variable groups (Laerd Statistics, 2021). The sixth assumption of linearity between the covariates and dependent variables were tested by first splitting the SPSS data set and running Pearson bivariate correlations for the two covariates and the three dependent variables for each primary care physician group. The Pearson bivariate correlations were followed by the plotting of scatterplot matrices with loess lines for the covariate-dependent variable relationships for each group of the independent variable, which are presented in Figures B1 through B6 in Appendix B.

Table 4 provides the Pearson bivariate correlations for the covariates and the three dependent variables by primary care physician group. There were no significant correlations between physicians' years of practice and number of patients seen per week and the dependent variables of Lyme disease knowledge, attitudes, and antibiotic treatment practices for the physicians practicing in the high-incidence state of Wisconsin. Results further showed that no significant relationships were found between the number of patients per week and the dependent variables of Lyme disease knowledge, attitudes, and antibiotic treatment practices for the physicians practicing in the low-incidence state of Michigan. However, Michigan primary care physicians' years of practice was significantly correlated with their Lyme disease knowledge, $r(33) = .56$, $p < .001$, and antibiotic treatment practices, $r(33) = .43$, $p = .012$ (the relationship between years and practice and Lyme disease attitudes was not significant for Michigan physician). Due to these findings, only years of practice was included as a covariate in the MANCOVA.

Table 4

Pearson Bivariate Correlations: Number of Years Practicing as a Primary Care Physician and Number of Patients Seen per Week and Lyme Disease Knowledge, Attitudes, and Antibiotic Treatment Practices for Each Physician Group

Physician Variables	Wisconsin (high-incidence Lyme disease state) *n* = 32			Michigan (low-incidence Lyme disease state) *n* = 33		
	LD knowledge	*LD attitudes*	*LD treatment practices*	*LD knowledge*	*LD attitudes*	*LD treatment practices*
Years of practice	-.10	-.13	-.15	.56***	.05	.43*
No. of patients per week	.07	.06	-.09	.19	.16	.08

Note. LD = Lyme disease. * $p < .05$. *** $p < .001$.

Assumption 7: Homogeneity of Residuals

The seventh assumption for a one-way MANCOVA is that "there should be homogeneity of regression slopes" (Laerd Statistics, 2021, para. 13). The assumption of homogeneity of regression slopes between dependent variables and between covariates and dependent variables for each independent variable group is met if the residuals fall above and below the center horizontal line. This assumption was tested by computing scatterplot matrices with loess lines, as were done for Assumptions 5 and 6. As noted in Figures A1 through A3 and Figures B1 through B6, the residuals were equally dispersed above and below the center horizontal line. The assumption of homogeneity of residuals was met in this study.

Assumption 8: Homogeneity of Variances and Covariances

The eighth assumption for a one-way MANCOVA is homogeneity of variances and covariances (Laerd Statistics, 2021). The dependent variables' variances and covariances should be equal for the independent variable groups (Laerd Statistics, 2021). This assumption of homogeneity of variances was tested by conducting three separate Leven's tests of equality of error variances (see Appendix D). The Levene's test was not significant for Lyme disease knowledge, $F(1, 63) = 0.00$, $p = .981$, Lyme disease attitudes, $F(1, 63) = 2.22$, $p = .141$, or Lyme disease antibiotic treatment practices, $F(1, 63) = 2.60$, $p = .112$. The assumption of homogeneity of variances was met in this study.

The assumption of homogeneity of covariances was tested by computing a Box's *M* test of equality of covariance matrices (see Appendix D). The Box's *M* test was not significant, $M = 6.56$, $p = .399$. The assumption of homogeneity of covariances was met in this study.

Assumption 9: No Significant Univariate Dependent Variable Outliers for Each Independent Variable Group

The ninth assumption for the one-way MANCOVA is that there are no significant univariate dependent variable outliers for each of the two independent variables (Laerd, 2021). To test for the assumption of no significant univariate dependent variable outliers, the researcher computed and inspected the standardized residuals for each of the three dependent variables for the two independent variable groups. The assumption is met if the standardized residuals are less than +/- 2.4 (Field, 2013). The standardized residuals for the dependent variables for each independent variable group are presented in Figures C1 through C3 in Appendix C. All the standardized residuals were less than +/- 2.4 (Field, 2013). The assumption of no significant univariate dependent variable outliers for each independent variable group was met.

Assumption 10: No Significant Multivariate Dependent Variable Outliers for Each Independent Variable Group

The tenth assumption for the one-way MANCOVA is that there should be no significant multivariate dependent variable outliers for each of the independent variable groups (Laerd Statistics, 2021). This was tested by computing Mahalanobis distance values with associated significance value ($p < .05$) for each case to identify any cases that is a multivariate outlier. None of the cases had Mahalanobis distance values that were significant at $p < .05$ (see Table 5). The assumption of no significant multivariate dependent variable outliers for each independent variable groups was met.

Table 5

Mahalanobis Distance Values and Associated Significance: Primary Care Physicians in High- Versus Low-Incidence Midwestern States

Wisconsin (High-incidence Lyme disease state) *n* = 32		Michigan (Low-incidence Lyme disease state) *n* = 33	
Mahalanobis distance value	*p*	Mahalanobis distance value	*p*
2.64	.45	2.37	.50
4.83	.18	4.65	.20
3.40	.33	3.65	.30
1.19	.76	3.14	.37
2.65	.45	3.58	.31
3.56	.31	4.88	.18
2.75	.43	5.54	.14
0.58	.90	1.01	.80
1.36	.71	3.75	.29
1.47	.69	3.33	.34
6.63	.08	3.62	.31
1.71	.64	0.25	.97
2.33	.51	3.93	.27
3.68	.30	1.05	.79
1.29	.73	3.65	.30
4.43	.22	1.79	.62
1.61	.66	5.15	.16
7.91	.05	3.79	.29
0.31	.96	0.69	.88
3.49	.32	1.65	.65
2.16	.54	1.79	.62
0.90	.80	1.65	.65
3.93	.27	3.92	.27
0.58	.90	1.14	.77
11.34	.01	0.70	.87
7.29	.06	5.07	.17
2.13	.55	2.33	.51
3.97	.27	3.84	.28
4.50	.21	1.14	.77
3.48	.32	1.67	.64
0.56	.90	0.78	.85
0.56	.90	3.45	.33
		3.73	.29

Assumption 11: Multivariate Normality

The eleventh assumption for a one-way MANCOVA is that there should be multivariate normality. This assumption was tested by computing Shapiro-Wilk tests of normality (Laerd Statistics, 2021). The Shapiro-Wilk tests were significant for Lyme disease knowledge *S-W*(65) = .96, *p* = .021, and Lyme disease treatment, *S-W*(65) = .88, *p* < .001, but not for Lyme disease attitudes, *S-W*(65) = .97, *p* = .073. As this assumption was the only one violated, as it was not violated for Lyme disease attitudes, and due to the small sample size, no changes were made to the data set. However, the violation of the multivariate normality assumption is noted as a study limitation in Chapter 5.

Hypothesis Testing: One-Way MANCOVA

To address the study's three research questions, a one-way MANCOVA, controlling for physician's years of practice, was conducted. As the sample sizes for the physicians were small, a Bonferroni-adjusted significance level was set to *p* < .016 (i.e., .05 divided by 3, the number of research questions). Results of the one-way MANCOVA include both the overall model effects and the univariate effects, which are presented by research question. The multivariate and univariate results for the one-way MANCOVA are presented in Appendix D.

The multivariate model findings were Wilks λ= .87, *F*(3, 60) = 3.10, *p* = .033, partial η^2 = .14. While the multivariate model would usually have been considered significant (i.e., *p* = .033), with the Bonferroni adjusted critical *p*-value of *p* < .016, it was not considered significant. The following subsections present the study research questions and the associated univariate results of the one-way MANCOVA. The univariate results, with significance set at $p < .016$, informed the decision to reject or fail to reject the null hypotheses for the respective research question.

Research Question 1

The first research question was "Is there a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin versus Michigan) on their knowledge of Lyme disease?" The univariate results from the one-way MANCOVA conducted to address the first research question were significant, $F(1, 62) = 5.35$, $p = .014$, partial $\eta^2 = .08$. The physicians in the high-incidence Lyme disease state of Wisconsin had a significantly higher Lyme disease knowledge mean score ($M = .82$, $SD = .12$) as compared to physicians in the low-incidence Lyme disease state of Michigan ($M = .75$, $SD = .13$). As the results were significant, the null hypothesis failed to be retained.

Research Question 2

The second research question was "Is there is a significant difference between primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin versus Michigan) on their attitudes about their patients' risk of contracting Lyme disease?" The univariate results from the one-way MANCOVA conducted to address the second research question were not significant, $F(1, 62) = 0.55$, $p = .463$, partial $\eta^{2\,=}$ .01. The physicians in the high-incidence Lyme disease state of Wisconsin had a similar attitude regarding patients' Lyme disease risk ($M = .43$, $SD = .18$) as compared to the physicians in the low-incidence Lyme disease state of Michigan ($M = .41$, $SD = .14$). Due to the non-significant findings, the null hypothesis was retained.

Research Question 3

The third research question was "Is there is a significant difference between Primary care physicians practicing in a high- versus low-incidence Lyme disease Midwestern state (i.e., Wisconsin versus Michigan) on their use of Lyme disease antibiotic treatment practices?" The univariate results from the one-way MANCOVA for the third research question were significant, $F(1, 62) = 8.82$, $p = .004$, partial $\eta^{2\,=}$ .13. The physicians in the high-incidence Lyme disease state of Wisconsin had a significantly higher Lyme disease antibiotic treatment practices mean score ($M = .83$, $SD = .12$) than did the physicians in the low-incidence Lyme disease state of Michigan ($M = .72$, $SD = .16$). Due to the significant findings, the null hypothesis failed to be retained.

Summary

The purpose of this quantitative cross-sectional causal comparative study was to examine Lyme disease knowledge, attitudes, and treatment practices differences between primary care physicians in high- versus low-incidence Lyme disease Midwestern states. The study was conducted with 65 physicians, with 32 physicians in the high-incidence state of Wisconsin and 33 physicians in the low-incidence state of Michigan. Almost half (49.2%) of the primary care physicians had the specialty of family medicine/family practice/general practice and the majority (53.8%) were male. The physicians had an average of 19.5 years of practice and saw an average of almost 89 patients per week.

A one-way MANCOVA, with a Bonferroni-adjusted critical significance level of $p < .016$, was conducted to address the study's research questions, which focused on whether there were significant differences in Lyme disease knowledge, attitudes about patient risk for contracting Lyme disease, and practices concerning the use of antibiotic treatment for Lyme disease between physicians in the high- versus low-incidence Midwestern states of Wisconsin and Michigan, respectively. The univariate results for the one-way MANCOVA regarding physicians' Lyme disease knowledge and antibiotic treatment practices were significant. Physicians in the high-incidence state of Wisconsin had significantly higher Lyme disease knowledge and antibiotic treatment practices mean scores of 82% and 83%, respectively, as compared to the physicians in the low-incidence Lyme disease state of Michigan (who had scores of 75% and 72% respectively). The univariate results from the one-way MANCOVA showed non-significance regarding physicians' attitudes regarding their patients' risk for contracting Lyme disease after a tick bite. Physicians had similar attitudes, with Wisconsin physicians reporting that their patients had a 41% risk for Lyme disease and Michigan physicians reporting that their patients had a 43% risk for Lyme disease.

This study addressed the gap in the literature regarding differences in Lyme disease knowledge, attitudes, and antibiotic treatment practices across physicians in low- versus high-incidence Midwestern states. As stated by Singh et al. (2016, p. 48), there is a need for closer collaboration between physicians, especially those in low-incidence Lyme disease states, and public health officials "to promote education and awareness as a key step to successfully reducing the burden of Lyme disease." This study helped to address the gap in the physicians' Lyme disease knowledge, attitudes, and treatment practices literature as noted by Singh et al. (2016). The relevance of the study's findings is discussed in Chapter 5, the last chapter of the dissertation. In Chapter 5, the study findings are discussed in relation to prior research and the guiding theory, Cabana et al.'s (1999) BPBC model. The knowledge gained from this study helps to inform practice and future research, topics also discussed in Chapter 5.

Chapter 5: Discussion

The problem addressed in this study was that it was not known whether primary care physicians in high-incidence (i.e., Wisconsin) versus low-incidence (i.e., Wisconsin) Lyme disease Midwestern states reported significant differences in Lyme disease knowledge, attitudes about patient risk for contracting Lyme disease, and practices concerning the use of antibiotic treatment. The study was conducted with 65 physicians, resulting in a total response rate of 1.2%. Of the participants, 53.8% were male and 46.2% were female. Almost half (49.2%) of the participants were primary care physicians specializing in family medicine/family practice/general practice, 26.2% had a specialty of internal medicine, and 24.6% had other primary care specialties, most often emergency medicine, urology, pulmonary medicine, and interventional/holistic medicine. The physicians had practiced for an average of 19.52 years and reported seeing an average of 88.77 patients per week.

The study had one independent variable, which was primary care physicians working in a high-incidence Lyme disease state (n = 32 in Wisconsin) versus primary care physicians working in a low-incidence Lyme disease state (n = 33 in Michigan). There three dependent variables were assessed using scales and items from the LD-KAPI (Magri et al., 2002), specifically (a) the LDK scale measuring physicians' knowledge of Lyme disease regarding its causative agent, incubation period, and symptoms; (b) a single item assessing physicians' attitudes regarding patients' risk for Lyme disease after a tick bite; and (c) the LDTP scale regarding the physicians' correct practices of Lyme disease antibiotic treatment. The physicians had an average LDK scale score regarding Lyme disease knowledge of 78%, they reported that, on average, 42% of their patients were at risk for Lyme disease after a tick bit, and they had an average score of 77% on the LDTP scale concerning Lyme disease treatment practices.

I conducted a one-way MANCOVA, controlling for physicians' years of practice, to address the study's three research questions to determine whether primary care physicians in the high- versus low-incidence Midwestern states of Michigan and Wisconsin, respectively, had significantly different Lyme disease knowledge, attitudes, and practices scores. Due to the small sample size, a Bonferroni-adjusted significance level of $p < .016$ was used to determine significance. The univariate results from the one-way MANCOVA for the first research question regarding Lyme disease knowledge showed that physicians in the high-incidence state of Wisconsin had a significantly higher Lyme disease knowledge score of 82% than did physicians in the low-incidence Lyme disease state of Michigan, who had a mean score of 75%. The univariate results from the one-way MANCOVA for the second research question regarding Lyme disease attitudes about patient risk were not significant: Wisconsin physicians reporting that their patients had a 41% risk for Lyme disease and Michigan physicians reporting that their patients had a 43% risk for Lyme disease. Finally, the univariate results from the one-way MANCOVA for the third and final research question regarding Lyme disease antibiotic treatment practices were significant. The physicians in the high-incidence Lyme disease state of Wisconsin had a significantly higher Lyme disease treatment practices mean score of 83% than did the physicians in the low-incidence Lyme disease state of Michigan, who had a mean score of 72%.

Chapter 5 provides information on the study findings and conclusions, with sections on specific topics. The first section presents interpretations of study findings, with subsections discussing results vis-à-vis prior research and the guiding theory, Cabana et al.'s (1999) BPBC model. The chapter continues with a section on study limitations, followed by sections presenting study recommendations and implications. The chapter ends with a conclusion section.

Interpretations of the Findings

The study findings had similarities and differences to existing previous empirical work regarding primary care physicians' Lyme disease knowledge, attitudes, and practices, all of which utilized Magri et al.'s (2002) LD-KAPI to assess the Lyme disease constructs. Findings are also relevant to Cabana et al.'s (1999) BPBC model, the theory that guided this study. The following subsections present information on the empirical and theoretical interpretations of study findings.

Interpretations of the Findings: Empirical Literature

Despite the concerns that state endemicity of Lyme disease plays a role in influencing physicians' Lyme disease knowledge, attitudes, and treatment in high-incidence Lyme disease states (Lavoie et al., 2017), few studies have explored such topics (Brett et al., 2014; Ferrouillet et al., 2015; Gasmi et al., 2017), especially in low-incidence states (Henry et al., 2012; Hill & Holmes, 2015). In this study, I found that physicians in the high-incidence Lyme disease Midwestern state of Wisconsin had a Lyme disease knowledge score of 82%. The Wisconsin physicians' knowledge score of 82% was comparable to the knowledge score of 77% noted in Magri et al.'s (2002) LD-

KAPI study and the scores of 80% and 83% reported by Ferrouillet et al. (2015) and Gasmi et al. (2017), both of which utilized the LD-KAPI to assess Lyme disease knowledge scores with primary care physicians in Quebec, a high-incidence Lyme disease province in Canada.

The study analyses documented that physicians practicing in the low-incidence state of Michigan had a Lyme disease knowledge score of 75%, significantly lower than Wisconsin physicians' score of 82%. The Michigan physicians' Lyme disease knowledge score of 75% found in this study was similar to the Lyme disease knowledge score of 76% reported by Henry et al. (2012) in their study with physicians in the low-incidence Canadian province of British Columbia but higher than the score of 59% found in Hill and Holmes's (2015) study with physician in the low-incidence Lyme disease state of Arkansas. Although no study to date has examined Lyme disease knowledge differences among physicians in high- versus low-incidence states or provinces, the reported percentage scores aligned with those found in previous empirical work specific to high-incidence Canadian provinces (Ferrouillet et al., 2015; Gasmi et al., 2017; Magri et al., 2002) and low-incidence Lyme disease states (Henry et al., 2012; Hill & Holmes, 2015).

This study examined primary care physicians' attitudes concerning their patients' risk for contracting Lyme disease after a tick bite. Findings showed that Wisconsin and Michigan physicians had similar attitude scores of 43% and 41%, respectively. The risk percentages of 43% and 41% were similar to the percentage of 49% reported by Ferrouillet et al. (2015) in their study with Quebecois physicians. However, the attitude risk percentage of 41% found for physicians in the low-incidence state of Michigan was substantially higher than the attitude risk percentages of 17% and 20%, respectively reported by Henry et al. (2012) and Hill and Holmes (2015) in their studies with physicians in low-incidence areas.

The last topic explored in this study was the Midwestern physicians' correct practices regarding antibiotic treatment for Lyme disease. The physicians in the high-incidence Lyme disease state of Wisconsin had a significantly higher Lyme disease antibiotic treatment practices score of 83% than did the physicians in the low-incidence Lyme disease state of Michigan, who had a mean score of 72%. Ferrouillet et al. (2015), in their study in the high-incidence Lyme disease province of Quebec, reported an antibiotic treatment practice knowledge score of 85%, similar to the score of 83% reported by Wisconsin physicians in this study. The antibiotic treatment knowledge score of 72%, although low, was substantially higher than the percentages between 40% to 50% reported by Henry et al. (2012) and Hill and Holmes (2015) in their studies with physicians in low-incidence states.

In summary, results found in this study aligned with previous research that utilized the LD-KAPI to assess primary care physicians' Lyme disease knowledge, attitudes, and antibiotic treatment practices. As seen in previous work conducted with physicians in high-incidence states and provinces (Ferrouillet et al., 2015; Gasmi et al., 2017; Magri et al., 2002), primary care physicians in Wisconsin, a high-incidence Lyme disease state, reported relatively high levels of Lyme disease knowledge and antibiotic treatment practices and felt that their patients had a less than 50% of contracting Lyme disease from a tick bite. In contrast, physicians in the low-incidence state of Michigan had less knowledge of Lyme disease and associated antibiotic treatment practices, with scores similar to those reported by Henry et al. (2012) and Hill and Holmes (2015) in their studies with physicians working in states having low-incidence rates of Lyme disease. The one difference specific to Michigan physicians as compared to physicians in other low-incidence Lyme disease states was that the physicians in this study reported that their patients had higher risk for contracting Lyme disease after a tick bite as compared to the physicians in the studies by Henry et al. and Hill and Holmes.

Interpretations of the Findings: Guiding Theory

Cabana et al.'s (1999) BPBC provided the theoretical guidance for this study. Fischer et al. (2016) and Lavoie et al. (2017) argued that the BPBC model is an important theory for to guide research examining physicians' knowledge, attitude, and practices barriers concerning the treatment of chronic disease, and numerous studies have utilized the BPBC model to better understand physicians' knowledge, attitudes, and treatment of diabetes, hypertension, and asthma (Dash et al., 2020; Saint-Pierre et al., 2019; Sharpe et al., 2020), with studies confirming that disease knowledge, attitude, and practices differences exist across physicians working in different settings and geographical areas (Fischer et al., 2016; Liang et al., 2017; Nelson et al., 2015). Although Magri et al. (2002) utilized Cabana et al.'s BPBC theory to inform the development of the LD-KAPI, the instrument used in this study, the BPBC theory has not been applied to physicians' Lyme disease knowledge, attitudes, and antibiotic treatment practices.

This study tested Cabana et al.'s (1999) BPBC theoretical postulate, elaborated upon by Lavoie et al. (2017), that geographical factors, including regional disease endemicity, can act as barriers to primary care physicians' knowledge, attitude, and treatment practices of a disease. In this study, it was posited that the level of Lyme disease state endemicity played a role in shaping primary care physicians' Lyme disease knowledge, attitude, and practices. Specifically, Wisconsin physicians, as they worked in a high-incidence Lyme disease state, were hypothesized to have higher levels of Lyme disease knowledge, attitudes that their patients were at increased risk for Lyme disease, and antibiotic treatment practice knowledge, as compared to Michigan physicians who worked in a low-incidence Lyme disease state. The study findings supported the theoretical postulate that physicians working in Wisconsin, a high-incidence Lyme disease state, did in fact have higher levels of knowledge concerning Lyme disease and knowledge of the correct antibiotic treatment practices for Lyme disease than did physicians working in Michigan, a low-incidence Lyme disease state. However, physicians' attitudes concerning their patients' risk for contracting Lyme disease were similar, which was a theoretical contradiction. Study findings suggest that geographical endemicity of a disease may play more of a role regarding physicians' knowledge - in general and specific to antibiotic treatment practices - more so than their attitudes of patients' Lyme disease risk.

Limitations of the Study

Although this study had a notable strength in that it addressed a pertinent gap in the empirical literature regarding Lyme disease knowledge, attitude, and antibiotic treatment differences between physicians working in high- versus low-incidence Lyme disease Midwestern states, it did have limitations. One limitation was the small study sample size of 65 (32 physicians in Wisconsin and 33 physicians in Michigan). The original plan for the study was to obtain a total sample of 458 physicians, with 229 physicians per state. The data collection period lasted over 5 months, yet I was not able to obtain the desired sample size, despite sending out numerous emails to physicians. The response rate was 1.2%, considerably lower than the response rate range of 20% to 60% found in studies using online questionnaires with physicians (Cunningham et al., 2015; So et al., 2018). The low response rate may have been a consequence of conducting a study with physicians during the COVID-19 pandemic. Primary care physicians may have been especially busy during COVID-19 and likely did not have the time to complete an online survey that did not pertain to the pandemic. There was a benefit however that the sample sizes were relatively equal across the two states. There was a limitation in that the data did not meet the assumption of multivariate normality; however, other assumptions for a one-way MANCOVA were met.

This study had additional limitations. As the study was nonexperimental and comparative in design and not a true experiment, results cannot be said to be causal. That is, it cannot be stated that working in a high-incidence Lyme disease state caused Wisconsin physicians to have higher levels of Lyme disease knowledge and antibiotic treatment practices as compared to physicians in the low-incidence Lyme disease state of Michigan. The study findings can only be discussed in relation to Cabana et al.'s (1999) BPBC theory; although other theories may apply to this study, findings cannot be generalized to such models. The use of a nonexperimental design may have introduced the self-selection bias into the study. It may have been that the physicians who participated in this study had higher levels of Lyme disease knowledge, attitudes, and treatment practices than those who chose not to participate, regardless of their state of employment. Furthermore, the study was limited to primary care physicians in Wisconsin and Michigan. As such, study findings cannot be generalized to physicians who are not primary care physicians working in these Midwestern states or to primary care physicians practicing in other American states.

Recommendations

There are numerous recommendations for future empirical work that build from this study and its findings. Replication of study findings is a cornerstone of the scientific method (Moring, 2014), and replication of studies is needed on environmental public health topics that have received minimal empirical attention (Hicks, 2021). There is a need for future studies to examine Lyme disease knowledge, attitude, and antibiotic treatment practice differences using large sample sizes of physicians working in the high- and low-incidence Lyme disease states of Wisconsin and Michigan. Research can be extended to comparisons between high- and low-incidence states throughout America. It would also be interesting to examine whether Lyme disease knowledge, attitude, and practice differences exists in differing high-incidence states, for example, Wisconsin versus Connecticut, or differing low-incidence states, such as Michigan and Arkansas. Regional differences (e.g., states grouped by Northeast, Northwest, Southern, Midwestern, and Pacific regions) would also add to the literature on primary care physicians' Lyme disease knowledge, attitudes, and treatment practices.

There are future research recommendations based on instrument issues and the operationalization of physicians' Lyme disease knowledge, attitudes, and treatment practices. A benefit of this study was its use of Magri et al.'s (2002) LD-KAPI, an instrument utilized in prior research (Ferrouillet et al., 2015; Gasmi et al., 2017; Henry et al., 2012; Hill & Holmes, 2015). However, the LD-KAPI has not received extensive psychometric and validation attention, nor has it been updated since 2002 (Magri et al., 2002). Psychometric research on the LD-KAPI as a valid tool to assess physicians' Lyme disease knowledge, attitudes, and practices would be a great contribution to the literature. Studies in which new instruments are developed and validated with regard to physicians' knowledge of Lyme disease treatment practices other than antibiotic use (e.g., Lyme disease vaccinations or preventative care) would also add to the research.

The last set of recommendations pertain to the use of different methodologies and designs. Qualitative descriptive studies that explore physicians' Lyme disease knowledge, attitudes, and treatment practices are needed, as are phenomenological studies that capture physicians' lived experiences in treating Lyme disease in their patients. Quantitative correlational studies are also needed to understand the relationships between physicians' Lyme disease knowledge, attitudes, and practices. It may be, for example, that primary care physicians' lack of Lyme disease knowledge may contribute to an incorrect or late diagnoses of Lyme disease or inadequate or even harmful treatment practices, as suggested by Conant et al. (2018). Studies that utilize moderation to explore differential pathways between Lyme disease knowledge and attitudes and treatment practice outcomes between physicians in high- versus low-incidence states would also be very enlightening.

Implications

This study, the first to examine if there were differences in Lyme disease knowledge, attitudes about patient risk, and antibiotic treatment between primary care physicians in Wisconsin, a high-incidence state, and Michigan, a low-incidence state, offers numerous implications for positive social change. Physicians in Michigan, a low-incidence state, had relatively low knowledge of Lyme disease and its antibiotic treatment. The knowledge and treatment scores for Wisconsin physicians was significantly higher, but they could be improved. It is important to increase physicians' lack of awareness and/or use if clinical guidelines to diagnosis and treat Lyme disease, as an incorrect and overlooked diagnosis can have numerous public health consequences (Beck et al., 2021). Patients left untreated for Lyme disease will likely progress and worsen, greatly impairing their quality of life (Brett et al., 2014; Singh et al., 2016), and antibiotic treatment without actual reason can also impart negative health consequences (Beck et al., 2021). The study findings may be helpful in informing initiatives and trainings that are aimed at enhancing Midwestern physicians' Lyme disease knowledge and improving their antibiotic treatment practices.

The study findings can be used to impart change in public health initiatives targeting Lyme disease. Both groups of physicians felt their patients were at little risk for contracting Lyme disease after a tick bit (43% for Wisconsin physicians and 41% for Michigan physicians). An overlooked Lyme disease diagnosis resulting from attitudinal biases that patients are not at risk can result not only in misdiagnoses but also the underreporting of Lyme disease. In turn, the incorrect reporting of Lyme disease cases may limit the capturing of accurate cases, resulting in incorrect public health surveillance data for Wisconsin and Michigan. Information gained in this study concerning the similarities and differences concerning Lyme disease knowledge, attitudes, and practices in Wisconsin and Michigan can be used to inform physician and public health educational and training initiatives, benefiting both a high-incidence (Wisconsin) and a low-incidence (Michigan) Midwestern state. It is important to ensure that primary care physicians who are key stakeholders in providing healthcare to the general population know how best to diagnose, treat, and report Lyme disease cases and that correct public health surveillance data are gathered on Lyme disease.

Conclusion

This study examined if Lyme disease knowledge, attitudes about patients' risk for getting Lyme disease after a tick bite, and Lyme disease antibiotic treatment practices differences existed between primary care physicians in Wisconsin, a high-incidence Lyme disease state, and Michigan, a low-incidence Lyme disease state. The findings showed that physicians in the high-incidence state of Wisconsin had significantly higher levels of Lyme disease knowledge and antibiotic treatment practices than did physicians in the low-incidence state of Michigan; however, both groups of physicians had similar and somewhat low attitudes regarding their patients' risk for contracting Lyme disease after a tick bite.

In the United States Lyme disease remains a serious disease, and rates of Lyme disease are increasing for both Wisconsin and Michigan (CDC, 2020c). The Midwestern region's changing climate and environmental landscape make it increasingly habitable to the *I. scapularis* tick (Gardner et al., 2020; Maestas et al., 2016), yet the incidence of Lyme disease may be underreported in the Midwestern region, especially Michigan (Lantos, 2017). The findings from this study suggested that the underreporting of Lyme disease cases in the Midwestern may be due to physicians' lack of knowledge regarding Lyme disease, attitudes that patients are not at risk for Lyme disease, and low antibiotic treatment practices of primary care physicians in Michigan and Wisconsin. As stated by Singh et al. (2016, p. 48), there is a need for closer collaboration between physicians, especially those in low-incidence Lyme disease states, and public health officials "to promote education and awareness as a key step to successfully reducing the burden of Lyme disease." This study provided the step in the right direction toward increasing awareness of the physician and public health needs regarding Lyme disease knowledge, attitudes, and treatment in the states of Wisconsin and Michigan.

References

Aitken, C., Power, R., & Dwyer, R. (2008). A very low response rate in an on-line survey of medical practitioners. *Australian and New Zealand Journal of Public Health*, *32*(3), 288-289. https://doi.org/10.1111/j.1753-6405.2008.00232.x

Ali, A., Vitulano, L., Lee, R., Weiss, T. R., & Colson, E. R. (2014). Experiences of patients identifying with chronic Lyme disease in the healthcare system: A qualitative study. *Family Practice*, *15*(1), 1-8. https://doi.org/10.1186/1471-2296-15-79

Allen, H. B., Vin, H., Warner, C., & Joshi, S. (2016). Lyme Disease: Beyond erythema migrans. *Journal of Clinical & Experimental Dermatology Research*, *7*(2), 1-4. https://doi.org/10.4172/2155-9554.1000330

American Medical Association. (2022). *Doctor Finder*. https://doctorfinder.ama-assn.org/doctorfinder/home.jsp?

Baldwin, L. (2018). *Research concepts for the practitioner of educational leadership.* Brill Publishers.

Ballard, K., & Bone, C. (2021). Exploring spatially varying relationships between Lyme disease and land cover with geographically weighted regression. *Applied Geography*, *127*, 102383. https://doi.org/10.1016/j.apgeog.2020.102383

Beck, A. R., Marx, G. E., & Hinckley, A. F. (2021). Diagnosis, treatment, and prevention practices for Lyme disease by clinicians, United States, 2013-2015. *Public Health Reports*, *136*(5), 609-617. https://doi.org/10.1177/0033354920973235

Brett, M. E., Hinckley, A. F., Zielinski-Gutierrez, E. C., & Mead, P. S. (2014). U.S. healthcare providers' experience with Lyme and other tick-borne diseases. *Ticks and Tick-borne Diseases*, *5*(4), 404-408. https://doi.org/10.1016/j.ttbdis.2014.01.008

Bron, G. M., Fernandez, M. D. P., Larson, S. R., Maus, A., Gustafson, D., Tsao, J. I., Giuk-Wasser, M. A., Bartholomay, L. C., & Paskewitz, S. M. (2020). Context matters: Contrasting behavioral and residential risk factors for Lyme disease between high-incidence states in the Northeastern and Midwestern United States. *Ticks and Tick-borne Diseases*, *11*(6), 101515. https://doi.org/10.1016/j.ttbdis.2020.101515

Brtnikova, M., Crane, L. A., Allison, M. A., Hurley, L. P., Beaty, B. L., & Kempe, A. (2018). A method for achieving high response rates in national surveys of US primary care physicians. *PloS One*, *13*(8), e0202755. https://doi.org/10.1371/journal.pone.0202755

Cabana, M. D., Rand, C. S., Powe, N. R., Wu, A. W., Wilson, M. H., Abboud, P. A. C., & Rubin, H. R. (1999). Why don't physicians follow clinical practice guidelines?: A framework for improvement. *JAMA, 282*(15), 1458-1465. https://doi.org/10.1001.jama.282.15.1458

Centers for Disease Control and Prevention. (2017). *Lyme disease: 2017 case definition*. https://wwwn.cdc.gov/nndss/conditions/lyme-disease/case-definition/2017/

Centers for Disease Control and Prevention. (2020a). *Signs and symptoms of untreated Lyme disease*. https://www.cdc.gov/lyme/signs_symptoms/index.html

Centers for Disease Control and Prevention. (2020b). *Case definitions for infectious conditions under public health surveillance*. https://www.cdc.gov/mmwr/preview/mmwrhtml/00047449.htm

Centers for Disease Control and Prevention. (2020c). *Lyme disease data tables*. https://www.cdc.gov/lyme/stats/tables.html#:~:text=Lyme%20disease%20incidence%20rates%20by%20state,%202009-2018%20,%20%200.0%20%2021%20more%20rows

Centers for Disease Control and Prevention. (2020d). *Recent surveillance data*. https://www.cdc.gov/lyme/datasurveillance/recent-surveillance-data.html

Chen, H., Cohen, P., & Chen, S. (2010). How big is a big odds ratio? Interpreting the magnitudes of odds ratios in epidemiological studies. *Communications in Statistics—Simulation and Computation®*, *39*(4), 860-864. https://doi.org/10.1080/03610911003650383

Conant, J. L., Powers, J., Sharp, G., Mead, P. S., & Nelson, C. A. (2018). Lyme disease testing in a high-incidence state: clinician knowledge and patterns. *American Journal of Clinical Pathology*, *149*(3), 234-240. https://doi.org/10.1093/ajcp/aqx153

Cunningham, C. T., Quan, H., Hemmelgarn, B., Noseworthy, T., Beck, C. A., Dixon, E., Samuel, S., Ghali, W. A., Sykes, L. L., & Jetté, N. (2015). Exploring physician specialist response rates to web-based surveys. *BMC Medical Research Methodology*, *15*(1), 1-8. https://doi.org/10.1186/s12874-015-0016-z

Dash, S., Delibasic, V., Alsaeed, S., Ward, M., Jefferson, K., Manca, D. P., & Arcand, J. (2020). Knowledge, attitudes, and behaviours related to physician-delivered dietary advice for patients with hypertension. *Journal of Community Health*, *45*(5), 1067-1072. https://doi.org/10.1007/s10900-020-00831-x

Davies, K. S. (2011). Physicians and their use of information: A survey comparison between the United States, Canada, and the United Kingdom. *Journal of the Medical Library Association: JMLA*, *99*(1), 88-91. https://doi.org/10.3163/1536-5050.99.1.015

Dong, Y., Huang, Z., Zhang, Y., Wang, Y. X., & La, Y. (2020). Comparing the climatic and landscape risk factors for Lyme disease cases in the Upper Midwest and Northeast United States. *International Journal of Environmental Research and Public Health*, *17*(5), 1548-1563. https://doi.org/10.3390/ijerph17051548

Eisen, L (2020). Stemming the rising tide of human-biting ticks and tickborne diseases, United States. *Emerging Infectious Diseases*, *26*(4), 641-647. https://doi.org/10.3201/eid2604.191629

Ellis, T. J., & Levy, Y. (2009). Towards a guide for novice researchers on research methodology: Review and proposed methods. In E.B. Cohen (Ed.). *Issues in Informing Science & Information Technology* (pp. 328-345). Babcock Press.

Fabrigar, L. R., Wegener, D. T., & Petty, R. E. (2020). A validity-based framework for understanding replication in psychology. *Personality and Social Psychology Review*, *24*(4), 316-344. https://doi.org/10.1177/1088868320931366

Fang, Y., Wang, H. H., Liang, M., Yeung, M. S., Leung, C., Chan, C. H., Cheung, W. Huang, J. L. W., Huang, J., Sit, R. W. S., Wong, S. Y. S., & Wong, M. C. (2018). The adoption of hypertension reference framework: An investigation among primary care physicians of Hong Kong. *PLOS One*, *13*(10), e0205529. https://doi.org/10.1371/journal.pone.0205529

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175-191. https://doi.org/10.3758/bf03193146

Ferrouillet, C., Milord, F., Lambert, L., Vibien, A., & Ravel, A. (2015). Lyme disease: Knowledge and practices of family practitioners in southern Quebec. *The Canadian Journal of Infectious Diseases & Medical Microbiology*, 26(3), 151-156. https://doi.org/10.1155/2015/846963

Field, A. (2013). *Statistics using SPSS*. Sage.

Filzmoser, P. (2004). *A multivariate outlier detection method*. Sage.

Fischer, F., Lange, K., Klose, K., Greiner, W., & Kraemer, A. (2016). Barriers and strategies in guideline implementation: A scoping review. *Healthcare, 4*(3), 36-48. https://doi.org/10.3390/healthcare4030036

Fischhoff, I. R., Keesing, F., & Ostfeld, R. S. (2019). Risk factors for bites and diseases associated with black-legged ticks: a meta-analysis. *American Journal of Epidemiology*, *188*(9), 1742-1750. https://doi.org/10.1093/aje/kwz130

Gardner, A. M., Pawlikowski, N. C., Hamer, S. A., Hickling, G. J., Miller, J. R., Schotthoefer, A. M., & Allan, B. F. (2020). Landscape features predict the current and forecast the future geographic spread of Lyme disease. *Proceedings. Biological Sciences*, *287*(1941), 20202278. https://doi.org/10.1098/rspb.2020.2278

Gasmi, S., Ogden, N. H., Lindsay, L. R., Burns, S., Fleming, S., Badcock, J., ... & Koffi, J. K. (2017). Emerging Infections: Surveillance for Lyme disease in Canada: 2009–2015. *Canada Communicable Disease Report*, *43*(10), 194-199. https://doi.org/10.14745/ccdr.v43i10a01

Gay, L. R., & Airasian, P. (2000). *Educational research: Competencies for analysis and application*. Upper Saddle River, NJ: Merrill Prentice Hall.

Ginsberg, H. S., Hickling, G. J., Burke, R. L., Ogden, N. H., Beati, L., LeBrun, R. A., Arsnoe, I.M., Gehrold, R., Han, S., Jackson, K., Maestas, L., Moody, Pang, G., Ross, B., Rulison, E.L., & Tsao, J. I. (2021). Why Lyme disease is common in the northern US, but rare in the south: The roles of host choice, host-seeking behavior, and tick density. *PLoS Biology*, *19*(1), e3001066. https://doi.org/10.1371/journal.pbio.3001066

Gomes-Solecki, M., Arnaboldi, P. M., Backenson, P. B., Benach, J. L., Cooper, C. L., Dattwyler, R. J., & Lundberg, U. (2019). Protective immunity and new vaccines for LD. *Clinical Infectious Diseases*, 70(8), 1768-1773. https://doi.org/10.1371/journal.pbio.3001066

Goodarzi, Z., Hanson, H. M., Jette, N., Patten, S., Pringsheim, T., & Holroyd-Leduc, J. (2018). Barriers and facilitators for guidelines with depression and anxiety in Parkinson's disease or dementia. *Canadian Journal on Aging*, *37*(2), 185-199. https://doi.org/10.1017/s0714980818000053

Greig, J. D., Young, I., Harding, S., Mascarenhas, M., & Waddell, L. A. (2018). Climate change and Lyme disease: A scoping review of Lyme disease research relevant to public health. *Canada Communicable Disease Report*, *44*(10), 243-257. https://doi.org/10.14745/ccdr.v44i10a03

Henry, B., Crabtree, A., Roth, D., Blackman, D., & Morshed, M. (2012). LD: Knowledge, beliefs, and practices of physicians in a low-endemic area. *Canadian Family Physician*, *58*(5), e289-e295. https://doi.org/10.1016/j.jcjd.2012.07.348

Hill, D., & Holmes, T. (2015). Provider knowledge, attitudes, and practices regarding Lyme disease in Arkansas. *Journal of Community Health*, *40*(2), 339-346. https://doi.org/10.1007/s10900-014-9940-9

Johnson, M., & Feder, H. M., Jr. (2010). Chronic LD: A survey of Connecticut primary care physicians. *The Journal of Pediatrics*, *157*(6), 1025-1029. https://doi.org/10.1016/j.jpeds.2010.06.031

Kaiser, S. V., Lam, R., Cabana, M. D., Bekmezian, A., Bardach, N. S., Auerbach, A., & The PRIS Network. (2020). Best practices in implementing inpatient pediatric asthma pathways: A qualitative study. *Journal of Asthma*, *57*(7), 744-754. https://doi.org/10.1080/02770903.2019.1606237

Laerd Statistics (2021). *One-way MANCOVA in SPSS statistics*. https://statistics.laerd.com/spss-tutorials/one-way-mancova-using-spss-statistics.php

Lantos, P. M. (2011). Chronic LD: The controversies and the science. *Expert Review of Anti-Infective Therapy*, *9*(7), 787-97. https://doi.org/10.1586/eri.11.63

Lantos, P. M., Tsao, J., Nigrovic, L. E., Auwaerter, P. G., Fowler, V. G., Ruffin, F., Foster, E., Lavoie, K. L., Rash, J. A., & Campbell, T. S. (2017). Changing provider behavior in the context of chronic disease management: Focus on clinical inertia. *Annual Review of Pharmacology and Toxicology*, *57*, 263-283. https://doi.org/10.1146/annurev-pharmtox-010716-104952

Lavoie, K. L., Rash, J. A., & Campbell, T. S. (2017). Changing provider behavior in the context of chronic disease management: focus on clinical inertia. *Annual Review of Pharmacology & Toxicology*, *57*(1), 263-283. https://doi.org/10.1146/annurev-pharmtox-010716-104952

Leys, C., Delacre, M., Mora, Y. L., Lakens, D., & Ley, C. (2019). How to classify, detect, and manage univariate and multivariate outliers, with emphasis on pre-registration. *International Review of Social Psychology*, *32*(1), 1-10. https://doi.org/10.5334/irsp.289

Liang, L., Bernhardsson, S., Vernooij, R. W., Armstrong, M. J., Bussières, A., Brouwers, M. C., & Gagliardi, A. R. (2017). Use of theory to plan or evaluate guideline implementation among physicians: a scoping review. *Implementation Science*, *12*(1), 1-12. https://doi.org/10.1186/s13012-017-0557-0

Liu, C., Wang, D., Deng, Z., Tang, Y., & Zhang, X. (2019). Determinants of antibiotic prescribing behaviors of primary care physicians in Hubei of China: A structural equation model based on the theory of planned behavior. *Antimicrobial Resistance and Infection Control, 8*, 23-32. https://doi.org/10.1186/s13756-019-0478-6

Maestas, L. P., Adams, S. L., & Britten, H. B. (2016). First evidence of an established population of *Ixodes scapularis* (Acari: Ixodidae) in South Dakota. *Journal of Medical Entomology*, *53*(4), 965-966. https://doi.org/10.1093/jme/tjw038

Magri, J. M., Johnson, M. T., Herring, T. A., & Greenblatt, J. F. (2002). Lyme disease knowledge, beliefs, and practices of New Hampshire primary care physicians. *The Journal of the American Board of Family Practice*, *15*(4), 277–284. https://doi.org/10.3122/jabfm.19.1.54

Mead, P. S. (2015). Epidemiology of Lyme disease. *Infectious Disease Clinics*, *29*(2), 187-210. https://doi.org/10.1016/j.idc.2015.02.010

Moring, B. (2014). *Research methods in psychology: Evaluating a world of information*. WW Norton & Company.

Nardi, P. M. (2018). *Doing survey research: A guide to quantitative methods*. Routledge.

Nelson, C. A., Saha, S., Kugeler, K. J., Delorey, M. J., Shankar, M. B., Hinckley, A., Mead, P. S. (2015). Incidence of clinician-diagnosed LD, United States, 2005–2010. *Emerging Infectious Diseases*, *21*(9), 1625-1631. https://doi.org/10.3201/eid2109.150417

Office for Human Research Protections (OHRP). (2020). *International compilation of human research standards*. https://www.hhs.gov/ohrp/sites/default/files/2020-international-compilation-of-human-research-standards.pdf

Pearson, S. (2015). LD: Cause, symptoms, prevention, and treatment. *Nurse Prescribing*, *13*(2), 88-93. https://doi.org/10.12968/npre.2015.13.2.88

Peretti-Watel, P., Ward, J., Lutaud, R., & Seror, V. (2019). Lyme disease: Insight from social sciences. *Medecine et Maladies Infectieuses*, *49*(2), 133-139. https://doi.org/10.1016/j.medmal.2018.12.005

Pit, S. W., Vo, T., & Pyakurel, S. (2014). The effectiveness of recruitment strategies on general practitioner's survey response rates: A systematic review. *BMC Medical Research Methodology*, *14*(1), 1-14. https://doi.org/10.1186/1471-2288-14-76

Rayment, C., & O'Flynn, N. (2018). Diagnosis and management of patients with Lyme disease: NICE guideline. *British Journal of General Practice*, *68*(676), 546-547. https://doi.org/10.3399/bjgp18x699713

Saint-Pierre, C., Prieto, F., Herskovic, V., & Sepúlveda, M. (2019). Relationship between continuity of care in the multidisciplinary treatment of patients with diabetes and their clinical results. *Applied Sciences*, *9*(2), 268-281. https://doi.org/10.3390/app9020268

Schwarz, N. (2014). *Cognition and communication: Judgmental biases, research methods, and the logic of conversation*. Psychology Press.

Schutzer, S. E., Body, B. A., Boyle, J., Branson, B. M., Dattwyler, R. J., Fikrig, E., Noel, J.G., Gomes-Solecki, M., Kintrup, M., Ledize, M., Levin, A.E., Lewinski, M., Liotta, L.A., Marques, A., & Branda, J. A. (2019). Direct diagnostic tests for Lyme disease. *Clinical Infectious Diseases*, *68*(6), 1052-1057. https://doi.org/10.1093/cid/ciy614

Scott, A., Jeon, S. H., Joyce, C. M., Humphreys, J. S., Kalb, G., Witt, J., & Leahy, A. (2011). A randomized trial and economic evaluation of the effect of response mode on response rate, response bias, and item non-response in a survey of doctors. *BMC Medical Research Methodology*, *11*(1), 1-12. https://doi.org/10.1186/1471-2288-11-126

Sharareh, N., Behler, R. P., Roome, A. B., Shepherd, J., Garruto, R. M., & Sabounchi, N. S. (2019). Risk factors of Lyme disease: An intersection of environmental ecology and systems science. *Healthcare*, *7*(2), 66-98. https://doi.org/10.3390/healthcare7020066

Sharpe, H., Claveria-Gonzalez, F. C., Davidson, W., Befus, A. D., Leung, J. P., Young, E., Walker, B., & Asthma Working Group, Respiratory Health Strategic Clinical Network, Alberta Health Services. (2020). Adult asthma diagnosis: Physician reported challenges in Alberta-based primary care practices. *SAGE Open Nursing*, *6*, 2377960820925984. https://doi.org/10.1177/2377960820925984

Singh, S., Parker, D., Mark-Carew, M., Robert White, I. I., & Fisher, M. (2016). Lyme disease in West Virginia: An assessment of distribution and clinicians' knowledge of disease and surveillance. *West Virginia Medical Journal*, *112*(4), 48-55.

Stone, B. L., Tourand, Y., & Brissette, C. A. (2017). Brave new worlds: The expanding universe of Lyme disease. *Vector-Borne and Zoonotic Diseases*, *17*(9), 619-629. https://doi.org/10.1089/vbz.2017.2127

Tabachnick, B.G., & Fidell, L.S. (2019). *Using multivariate statistics*. Sage.

Waddell, L. A., Greig, J., Mascarenhas, M., Harding, S., Lindsay, R., & Ogden, N. (2016). The accuracy of diagnostic tests for Lyme disease in humans: A systematic review and meta-analysis of North American research. *PloS One*, *11*(12), e0168613. https://doi.org/10.1371/journal.pone.0168613

Wang, Y. X., Matson, K. D., Xu, Y., Prins, H. H., Huang, Z. Y., & de Boer, W. F. (2019). Forest connectivity, host assemblage characteristics of local and neighboring counties, and temperature jointly shape the spatial expansion of Lyme disease in United States. *Remote Sensing*, *11*(20), 2354-2376. https://doi.org/10.3390/rs11202354

Wolf, M. J., Watkins, H. R., & Schwan, W. R. (2020). *Ixodes scapularis*: Vector to an increasing diversity of human pathogens in the upper Midwest. *WMJ: Official Publication of the State Medical Society of Wisconsin*, *119*(1), 16-32. https://doi.org/10.3390/rs11202354

Zhengdong, L. I. (2011). Error analysis of sampling frame in sample survey. *Studies in Sociology of Science*, *2*(1), 14-21. http://dx.doi.org/10.3968/j.sss.1923018420110201.003

Appendix A: Scatterplot Matrices With Loess lines: Dependent Variables for Each Independent Variable Group

Figure A1

Scatterplot Matrices With Loess Lines: Lyme Disease Knowledge and Lyme Disease Attitudes

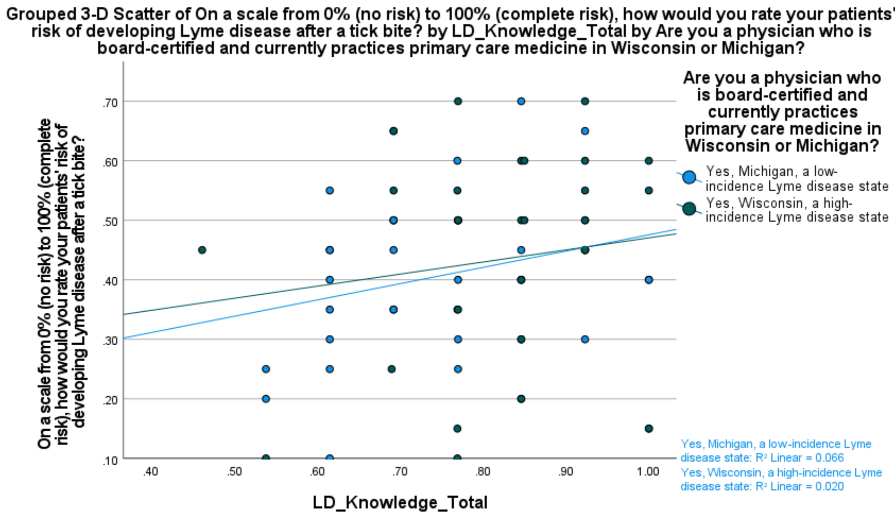


Figure A2

Scatterplot Matrices With Loess Lines: Lyme Disease Knowledge and Lyme Disease Antibiotic Treatment Practices

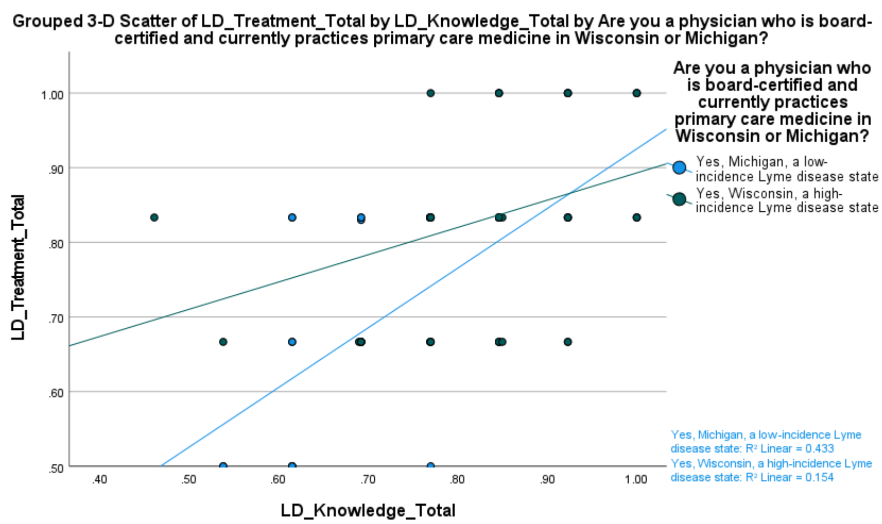
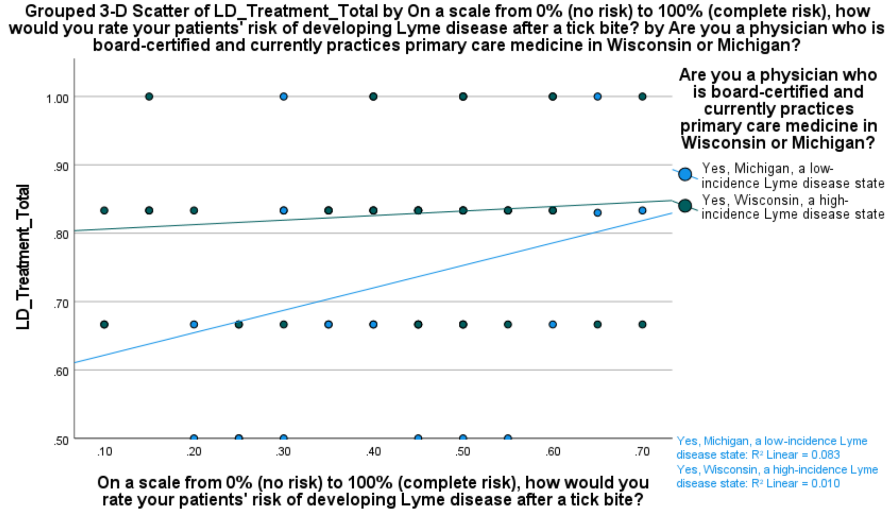


Figure A3

Scatterplot Matrices With Loess Lines: Lyme Disease Attitudes and Lyme Disease Antibiotic Treatment Practices



Appendix B: Scatterplot Matrices With Loess lines: Covariates With Dependent Variables for Each Independent Variable Group

Figure B1

Scatterplot Matrices: Physician Years of Practice and Lyme Disease Knowledge

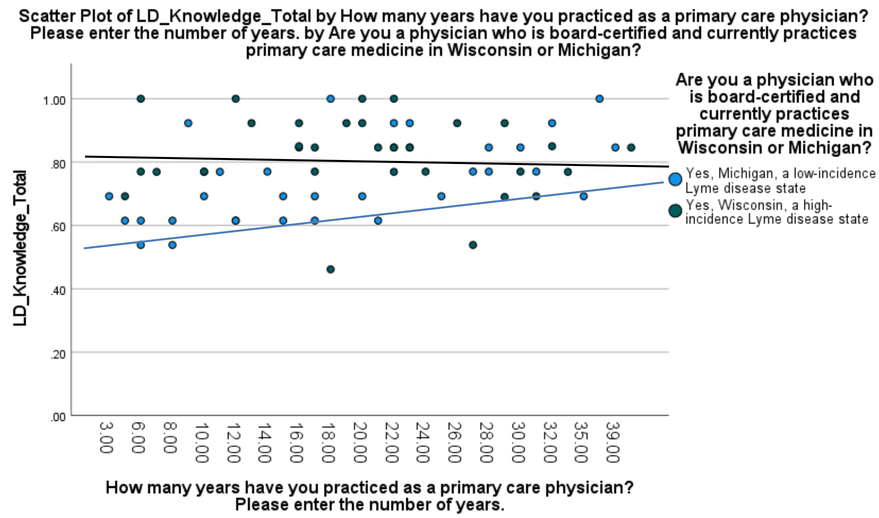


Figure B2

Scatterplot Matrices: Physician Years of Practice and Lyme Disease Attitudes

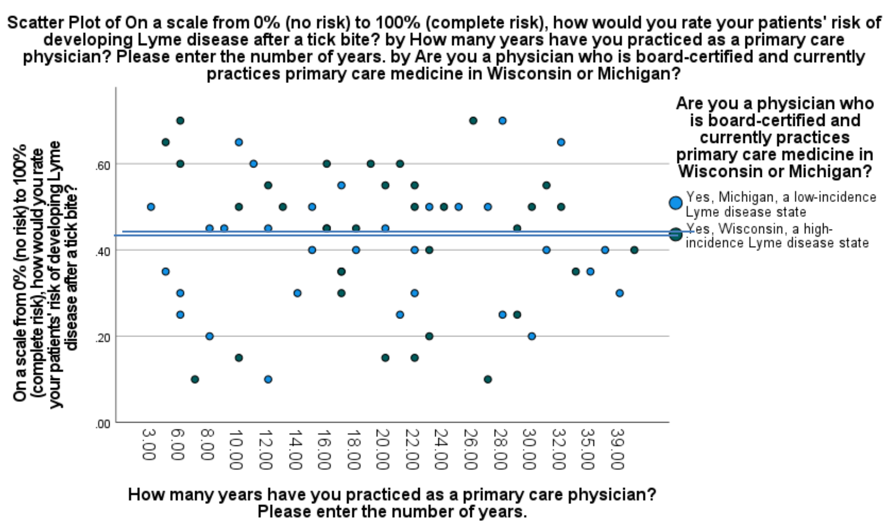


Figure B3

Scatterplot Matrices: Physician Years of Practice and Lyme Disease Antibiotic Treatment Practices

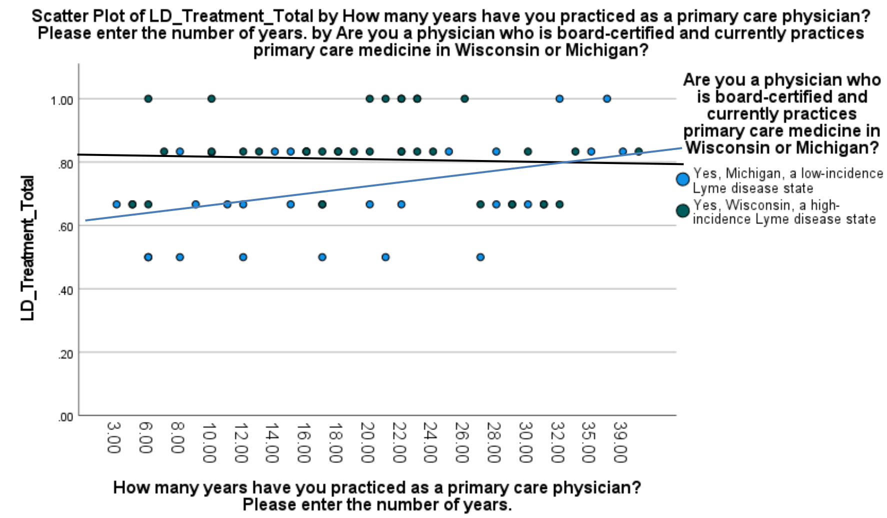


Figure B4

Scatterplot Matrices: Number of Patients Seen per Week and Lyme Disease Knowledge

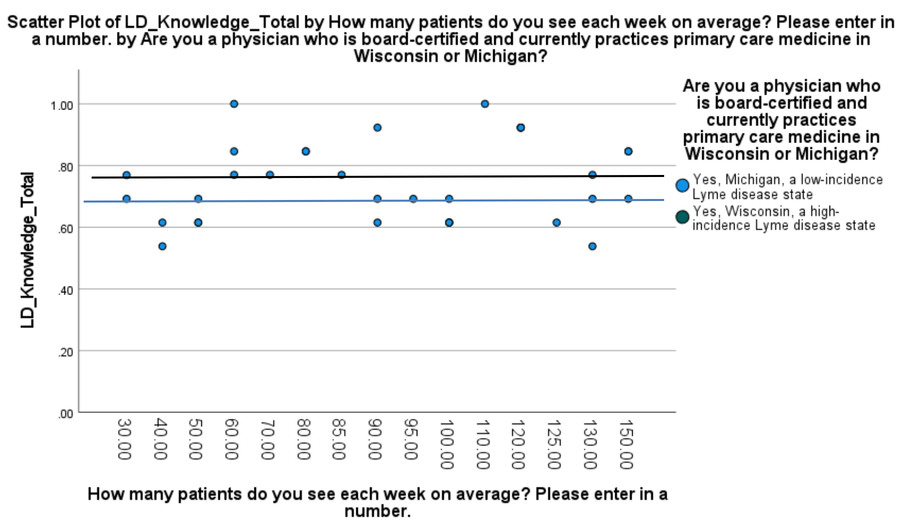


Figure B5

Scatterplot Matrices: Number of Patients Seen per Week and Lyme Disease Attitudes

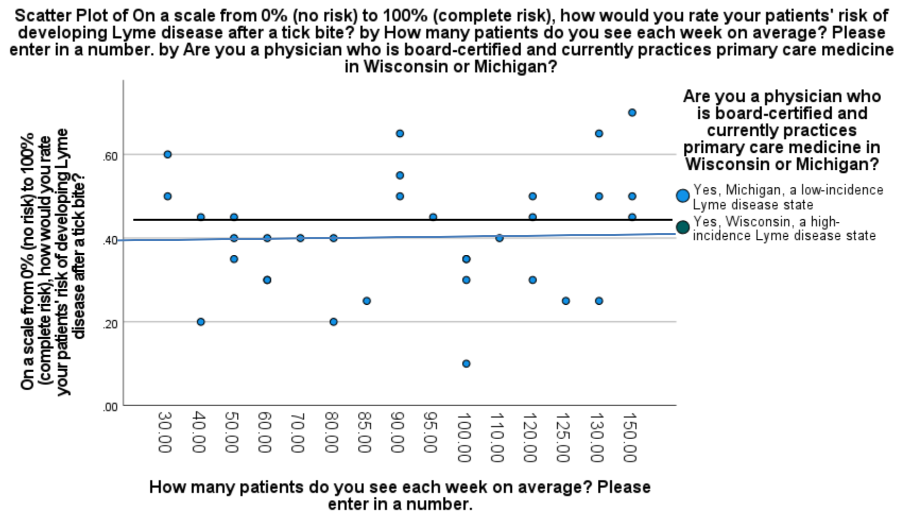
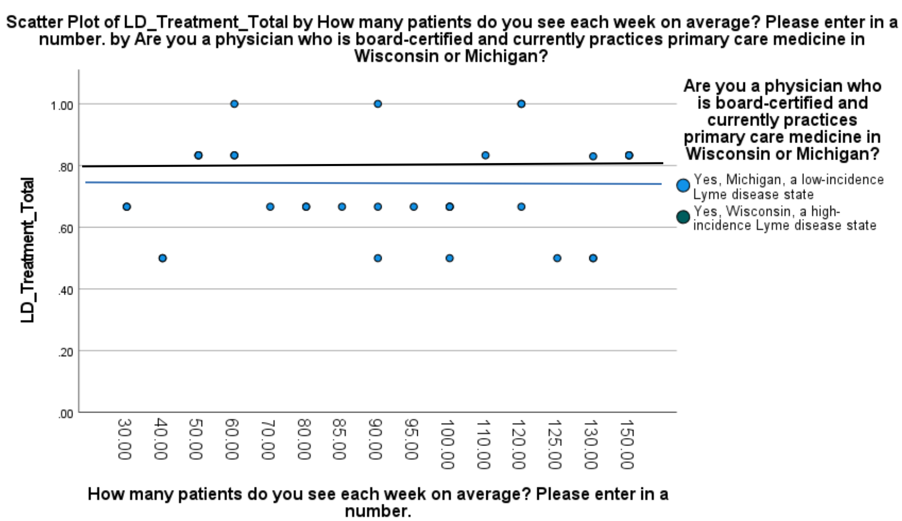


Figure B6

Scatterplot Matrices: Number of Patients Seen per Week and Lyme Disease Antibiotic Treatment Practices



Appendix C: Standardized Residuals for the Dependent Variables for each Independent Variable Group

Figure C1

Standardized Residuals for Lyme Disease Knowledge for Each Physician Group

Crosstab

			LD_Knowledge_Total											
			.46	.54	.62	.69	.69	.77	.77	.85	.85	.92	1.00	Total
Are you a physician who is board-certified and currently practices primary care medicine in Wisconsin or Michigan?	Yes, Michigan, a low-incidence Lyme disease state	Count	0	2	8	0	7	1	4	5	0	4	2	33
		% within Are you a physician who is board-certified and currently practices primary care medicine in Wisconsin or Michigan?	0.0%	6.1%	24.2%	0.0%	21.2%	3.0%	12.1%	15.2%	0.0%	12.1%	6.1%	100.0%
		% within LD_Knowledge_Total	0.0%	66.7%	100.0%	0.0%	77.8%	20.0%	44.4%	45.5%	0.0%	40.0%	33.3%	50.8%
		Standardized Residual	-.7	.4	2.0	-.7	1.1	-1.0	-.3	-.2	-1.0	-.5	-.6	
	Yes, Wisconsin, a high-incidence Lyme disease state	Count	1	1	0	1	2	4	5	6	2	6	4	32
		% within Are you a physician who is board-certified and currently practices primary care medicine in Wisconsin or Michigan?	3.1%	3.1%	0.0%	3.1%	6.3%	12.5%	15.6%	18.8%	6.3%	18.8%	12.5%	100.0%
		% within LD_Knowledge_Total	100.0%	33.3%	0.0%	100.0%	22.2%	80.0%	55.6%	54.5%	100.0%	60.0%	66.7%	49.2%
		Standardized Residual	.7	-.4	-2.0	.7	-1.2	1.0	.3	.3	1.0	.5	.6	
Total		Count	1	3	8	1	9	5	9	11	2	10	6	65
		% within Are you a physician who is board-certified and currently practices primary care medicine in Wisconsin or Michigan?	1.5%	4.6%	12.3%	1.5%	13.8%	7.7%	13.8%	16.9%	3.1%	15.4%	9.2%	100.0%
		% within LD_Knowledge_Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Figure C2

Standardized Residuals for Lyme Disease Attitudes for Each Physician Group

Crosstab

			On a scale from 0% (no risk) to 100% (complete risk), how would you rate your patients' risk of developing Lyme disease after a tick bite?													
			.10	.15	.20	.25	.30	.35	.40	.45	.50	.55	.60	.65	.70	Total
Are you a physician who is board-certified and currently practices primary care medicine in Wisconsin or Michigan?	Yes, Michigan, a low-incidence Lyme disease state	Count	1	0	2	3	4	3	5	5	5	1	1	2	1	33
		% within Are you a physician who is board-certified and currently practices primary care medicine in Wisconsin or Michigan?	3.0%	0.0%	6.1%	9.1%	12.1%	9.1%	15.2%	15.2%	15.2%	3.0%	3.0%	6.1%	3.0%	100.0%
		% within On a scale from 0% (no risk) to 100% (complete risk), how would you rate your patients' risk of developing Lyme disease after a tick bite?	33.3%	0.0%	66.7%	75.0%	80.0%	60.0%	71.4%	62.5%	45.5%	20.0%	20.0%	66.7%	33.3%	50.8%
		Standardized Residual	-.4	-1.2	.4	.7	.9	.3	.8	.5	-.2	-1.0	-1.0	.4	-.4	
	Yes, Wisconsin, a high-incidence Lyme disease state	Count	2	3	1	1	1	2	2	3	6	4	4	1	2	32
		% within Are you a physician who is board-certified and currently practices primary care medicine in Wisconsin or Michigan?	6.3%	9.4%	3.1%	3.1%	3.1%	6.3%	6.3%	9.4%	18.8%	12.5%	12.5%	3.1%	6.3%	100.0%
		% within On a scale from 0% (no risk) to 100% (complete risk), how would you rate your patients' risk of developing Lyme disease after a tick bite?	66.7%	100.0%	33.3%	25.0%	20.0%	40.0%	28.6%	37.5%	54.5%	80.0%	80.0%	33.3%	66.7%	49.2%
		Standardized Residual	.4	1.3	-.4	-.7	-.9	-.3	-.8	-.5	.3	1.0	1.0	-.4	.4	
Total		Count	3	3	3	4	5	5	7	8	11	5	5	3	3	65
		% within Are you a physician who is board-certified and currently practices primary care medicine in Wisconsin or Michigan?	4.6%	4.6%	4.6%	6.2%	7.7%	7.7%	10.8%	12.3%	16.9%	7.7%	7.7%	4.6%	4.6%	100.0%
		% within On a scale from 0% (no risk) to 100% (complete risk), how would you rate your patients' risk of developing Lyme disease after a tick bite?	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Figure C3

Standardized Residuals for Lyme Disease Antibiotic Treatment Practices for each Physician Group

Crosstab

			LD_Treatment_Total					
			.50	.67	.83	.83	1.00	Total
Are you a physician who is board-certified and currently practices primary care medicine in Wisconsin or Michigan?	Yes, Michigan, a low-incidence Lyme disease state	Count	7	12	1	9	4	33
		% within Are you a physician who is board-certified and currently practices primary care medicine in Wisconsin or Michigan?	21.2%	36.4%	3.0%	27.3%	12.1%	100.0%
		% within LD_Treatment_Total	100.0%	60.0%	100.0%	34.6%	36.4%	50.8%
		Standardized Residual	1.8	.6	.7	-1.2	-.7	
	Yes, Wisconsin, a high-incidence Lyme disease state	Count	0	8	0	17	7	32
		% within Are you a physician who is board-certified and currently practices primary care medicine in Wisconsin or Michigan?	0.0%	25.0%	0.0%	53.1%	21.9%	100.0%
		% within LD_Treatment_Total	0.0%	40.0%	0.0%	65.4%	63.6%	49.2%
		Standardized Residual	-1.9	-.6	-.7	1.2	.7	
Total		Count	7	20	1	26	11	65
		% within Are you a physician who is board-certified and currently practices primary care medicine in Wisconsin or Michigan?	10.8%	30.8%	1.5%	40.0%	16.9%	100.0%
		% within LD_Treatment_Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Appendix D: One-Way MANCOVA Findings

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Intercept	Pillai's Trace	.888	158.306[b]	3.000	60.000	<.001	.888	474.918	1.000
	Wilks' Lambda	.112	158.306[b]	3.000	60.000	<.001	.888	474.918	1.000
	Hotelling's Trace	7.915	158.306[b]	3.000	60.000	<.001	.888	474.918	1.000
	Roy's Largest Root	7.915	158.306[b]	3.000	60.000	<.001	.888	474.918	1.000
Years_in_Practice	Pillai's Trace	.087	1.905[b]	3.000	60.000	.138	.087	5.715	.469
	Wilks' Lambda	.913	1.905[b]	3.000	60.000	.138	.087	5.715	.469
	Hotelling's Trace	.095	1.905[b]	3.000	60.000	.138	.087	5.715	.469
	Roy's Largest Root	.095	1.905[b]	3.000	60.000	.138	.087	5.715	.469
Physician_Location	Pillai's Trace	.134	3.103[b]	3.000	60.000	.033	.134	9.308	.696
	Wilks' Lambda	.866	3.103[b]	3.000	60.000	.033	.134	9.308	.696
	Hotelling's Trace	.155	3.103[b]	3.000	60.000	.033	.134	9.308	.696
	Roy's Largest Root	.155	3.103[b]	3.000	60.000	.033	.134	9.308	.696

a. Design: Intercept + Years_in_Practice + Physician_Location

b. Exact statistic

c. Computed using alpha = .05

Box's Test of Equality of Covariance Matrices[a]

Box's M	6.558
F	1.036
df1	6
df2	28679.057
Sig.	.399

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Years_in_Practice + Physician_Location

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
LD_Knowledge_Total	.001	1	63	.981
On a scale from 0% (no risk) to 100% (complete risk), how would you rate your patients' risk of developing Lyme disease after a tick bite?	2.219	1	63	.141
LD_Treatment_Total	2.596	1	63	.112

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Years_in_Practice + Physician_Location

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[d]
Corrected Model	LD_Knowledge_Total	.166[a]	2	.083	5.370	.007	.148	10.740	.825
	On a scale from 0% (no risk) to 100% (complete risk), how would you rate your patients' risk of developing Lyme disease after a tick bite?	.016[b]	2	.008	.321	.727	.010	.642	.099
	LD_Treatment_Total	.237[c]	2	.118	6.236	.003	.167	12.472	.880
Intercept	LD_Knowledge_Total	6.085	1	6.085	393.718	<.001	.864	393.718	1.000
	On a scale from 0% (no risk) to 100% (complete risk), how would you rate your patients' risk of developing Lyme disease after a tick bite?	2.261	1	2.261	88.316	<.001	.588	88.316	1.000
	LD_Treatment_Total	6.084	1	6.084	320.773	<.001	.838	320.773	1.000
Years_in_Practice	LD_Knowledge_Total	.071	1	.071	4.606	.036	.069	4.606	.561
	On a scale from 0% (no risk) to 100% (complete risk), how would you rate your patients' risk of developing Lyme disease after a tick bite?	.003	1	.003	.133	.716	.002	.133	.065
	LD_Treatment_Total	.054	1	.054	2.847	.097	.044	2.847	.383
Physician_Location	LD_Knowledge_Total	.083	1	.083	5.353	.014	.079	5.343	.624
	On a scale from 0% (no risk) to 100% (complete risk), how would you rate your patients' risk of developing Lyme disease after a tick bite?	.014	1	.014	.545	.463	.009	.545	.112
	LD_Treatment_Total	.167	1	.167	8.818	.004	.125	8.818	.832
Error	LD_Knowledge_Total	.958	62	.015					
	On a scale from 0% (no risk) to 100% (complete risk), how would you rate your patients' risk of developing Lyme disease after a tick bite?	1.588	62	.026					
	LD_Treatment_Total	1.176	62	.019					
Total	LD_Knowledge_Total	41.038	65						
	On a scale from 0% (no risk) to 100% (complete risk), how would you rate your patients' risk of developing Lyme disease after a tick bite?	13.070	65						
	LD_Treatment_Total	40.383	65						
Corrected Total	LD_Knowledge_Total	1.124	64						
	On a scale from 0% (no risk) to 100% (complete risk), how would you rate your patients' risk of developing Lyme disease after a tick bite?	1.604	64						
	LD_Treatment_Total	1.412	64						

a. R Squared = .148 (Adjusted R Squared = .120)

b. R Squared = .010 (Adjusted R Squared = -.022)

c. R Squared = .167 (Adjusted R Squared = .141)

d. Computed using alpha = .05

Descriptive Statistics

	Are you a physician who is board-certified and currently practices primary care medicine in Wisconsin or Michigan?	Mean	Std. Deviation	N
LD_Knowledge_Total	Yes, Michigan, a low-incidence Lyme disease state	.7460	.13113	33
	Yes, Wisconsin, a high-incidence Lyme disease state	.8224	.12432	32
	Total	.7836	.13254	65
On a scale from 0% (no risk) to 100% (complete risk), how would you rate your patients' risk of developing Lyme disease after a tick bite?	Yes, Michigan, a low-incidence Lyme disease state	.4061	.13962	33
	Yes, Wisconsin, a high-incidence Lyme disease state	.4344	.17663	32
	Total	.4200	.15831	65
LD_Treatment_Total	Yes, Michigan, a low-incidence Lyme disease state	.7221	.15950	33
	Yes, Wisconsin, a high-incidence Lyme disease state	.8281	.11581	32
	Total	.7743	.14856	65