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Lyme disease human surveillance in Ontario:

A systematic review

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Authors

Mark P. Nelder, PhD
Senior Program Specialist
Enteric, Zoonotic & Vector-borne Diseases
Communicable Diseases, Emergency Preparedness and Response

Curtis Russell, PhD
Senior Program Specialist
Enteric, Zoonotic & Vector-borne Diseases
Communicable Diseases, Emergency Preparedness and Response

Samir Patel, PhD, FCCM (D) ABMM
Clinical Microbiologist
Public Health Ontario Laboratories

Stephen Moore, MPH
Manager
Enteric, Zoonotic & Vector-borne Diseases
Communicable Diseases, Emergency Preparedness and Response

Doug Sider, MD, MSc, FRCPC
Medical Director
Communicable Diseases, Emergency Preparedness and Response

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Disclaimer

This document was developed by Public Health Ontario (PHO). PHO provides scientific and technical advice to Ontario's government, public health organizations and health care providers. PHO's work is guided by the current best available evidence.

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Contents

Introduction **6**

Purpose and Objectives 6
Background 6

Methodology **8**

Search Strategy 8
Study Selection 8
Data Extraction and Quality Assessment 9

Findings **10**

Study Characteristics and Quality Assessment 10
Descriptive Analysis 13
Administrative claims databases 13
Reportable disease databases 14

Discussion **15**

Administrative claims databases 15
Physician surveys 16
Public health laboratory databases 16
Systematic review limitations 17

Conclusions **18**

References **19**

Appendix 1. ..... **23**

Quality assessment of human disease surveillance studies reviewed 23

Introduction

Purpose and Objectives

In order to provide the latest, evidence-based advice on surveillance, Public Health Ontario (PHO) performed a systematic literature review to assess methods and best practices for Lyme disease surveillance. This review assesses the applicability of currently available methods to Ontario and provides the basis for the updated Human Disease Surveillance section in PHO's *Technical report: Update on Lyme disease prevention and control. Second edition*. Assessing the gamut of available methods that could apply to the Ontario context is especially important given that most studies reviewed were carried out in jurisdictions with differing social, environmental and ecological conditions as well as healthcare, public health and surveillance systems. The primary objectives of this report are to:

- assess Lyme disease surveillance methods reported in the literature and the relevance of these methods to public health surveillance in Ontario;
- explain the purpose of different surveillance methods and how they relate to one other; and
- based on the above, assess the appropriateness of Ontario's current Lyme disease surveillance methods and determine whether other methods could be applied.

Background

Lyme disease is a bacterial spirochete infection caused by *Borrelia burgdorferi* and is transmitted to humans through the bite of an infectious blacklegged tick, *Ixodes scapularis*. Lyme disease is the most common vector-borne disease in North America, with an estimated 300,000 cases annually in the United States (US) alone.[1-3] Lyme disease was first recognized in 1975, when it was initially described as a cluster of juvenile rheumatoid arthritis cases in several towns in Connecticut, US.[4] Soon after the description of Lyme disease in the early 1980s, the blacklegged tick was identified as the vector of *B. burgdorferi* in New York, US.[5,6] Lyme disease is found throughout eastern North America, including southern portions of Canada, wherever blacklegged ticks are present; however, disease rates are highest in the Northeast and Upper Midwestern US states.[7]

With expanding *I. scapularis* populations and increased public and health care clinician awareness, the incidence of Lyme disease has increased in Ontario since it became a reportable disease in the province in 1988. The first isolation of *B. burgdorferi* from a blacklegged tick in Ontario occurred in 1993, when a tick removed from a dog in Kenora (Northwestern Health Unit) tested positive for the agent of Lyme disease.[8] In 2014, Ontario reported 220 confirmed and probable human cases of Lyme disease (incidence rate of 1.6 cases per 100,000 population).[9] Overall, the incidence of Lyme disease in Ontario has increased steadily since 2002. In Ontario, approximately 70% of all reported cases are reported in

June, July and August. This peak in cases during the summer months is similar to other Lyme disease-endemic regions in the US and Canada and coincides with both greater participation in outdoor activities and increased presence of infectious nymphs in the environment. Compared to adult blacklegged ticks, blood-feeding nymphs are much more difficult to detect and are more likely to go unnoticed, allowing them to feed longer, leading to a greater risk of *B*. *burgdorferi* infection.

Incidence rates for Lyme disease are higher in specific public health units (PHUs), including Eastern Ontario (EOH); Hastings and Prince Edward Counties (HPE); Kingston, Frontenac and Lennox & Addington (KFL); Leeds, Grenville and Lanark District (LGL); Ottawa (OTT); and Renfrew (REN). This trend of higher incidence of cases in the Eastern Region (EOH, HPE, KFL, LGL, OTT, REN) correlates with areas reporting a larger number of blacklegged ticks submitted through passive surveillance.[9]

Methodology

Search Strategy

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for conducting a systematic review were followed in the development of this review. A scientific literature search of English language articles was conducted using five electronic databases: Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) (Ovid interface: January 1, 1946 to April 16, 2015); Embase (Ovid Platform: January 1, 1988 to Week 15, 2015); Scopus (January 1, 1995 to April 17, 2015); Cochrane Database of Systematic Reviews (January 1, 1995 to April 17, 2015); CINAHL Plus with Full Text (January 1, 1995 to April 17, 2015). Our search used subject headings and keywords that included "Lyme", "burgdorferi", "borreliosis", neuroborreliosis", "Lyme disease", "Borrelia burgdorferi", "data collection", "biosurveillance", "public health surveillance", "population surveillance" and "epidemiological monitoring." The primary search strategy, developed in Medline, was customized into other databases to account for database-specific vocabulary and functionality differences. All searches were current as of April 17, 2015 (full search strategy for Ovid Medline, Table 1).

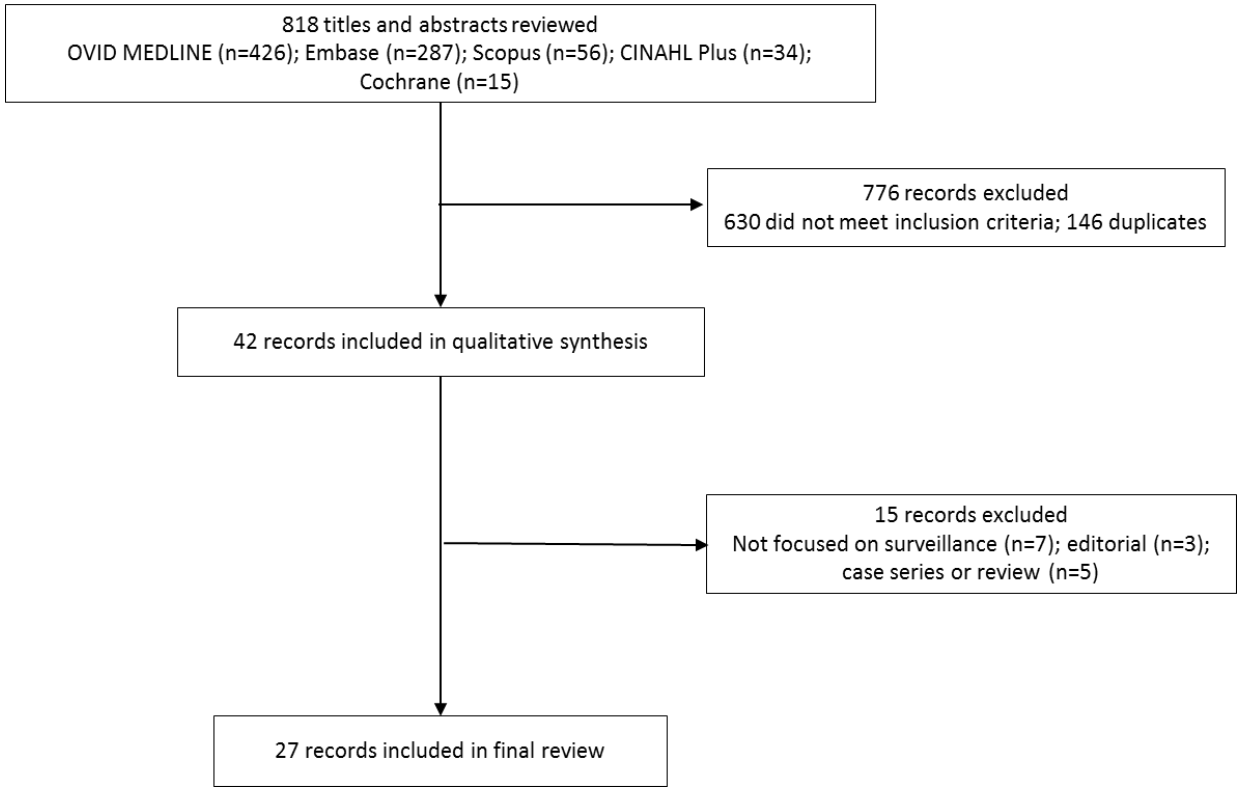
Table 1. Ovid Medline search strategy for human disease surveillance

#	Searches
1	(Lyme or burgdorferi or borreliosis or neuroborreliosis).tw,kf,kw. or Lyme disease/ or Borrelia burgdorferi/
2	Data Collection/mt, st or Seroepidemiologic studies/ or Biosurveillance/ or Epidemiological Monitoring/ or Public Health Surveillance/ or Population Surveillance/ or Sentinel Surveillance/ or ((active or passive or syndromic or sentinel or population) adj3 surveillance).tw,kf,kw.
3	1 and 2
4	*Lyme disease/ and ((method or surveillance) and (epidemiology or prevalence or incidence)).mp.
5	(*Lyme disease/ep or *Lyme disease/sn) and (method$ or surveillance).mp.
6	3 or 4 or 5
7	limit 6 to english language
8	limit 7 to last 20 years

Study Selection

Two reviewers independently screened titles and abstracts against eligibility criteria and differences resolved by consensus (Curtis Russell, Nina Jain-Sheehan) (Figure 1). Articles included in the review met the following inclusion criteria: 1) described human Lyme disease surveillance/disease risk/case underreporting; and 2) were published on or after January 1, 1995. Studies focusing on human case reports, case series and reviews were excluded, as were articles published as conference proceedings, editorials, perspectives or news.

Figure 1. Literature search and study selection for human surveillance



Data Extraction and Quality Assessment

A data extraction table was populated with first author(s), year of publication, study location, target disease, name of centralized reportable disease database, accessory case detection methods and the primary data elements (by method) collected in study.

To evaluate the quality of eligible primary studies and to reduce the risk of bias, two independent reviewers completed critical appraisals for each paper with disagreements resolved by consensus (Curtis Russell, Mark P. Nelder; Appendix 1). Quality assessments of studies were performed using the PHO MetaQAT Tool.[10] All studies were assessed using the MetaQAT Tool based upon four major categories: 1) assessment of relevancy (three specific questions); 2) assessment of reliability (three questions); 3) assessment of validity (eight questions); and 4) assessment of applicability. We did not calculate an overall quality score, as per agreement in the literature. [11]

Findings

Study Characteristics and Quality Assessment

Twenty-seven studies were included in the review (Table 2).[3,12-37] Fourteen studies were reported from the US, followed by Europe (n = 9) and Canada (n = 4). Twenty studies investigated Lyme disease only, six investigated Lyme disease in conjunction with other diseases and one study investigated ehrlichiosis surveillance. Four studies were published during the period from 1995 through 2002; eight studies from 2003 through 2008; and 15 studies from 2009 through 2015.

81% (22/27) of studies met 100% of quality criteria; another 7% (2/27) met at least 75% of quality criteria. Twenty-five of the 27 studies provided sufficient details of their methodology to allow for replication (Appendix 1).

Table 2. Summary of methods for the surveillance of Lyme disease, from 27 studies reviewed

Year; location; reference	Target disease*	Centralized reportable disease database or reporting agency	Accessory case detection method	Primary data elements**
1996; Maryland; Coyle[12]	LD	Maryland Department of Health and Mental Hygiene	Physician survey	**Database:** no. patients treated, no. diagnostic tests performed; **Accessory:** no. cases diagnosed, no. patients seen for tick bites, no. treated prophylactically, no. patients treated, no. serological tests ordered, antibiotic regimens, clinical characteristics, type of physician surveyed
1996; Connecticut; Meek [13]	LD	Connecticut Public Health Surveillance System	Physician survey	**Database:** type of medical practice reporting cases, type of physician reporting cases; **Accessory:** type of physician surveyed, place of practice, no. diagnoses
2000; England and Wales; Smith[14]	LD	Communicable Disease Surveillance Centre	Laboratory service survey	**Database:** not described, except for no. cases reported; **Accessory:** patient demographics, epidemiological information, clinical data

Year; location; reference	Target disease*	Centralized reportable disease database or reporting agency	Accessory case detection method	Primary data elements**
2002; Wisconsin; Naleway[15]	LD	Wisconsin Electronic Disease Surveillance System	Administrative claims database (Marshfield Clinic)	**Database:** patient demographics, epidemiological information, diagnostic test results; **Accessory:** patient demographics, epidemiological information, clinical data
2003; USA; Gardner[16]	Other	The National Electronic Telecommunications System for Surveillance	NA	**Database:** patient demographics, epidemiological information, diagnostic test results, clinical data
2005; Germany; Mehnert[17]	LD	Robert Koch Institute	NA	**Database:** patient demographics, epidemiological information, diagnostic test results, clinical data
2006; Ontario; Vrbova[18]	LD	Reportable Disease Information System	NA	**Database:** patient demographics, epidemiological information, diagnostic test results, clinical data
2007; Delaware; Kudish[19]	LD	Delaware Electronic Reporting Surveillance System	NA	**Database:** patient demographics, epidemiological information, diagnostic test results, antibiotic use, clinical data
2008; USA; Bacon[20]	LD	National Notifiable Disease Surveillance System	NA	**Database:** patient demographics, epidemiological information, diagnostic test results, clinical data
2008; Germany; Fulop[21]	LD	Robert Koch Institute	NA	**Database:** patient demographics, epidemiological information, diagnostic test results, clinical data
2008; New Jersey; McHugh[22]	LD	NJ Communicable Disease Reporting and Surveillance System	Electronic laboratory reporting	**Database:** patient demographics, epidemiological information, diagnostic test results, clinical data; **Accessory:** patient demographics
2008; Canada; Ogden[23]	LD	Notifiable Disease Surveillance System	NA	**Database:** epidemiological information, diagnostic test results, clinical data
2011; Québec; Bourre-Tessier[24]	LD	Institut National de Santé Publique du Québec	NA	**Database:** patient demographics, epidemiological information, diagnostic test results, clinical data
2011; British Columbia; Henry[25]	LD	Integrated Public Health Information System	Laboratory database; LD-enhanced surveillance database	**Database:** patient demographics, epidemiological information, diagnostic test results; **Laboratory Database:** patient demographics, epidemiological information, diagnostic test results; **LD-Enhanced Database:** patient demographics, epidemiological

Year; location; reference	Target disease*	Centralized reportable disease database or reporting agency	Accessory case detection method	Primary data elements**
				information, diagnostic test results
2012; Connecticut; Ertel[26]	LD	National Electronic Telecommunications System for Surveillance	NA	**Database:** patient demographics, epidemiological information, diagnostic test results, clinical data
2013; Switzerland; Altpeter[27]	LD, others	Sentinella (sentinel network, based on primary care physician reporting)	NA	**Database:** patient demographics, epidemiological information, diagnostic test results, hospitalization data, clinical data
2013; Tennessee; Jones[28]	LD, others	Tennessee Department of Health Center for Environmental and Communicable Diseases	Administrative claims database (Managed Care Organizations)	**Database:** patient demographics, epidemiological information; **Accessory:** patient demographics, epidemiological information
2013; USA; Kuehn[3]	LD	Centralized state databases, centralized national database	Administrative claims databases, clinical and laboratory reports, survey to public	**Database:** not described by authors; **Accessory:** not described by authors
2013; Poland; Paradowska-Stankiewicz[29]	LD	National Institute of Public Health - National Institute of Hygiene	NA	**Database:** patient demographics, diagnostic test results, clinical data
2013; Hungary; Zoldi[30]	LD, others	National Database of Epidemiological Surveillance System	GIS Pilot Study	**Database:** patient demographics, epidemiological information, diagnostic test results, clinical data; **Accessory:** patient demographics, forest layer, elevation
2014; USA; Hurt[31]	LD	NA	Military administrative claims database (Defense Medical Surveillance System)	**Accessory:** patient demographics, medical encounters
2014; Oklahoma; Johnson[32]	LD, others	Public Health Investigation and Disease Detection of Oklahoma	Electronic laboratory reporting	**Database:** patient demographics; **Accessory:** patient demographics, epidemiological information, diagnostic test results
2014; Maine; Robinson[33]	LD	Maine CDC National Electronic Disease Surveillance System Base System	Administrative claims database (Maine Health Data Organization)	**Database:** no. cases, patient demographics, epidemiological information, number hospitalizations; **Accessory:** patient demographics, hospital ID, medical record number, date of service, sequential visit number, no. outpatient and inpatient visits
2014; Czech	LD,	National Institute of	NA	**Database:** patient demographics,

Year; location; reference	Target disease*	Centralized reportable disease database or reporting agency	Accessory case detection method	Primary data elements**
Republic, Poland; Stefanoff[34]	others	Health in Prague; National Institute of Public Health-National Institute of Hygiene in Warsaw		epidemiological information, diagnostic test results, clinical data
2014; France; Vandenesch[35]	LD	Sentinelles (sentinel network, based on general practitioner reporting)	Administrative claims database (Programme de Médicalisation des Systèmes d'Information)	**Database:** patient demographics, epidemiological information, diagnostic test results, clinical data; **Accessory:** patient demographics, co-morbidities, length of hospitalization, hospital discharge reports
2014; Germany; Wilking[36]	LD	Robert Koch Institute	NA	**Database:** patient demographics, epidemiological information, diagnostic test results
2015; Minnesota; Robinson[37]	LD, others	Minnesota Department of Health	NA	**Database:** patient demographics

* LD, Lyme disease; "other(s)": anaplasmosis, ehrlichiosis, Rocky Mountain spotted fever, tick-borne encephalitis, tularemia

** no., number of; Accessory refers to additional case detection methods (e.g., physician survey, administrative claims database, laboratory database). Patient demographics (e.g., name, age, sex, location of residence, race/ethnicity); epidemiological information (e.g., illness onset date, number of tick bites, occupation, outdoor activities, travel history, clinical signs and symptoms); diagnostic test results (e.g., serology, polymerase chain reaction (PCR), culture, reporting date); and clinical data (e.g., clinical signs and symptoms, stage of disease).

Descriptive Analysis

Twenty-six studies used a centralized database for passive surveillance of case records (Table 2). While all data elements or variables for reportable disease databases were not fully described, these databases normally collected information on patient demographics (e.g., age, sex, location of residence), epidemiological information (e.g., illness onset date, case reporting date, tick bite history, travel history), diagnostic test results (e.g., serology, PCR, culture, reporting date) and clinical data (e.g., clinical signs and symptoms). Fifteen of 26 studies augmented case detection or epidemiological data using accessory methods. From the 26 studies that used a centralized database (i.e., mandatory reporting system), five studies augmented case detection and epidemiological data using administrative claims databases, followed by surveys directed at healthcare professionals (n = 3), laboratory databases (n = 3) and other methods (e.g., GIS pilot study of habitat, review of clinical records) (n = 3).

Administrative claims databases

Administrative claims databases provided additional data elements, including hospital inpatient and outpatient visits, length of hospital stay, co-morbidities and hospital discharge records. Surveys of healthcare professionals provided additional data on the number of patients treated for Lyme disease,

types of physicians making diagnoses, types of physician practices visited by potential Lyme disease patients, tick bite histories, number of patients treated prophylactically and types of antibiotics used to treat patients. Laboratory databases, in the studies reviewed, provided additional data on patient outdoor activities or occupation; history and numbers of tick bites; clinical signs and symptoms; types and numbers of diagnostic tests performed; and ethnicity. The use of an accessory method did not always mean that additional demographic, epidemiological, diagnostic or clinical data were collected, as in some cases similar data elements were collected to validate data collected by a reportable disease system.

Reportable disease databases

Reportable disease databases are the mainstay for countries and sub-country jurisdictions, where the collection of demographic, epidemiological and diagnostic data provides a spatiotemporal assessment of Lyme disease risk. Accessory methods were compared to reportable disease databases to validate completeness of data entry (England, Wales);[14] to evaluate the timeliness of mandatory reporting (Oklahoma);[32] to confirm incidence rates (Connecticut, Wisconsin);[13,15] to determine antibiotic use and clinical signs and symptoms (Maine);[33] and to determine extent of under-reporting (British Columbia, Connecticut, Maryland).[12,13,25] In terms of under-reporting, reportable disease systems captured 9% of cases in Maryland (1992–1993) (compared to estimated number of cases derived from accessory methods),[12] 10% of cases throughout the US (2008–2013),[3] 16% of cases in Connecticut (1992),[13] 32% of cases in Tennessee (2000–2009),[28] 34% of cases in Wisconsin (1992–1998)[15] and 65% of cases in British Columbia (1997–2008).[25]

Discussion

Administrative claims databases

Several jurisdictions augmented the mandatory reporting of cases using administrative claims databases, which are databases that collect information on patients that interact with the healthcare system (e.g., family practice offices, hospitals, long-term care facilities) for testing, diagnosis and treatment of Lyme disease in both government-funded (single-payer) and private healthcare settings. Potential Lyme disease cases are identified by syndromic- or pathogen-based analyses of medical codes indicative of Lyme disease, e.g., codes from the *Tenth Revision of the International Classification of Diseases* (ICD-10).[38 39] When administrative databases for a regional health network or a local medical practice are used, network-specific or laboratory-testing codes can be used to identify detect potential cases.[15]

Potential cases identified through an administrative database are then matched to cases in reportable disease or laboratory databases as per surveillance case definitions or positive diagnostic tests, respectively (e.g., confirmed, probable). Records are matched using personal identifiers (such as a health card number) that are common between the databases. In Ontario, available administrative databases include the Canadian Institute of Health Information's (CIHI) Discharge Abstract Database (which contains clinical and discharge records for hospitalized patients); the CIHI National Ambulatory Care Reporting System holds (data on emergency room visits, day surgeries and outpatient procedures); the Ontario Health Insurance Plan (data on physician claims for all procedures covered by the plan in Ontario, including family physician, emergency room and hospital stays); the Registered Persons Database (demographic data on anyone with a health card number); and the Ontario Drug Benefit Program (ODB, data on those ≥65 years old receiving medications).

The use of administrative databases has benefits to identifying cases; however, several limitations should be mentioned:

- Hospitalization with Lyme disease is uncommon, unless co-morbidities or underlying conditions lead to hospitalization; therefore, the CIHI Discharge Abstract Database may be of limited use to identify incident cases in otherwise healthy individuals.[33]
- While data from administrative claims can contain coding errors or omissions, in Ontario they are regarded as a reliable source of epidemiological information on patients.[40-43]
- Administrative data from the Ontario Health Insurance Plan, while useful in identifying cases, are not available on a real-time basis.
- In understanding Lyme disease treatment in Ontario, the ODB provides important information on treatment regimens for patients; however, the ODB is restricted to those aged over 65 years old, limiting the potential information.

Physician surveys

Physician surveys are an additional method to determine Lyme disease under-reporting and compliance with preventative, diagnostic and treatment guidelines. For example, physician surveys have been used to assess how closely physicians' criteria for clinical diagnoses of Lyme disease match criteria in surveillance case definitions, the types of physicians that diagnose Lyme disease (such as family physicians or dermatologists), the number of patients treated prophylactically (prior to or without definitive signs or symptoms or tick-bite histories) and the types of antibiotics used to treat patients.

Several caveats regarding physician survey data should be acknowledged.

- Estimates of total cases are based upon extrapolations from the proportion of physicians responding (59%-76% of all physicians).[12,13] In Maryland, surveys were sent to a random sample of 10% of the state's physicians. In Connecticut, 50% of all physicians received surveys; however, surveys only went to general practitioners, family physicians, pediatricians, internists or dermatologists.

- Researchers assumed non-respondents were no longer practicing medicine in Maryland or were not diagnosing Lyme disease; therefore, there was a bias towards physicians that were diagnosing Lyme disease.[12] When compared to the reportable disease database in Maryland, only 10% of the physician-diagnosed cases (self-reported) were matched to cases reported to the state; therefore, a large proportion of those not responding to the survey are indeed making Lyme disease diagnoses.

- Lyme disease in these surveys is considered a subjective assessment of both real and perceived cases of Lyme disease, based on clinical diagnoses only (i.e., patients treated for Lyme disease where the diagnosis was uncertain). Given the number of caveats associated with physician-directed surveys and the limitations of self-reported data, caution when interpreting the results of physician surveys is essential. While only two studies on the subject were reviewed, the studies that involved physician surveys did not provide evidence for their inclusion as a recommended method of augmenting reportable disease data.

Public health laboratory databases

Public health laboratories maintain databases to track diagnostic tests requested by healthcare providers. The databases collect overlapping demographic information as reportable disease systems, but normally provide more detailed information on the types of tests requested (e.g., serology, PCR, culture), respective test results and the dates that results were reported back to the healthcare provider. In many cases, laboratory databases are designed to support traditional reportable disease databases and operational requirements such as patient information (i.e. name, age, sex, and address), reporting of case results, tracking turnaround times, and monitoring performance characteristics of tests. As such, they are not designed to collect, or may not have the ability to describe, epidemiological

or clinical data. In Ontario, Lyme disease test requisitions specifically ask for clinical information, however, these data are not mandatory and are not fully provided on requisitions.

Systematic review limitations

This systematic review identified and assessed the methods used for Lyme disease surveillance; however, we must note several limitations. The review may be subject to language bias, due to the exclusion of non-English studies; however, we are not aware of any non-English studies on blacklegged tick surveillance in North America. Since we did not perform a search of the grey literature, our results may be biased towards positive results due to publication bias. Due to the heterogeneity of the settings where studies were performed, it was difficult to compare methods across studies.

Conclusions

This systematic review indicates reportable disease databases are the primary method for Lyme disease surveillance. Ontario's reportable disease database (iPHIS), as in most jurisdictions, will continue as the primary source of data for Lyme disease surveillance. Accessory databases collect additional demographic, epidemiological, diagnostic and clinical data that can provide improved estimates of Lyme disease incidence and the extent of under-reporting in mandatory disease reporting systems. In Ontario, the use of accessory databases can provide additional value to the core information provided by iPHIS and add to our understanding of the natural history of Lyme disease in the province. PHO will continue to compare and assess epidemiological data for Lyme disease cases identified through iPHIS and additional sources (i.e., administrative claims and laboratory databases).

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Appendix 1.

Quality assessment of human disease surveillance studies reviewed

Year*	First author	Assessment of relevancy	Assessment of reliability		Assessment of validity				Assessment of applicability
		[1] **Was the justification for the study clearly stated?** [2] **Does the study apply to the issue under consideration?** [3] **How similar or different is the study population or setting to yours? Is a difference likely to matter for the issue at hand?**	[1] **Is the rationale for study clearly stated, and does the study focus on a clearly defined issue?** [2] **Can the study be reproduced with the information provided?**	[3] **Are the research methodology and results clearly described?**	[1] **Is the research question congruent with the study design?**	[2] **Are the results consistent within the study; No major sources of bias?** [3] **Can chance findings be ruled out?**	[4] **Are the results conclusive?** [5] **Are the authors' conclusions clearly derived from the results?** [6] **Are potential discrepancies discussed?** [7] **Are limitations of work described?**	[8] **Are there any major methodological flaws that limit the validity of findings?**	[1] **Can the study results be interpreted and analyzed within the context of public health?**
1996	Coyle	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
1996	Meek	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2000	Smith	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2002	Naleway	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2003	Gardner	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2005	Mehnert	No	No	Yes	Yes	Yes	Yes/No	Yes/No	Yes
2006	Vrbova	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2007	Kudish	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2008	Bacon	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes

Year*	First author	Assessment of relevancy	Assessment of reliability		Assessment of validity				Assessment of applicability
		[1] **Was the justification for the study clearly stated?** [2] **Does the study apply to the issue under consideration?** [3] **How similar or different is the study population or setting to yours? Is a difference likely to matter for the issue at hand?**	[1] **Is the rationale for study clearly stated, and does the study focus on a clearly defined issue?** [2] **Can the study be reproduced with the information provided?**	[3] **Are the research methodology and results clearly described?**	[1] **Is the research question congruent with the study design?**	[2] **Are the results consistent within the study; No major sources of bias?** [3] **Can chance findings be ruled out?**	[4] **Are the results conclusive?** [5] **Are the authors' conclusions clearly derived from the results?** [6] **Are potential discrepancies discussed?** [7] **Are limitations of work described?**	[8] **Are there any major methodological flaws that limit the validity of findings?**	[1] **Can the study results be interpreted and analyzed within the context of public health?**
2008	Fulop	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2008	McHugh	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2008	Ogden	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2011	Bourre-Tessier	Yes	Yes	No	Yes/No	Yes	Yes	Yes	Yes
2011	Henry	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2012	Ertel	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2012	Jones	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2013	Altpeter	Yes	Yes	Yes/No	Yes	Yes	Yes	No	Yes
2013	Kuehn	Yes	No	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No	Yes
2013	Paradowska-Stankiewicz	Yes	Yes	Yes	Yes	Yes	Yes/No	No	Yes
2013	Zoldi	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2014	Hurt	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes

Year*	First author	Assessment of relevancy	Assessment of reliability		Assessment of validity				Assessment of applicability
		[1] **Was the justification for the study clearly stated?** [2] **Does the study apply to the issue under consideration?** [3] **How similar or different is the study population or setting to yours? Is a difference likely to matter for the issue at hand?**	[1] **Is the rationale for study clearly stated, and does the study focus on a clearly defined issue?** [2] **Can the study be reproduced with the information provided?**	[3] **Are the research methodology and results clearly described?**	[1] **Is the research question congruent with the study design?**	[2] **Are the results consistent within the study; No major sources of bias?** [3] **Can chance findings be ruled out?**	[4] **Are the results conclusive?** [5] **Are the authors' conclusions clearly derived from the results?** [6] **Are potential discrepancies discussed?** [7] **Are limitations of work described?**	[8] **Are there any major methodological flaws that limit the validity of findings?**	[1] **Can the study results be interpreted and analyzed within the context of public health?**
2014	Johnson	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2014	Robinson	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2014	Vandenesch	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2014	Wilking	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
2015	Robinson	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes

*Year study published

Public Health Ontario
480 University Avenue, Suite 300
Toronto, Ontario
M5G 1V2

647.260.7100
communications@oahpp.ca
www.publichealthontario.ca