Ticks and Tick-borne Diseases 9 (2018) 275–280

Contents lists available at ScienceDirect

Ticks and Tick-borne Diseases

journal homepage: www.elsevier.com/locate/ttbdis

Original article

Population-based *Borrelia burgdorferi* sensu lato seroprevalence and associated risk factors in Finland

Janko van Beek[a,b,*], Eeva Sajanti[c], Otto Helve[a], Jukka Ollgren[a], Mikko J. Virtanen[a], Harri Rissanen[d], Outi Lyytikäinen[a], Jukka Hytönen[c,e,1], Jussi Sane[a,1]

[a] Department of Health Security, National Institute for Health and Welfare, Helsinki, Finland
[b] European Programme for Public Health Microbiology Training (EUPHEM), European Centre for Disease Prevention and Control (ECDC), Stockholm, Sweden
[c] Institute of Biomedicine, University of Turku, Turku, Finland
[d] Department of Public Health Solutions, National Institute for Health and Welfare, Helsinki, Finland
[e] Microbiology and Genetics Department, Turku University Hospital, Turku, Finland

ARTICLE INFO

Keywords:
Borrelia burgdorferi
Lyme borreliosis
Seroprevalence
Risk factors
Finland

ABSTRACT

Lyme borreliosis (LB) is caused by *Borrelia burgdorferi* sensu lato (*Bb*-sl) and is the most common vector-borne disease in Europe. The objectives of this study were to determine the *Bb*-sl seroprevalence among the general Finnish adult population and to identify risk factors associated with *Bb*-sl-seropositive status. Two thousand sera from a nationwide health survey from 2011 were tested by whole-cell sonicate IgG ELISA, C6 peptide ELISA, and recomBead IgG 2.0 and test results were linked to a general health questionnaire. A multivariable logistic regression model was used to identify risk factors. The median age of the study population was 56 years (range 29–97) and the *Bb*-sl weighted seroprevalence was 3.9% (95% confidence interval (CI) 3.03–5.08). The weighted seroprevalence was significantly higher among males than females (adjusted odds ratio 1.91, 95%CI 1.21–3.04). The seroprevalence was highest in Southern, Central, and Eastern regions. The first *Bb*-sl seroprevalence study in Finland showed a seroprevalence of 3.9% (regional range 0.87%–6.12%). The results of this study can be used, together with previous data on LB incidence and spatial tick distribution, to target public health communication about preventive measures.

1. Introduction

Lyme borreliosis (LB) is the most common vector-borne disease in Europe mainly caused by the spirochetes *Borrelia* (*B.*) *burgdorferi* sensu stricto, *B. afzelii*, and *B. garinii* (Sykes and Makiello, 2017; Steere et al., 2016). The bacteria are transmitted to humans during blood feeding by a tick of the *Ixodes* genus of which *Ixodes ricinus* is most commonly distributed in Europe, while in Finland both *I. ricinus* and *I. persulcatus* (castor bean tick and taiga tick, respectively) are prevalent. The majority of LB cases present with erythema migrans (EM), an expanding red rash near the tick bite in an early phase of infection. Patients may develop a disseminated infection that includes neurological or cardiac manifestations at the early disseminated phase, and arthritis and acrodermatitis chronica atrophicans at the late phase (Stanek et al., 2012). The LB incidence and disease burden have generally increased during the last two decades and this is likely related to a higher abundance of the vector and due to a higher awareness among physicians (van den Wijngaard et al., 2015; Hofhuis et al., 2015; Fulop and Poggensee, 2008; Bennet et al., 2006). LB is a public health concern with a population-weighted average LB incidence estimated at 22.05 cases per 100 000 person-years in Western Europe, and with a geographical expansion towards higher altitudes and latitudes (Sykes and Makiello, 2017; Jaenson et al., 2012; Rizzoli et al., 2011). LB incidences vary greatly among countries likely depending on the abundance of borrelia infected ticks, level of awareness among physicians, and differences among surveillance systems. The reported estimates are most likely an underrepresentation of the total number of cases since LB is not a notifiable disease in most countries.

There is paucity of data regarding the epidemiology of LB in Finland since this topic has not been studied nationwide since 1988 (Schauman et al., 1989). The incidence of LB (EM and disseminated infection) was recently characterised by analysing different healthcare registries demonstrating that incidence has considerably increased over time and the geographical distribution has expanded (Sajanti et al., 2017). Two recent studies performed in Finland showed an increase in abundance of the vector *I. ricinus* in the Southwestern part of the country

* Corresponding author at: Department of Health Security, National Institute for Health and Welfare, Mannerheimintie 166, 00271, Helsinki, Finland.
E-mail address: johannes.vanbeek@thl.fi (J. van Beek).
[1] These authors equally contributed to this work.

https://doi.org/10.1016/j.ttbdis.2017.10.018
Received 14 June 2017; Received in revised form 26 October 2017; Accepted 31 October 2017
Available online 11 November 2017
1877-959X/

(Sormunen et al., 2016), and the expansion of the distribution area of borrelia-infected ticks up to the latitude 67° N in the southern border of Finnish Lapland (Laaksonen et al., 2017). This study aimed to estimate the *B. burgdorferi* sensu lato seroprevalence in a cross-sectional sample representative of the adult population in Finland to get an estimate of the disease prevalence among the general population and to get a better understanding of related risk factors to prioritise public health intervention measures.

2. Material and methods

2.1. Study specimens and questionnaire data

In brief, Health 2011 is a cross-sectional health survey that together with health examination and wide-ranging questionnaire data, includes sera, plasma, and DNA collected from approximately 4200 Finnish male and female participants aged ≥29 years living in Finland in 2011. The study used a stratified two-stage clustered sampling. Mainland Finland was first divided in 20 strata defined by the 15 largest towns and the remaining rural areas based on the five university hospital regions. 15 largest towns were selected and the remaining 65 health centres were selected from the rural strata thus having 80 stratum. Systematic sampling of people was performed so that the sample size in each stratum was proportional to the corresponding population base (Lundqvist and Mäki-Opas, 2016). Serum samples (n = 2000) were sampled for this study using simple random selection (each individual is chosen randomly and entirely by chance, such that each individual has the same probability of being selected) from the nationwide Health 2011 survey. For this study, demographic and other relevant variables were selected from the questionnaires. The Ethics Committee of the Hospital District of Helsinki and Uusimaa approved the Health 2011 Survey and all study participants signed an informed consent.

2.2. Serological test algorithm

All serum samples (n = 2000) were screened for IgG antibodies by in-house ELISA using borrelia whole-cell sonicate (WCS) as a coating antigen (Viljanen and Punnonen, 1989). This assay shows the results as arbitrary enzyme immunoassay units (EIU). Screening-positive samples (WCS IgG result ≥20 EIU) (n = 329) were further analyzed by C6 Lyme ELISA Kit (Immunetics, USA). Sera with positive or equivocal result in C6 Lyme ELISA, and sera with negative C6 Lyme ELISA and positive in WCS IgG ELISA (WCS IgG result ≥40 EIU), were further tested with *recom*Bead IgG 2.0 (Mikrogen, Germany) (n = 164) (Fig. 1).

2.3. Borrelia whole-cell sonicate IgG in-house ELISA

Microtiter plates (Thermo Fisher Scientific, USA) were coated overnight at 37 °C with whole cell antigen prepared from *B. burgdorferi* sensu stricto B31, ATCC 35210. After incubation, wells were washed

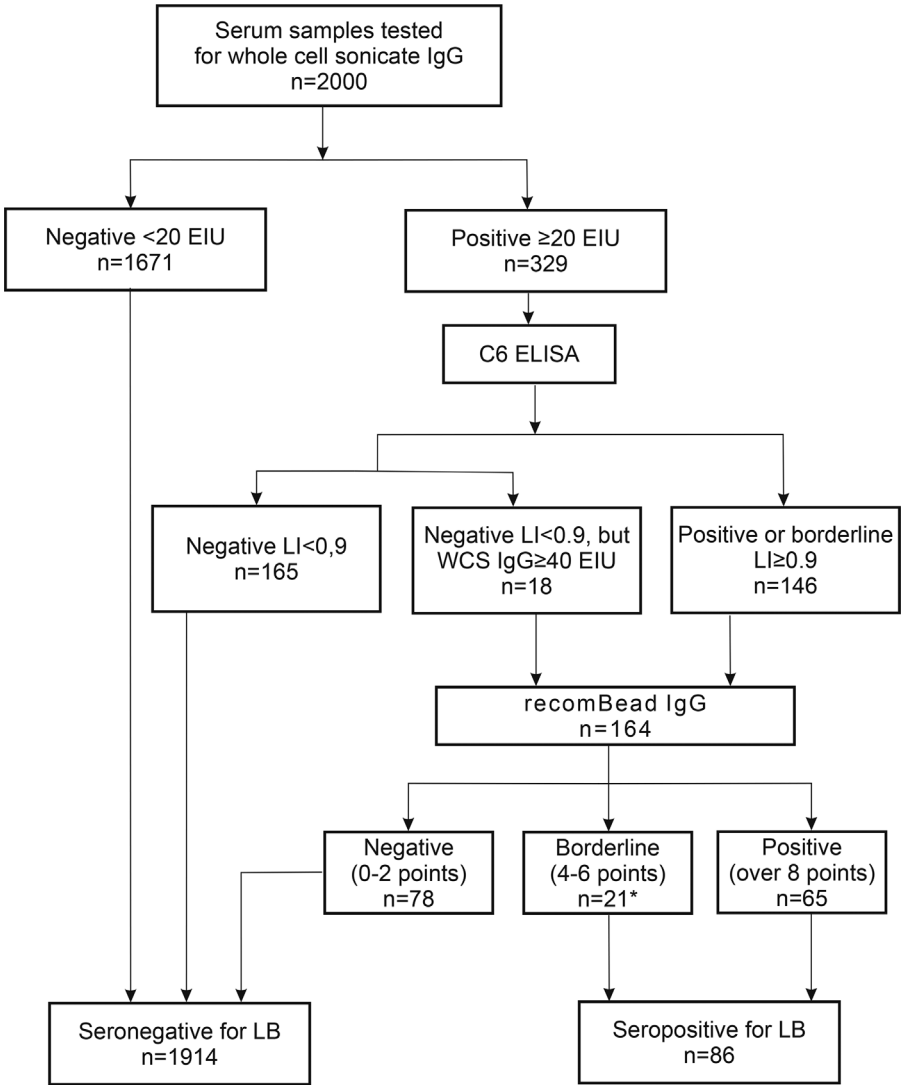

Fig. 1. Schematic overview diagnostic assay algorithm. *21 positive samples by whole cell sonicate IgG ELISA (≥20 EIU) and positive or equivocal/borderline by C6 Lyme ELISA Kit (LI ≥0.9) (Immunetics, Boston, MA, USA) were considered negative (4 points) or borderline result (5–6 points) by recomBead Borrelia IgG 2.0 (Mikrogen, Neuried, Germany) according to the interpretation criteria of the manufacturer. Antibodies were mainly against VlsE and/or p100 antigens. These samples were considered positive taken into account other test results (WCS IgG ELISA ≥20 EIU, C6 ELISA LI ≥0.9, and seroreactivity in recomBead IgG).