



Lyme borreliosis – state of the knowledge among medical students

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Abstract

Introduction and Objective. Lyme disease (LD) is becoming a serious problem worldwide. It is a bacterial infection caused by Gram-negative spirochaetes *Borrelia burgdorferi* sensu lato which are spread by tick bite, and are recognized as one of the most important tick-borne diseases. People spending time in the forests, meadows, and parks, or working in such environments are endangered to tick bites, which may cause the infection. Even though not each one of the parasites carries the disease, the illness itself is a serious condition and can simulate many other diseases, which is why it is often called 'the great imitator'. Therefore, it is very important to know the early symptoms of LD, as it can be cured effectively by antibiotics. The aim of this study was to determine whether young adults have sufficient knowledge regarding LD, how often tick bites occur within this population, and how many of them have been diagnosed with the illness in the past.

Materials and method. Data was collected with the use of a survey completed by 201 first-year medical students.

Results. The majority of the students had basic knowledge regarding the etiology, symptoms, and vectors of LD. There is a necessity to improve knowledge in the field of treatment, prophylaxis, and tick removal techniques. Half of the study participants had been bitten by a tick and some of them were diagnosed with LD.

Conclusions. Most of the participants reported a tick bite in the past, and/or confirmed an infection. The awareness level regarding the sickness needs to be improved in some aspects, with the use of social campaigns or advertisements. This would help with better recognition of the disease in the future.

Key words

Borrelia burgdorferi, borreliosis, ticks, *Borrelia*, vector-borne disease

INTRODUCTION

Lyme disease (LD) is a bacterial sickness caused by Gram-negative spirochaetes *Borrelia burgdorferi* sensu lato, which is now classified as a part of the genus *Borrelia* [1, 2]. The name of this bacterial disease comes from the town in Connecticut (USA), where David Snyderman and Allen Steere reported cases of a new disease, which manifested with such symptoms as oligoarthritis and skin rash [3]. Today, LD is recognized as one of the most important tick-borne diseases. It is vectored by hard ticks of *Ixodes* genus (*I. ricinus* in Europe, *I. persulcatus* in Asia, *I. scapularis* and *I. pacificus* in North America). Nowadays, many people seek refuge from the crowded cities in the forests, meadows and countryside, and thus they are at risk of being bitten by a tick. The illness itself is a serious condition and its symptoms can simulate many other diseases, which is why it is often called 'the great imitator' [4]. Non-specific symptoms can be observed which imitate benign conditions, like flu, to serious ones, affecting e.g. nervous system and joints, and can lead to major health damage, or be lethal in some cases [5–9].

Therefore it is very important to know the early symptoms of LD, as it can be cured effectively by antibiotics. It is also important to know the correct way of removing ticks from

the skin. Reusable tick removal tools are available in shops or pharmacies. Many people tend to marginalize tick bites as they are not aware of the diseases that can be spread by the parasites. Moreover, people often do not know how to properly remove a tick, and what to do after the bite.

The aim of this study was to determine whether first year medical students have a satisfactory level of knowledge regarding LD, and to assess whether there is a need to educate society about the disease. Another aim of this study was to investigate how many of the examined students have had some kind of contact with the disease, or with tick bites in the past.

MATERIALS AND METHOD

The studied group consisted of 201 first-year students from the Medical University in Lublin, eastern Poland, including 74 men and 137 women. Most of the participants were 19 or 20-years-old, but the overall age range of the examined group extended from 18–25 years old (on average 19.5). The data for the study was collected using the authorial survey, which was given to the students in April 2022.

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RESULTS

Participants. The respondents lived in various parts of Poland, i.e. in the regions recognized as endemic for tick-borne diseases: Lublin (46.70%), Masovian (19.30%) and Subcarpathian (14.20%) provinces. The studied group had at least one representative from every province, excluding Kuyavian-Pomeranian and Opole. Most of the respondents lived in cities with less than 100,000 habitants (33.30%), and some of them lived in larger cities, e.g. with 500,000 habitants (18.70%), or smaller towns with a population of less than 10,000 (20.70%). The majority of the students did not declare having a member of their family working in a job that entailed the risk of being bitten by a tick (60.50%). Other respondents stated that they do not spend much time in the forests, meadows or near lakes (51.50%), and some are members of the Polish Scouting and Guiding Association (10.50%), which is also a group at risk of tick-borne diseases.

Aetiology of the disease. At the beginning of the survey the respondents had to answer some basic questions about how one can be affected by LD:

- 95.50% of the answers concerned ticks as a vector of the disease; other responses included mosquitos (6.00%), pet animals (4.0%) and rodents (1.50%);
- most of the students stated that a bacteria is responsible for the disease (59%), while 23% believed that it is caused by a parasite, and 18% chose a virus;
- almost 90% respondents claimed that it was not possible to catch LD from another person (Figure 1, Figure 2).

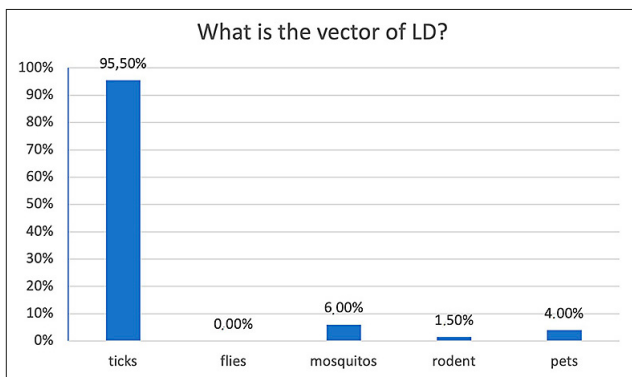


Figure 1. Survey response (part I)

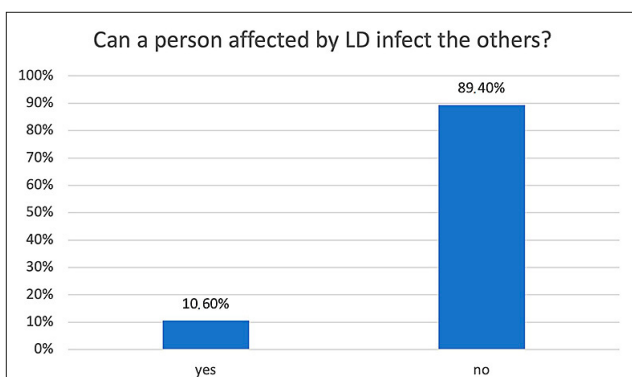


Figure 2. Survey response (part II)

An important question concerned the name of the disease. In Poland, 'Lyme disease' is used occasionally, but its Latin equivalent 'borreliosis' is significantly more popular. The following is the variety of answers about what LD is: only 27.30% of respondents claimed that it is in fact another name for borreliosis, while others stated that it is a type of the disease that affects the nervous system (31%), another name for tick-borne encephalitis (32.60%), or a type of borreliosis that affects animals (9.10%).

Symptoms of Lyme disease. The students were obligated to pick symptoms relevant to the sickness from a list. The percentage of the answers is presented in Figure 3.

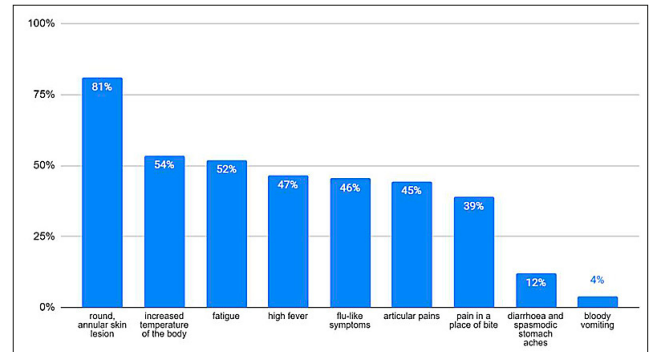


Figure 3. Signs and symptoms according to respondents

Most of the answers related to a skin lesion. Furthermore, according to the majority of the research group, the disappearance of the lesion did not mean that the disease had gone (96.40%). Equally, 82.90% of the respondents claimed that a primary cutaneous condition and the most characteristic skin lesion – erythema migrans (EM) – can never appear. However, knowledge regarding how it looks is distinct: an erythema transforming into a blister (19.50%), an erythema which transforms into an erosive skin (18%), or a red lesion that peels in the course of time (7.50%). The last question about the symptoms of LD concerned organs and systems that it can affect. The most frequently chosen one was the nervous system (88.10%), or the skin (65.80%), as well as osteoarticular (53%) and cardiovascular systems (45.50%). Only some of the students selected the gastric (12.40%) and genitourinary (5%) systems.

Prophylaxis. Some of the respondents affirms that there is an LD vaccine (42.60%). Hypothetically, the students were asked whether they would vaccinate themselves if they had the possibility – 88.40% answered positively.

Tick removal and post-exposure measures. The proper method for removing a tick has changed several times throughout years, and choosing which one to use can be confusing. The most frequently recurring answer to the question about the correct way to remove a tick was to wring it off the skin clockwise (58%). The other popular opinion (54%) was that a tick-removal device should be used, or to grab the tick's head, and using tweezers, remove it with a swift move (39%).

Another question concerned the connection between the risk of contracting LD and the amount of time a tick spends on the skin. Most respondents (66.80%) answered

that there is a higher risk of becoming sick if a tick is not removed quickly enough. The remaining question concerned the actions that should be taken after being bitten. More than half of the respondent (almost 60%) suggested that the removed tick should be secured and transported to a local veterinary in order to run a test for the presence LD. The second most popular opinion (26.20%) stated that the tick should be removed from the skin, the bite area should be cleaned using hydrogen peroxide, and then the skin should be observed in terms of EM appearance. The least popular option (14.80%) involved removing the tick and then taking antibiotics preventatively for 3 days.

Treatment. Most respondents knew that the disease can be treated if the therapy is started soon enough (72.40%). One percent of the students stated that the sickness retreats without any treatment. According to the responses, only 23.30% of the research group knows what medicine is used to cure LD (Figure 4).

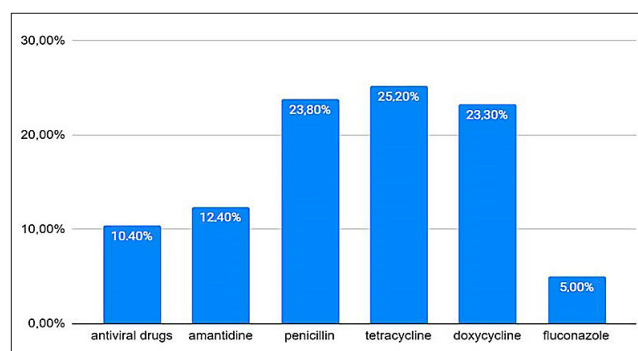


Figure 4. Treatment options according to respondents

Personal questions. The last part of the survey consisted of questions regarding whether the respondents or their family have had direct contact with Lyme disease or ticks in the past. About 52% of the students have ever been bitten by a tick; among them, about 14.40% have taken prophylactic antibiotics for some time. Moreover, 3.5% of the research group have been diagnosed with Lyme disease – 1% based on symptoms and a specific blood test, and 2.5% based only on symptoms. About 80% of the respondents have had somebody from their family bitten by a tick, and around 25% of whom were diagnosed with the condition.

DISCUSSION

Lyme disease is a major health problem that can affect each age group, and especially people living in green areas, which means in proximity to forests, lakes, meadows or parks. Both young adults, nearly 4% of the research group and their families, and 25% of the students have had a family member bitten in the past, and diagnosed with LD.

According to the studies of Sykes and Makiello, the weighted mean incidence rate of Lyme disease within the population of Western Europe is 22.05 cases per 100,000 persons/year [10]. In Eastern European countries this rate is even higher: Lithuania – 99.9 cases per 100,000 population in 2017 [11], Poland, the highest LD incidence rate in 2019 was registered in Podlaskie province – 107.7 cases per 100,000 population [12], and in Lublin province in 2017–2020 the average LD annual

incidence showed almost 95 cases per 100,000 population [13]. Poland's neighbour, the Czech Republic, noted around 45 cases per 100,000 population in 2016 [14]. In the USA, most cases are diagnosed in the northern states. The studies of Ginsberg et al. explains why such a phenomenon occurs in the USA, the reasons being a less-numerous population of ticks in the south, a tendency of multiple northern ticks to feast on the same animal, which increases the amount of reservoirs of the spirochaetes responsible for the disease, as well as the fact that the northern ticks tend to reside on leaves and branches, while the southern ticks – at ground level [15]. The incidence rate of LD is increasing annually, and according to the studies by Dykstra et al., in Washington state, throughout 2011–2016, there were almost twice as many cases of the disease [16]. In Finland, the rise of the cases 2014–2016 totalled from 44 per 100,000 population to 61 per 100,000 population [17]. The facts cited above show that it is important to have at least a basic knowledge about Lyme disease as it is becoming more and more present worldwide.

It is obvious that people living in the countryside are more at risk of contracting LD than living in the cities, although among the respondents of the current study who claimed to have had the disease in the past, only one had lived in a town with a population less than 10,000. This outcome correlates with the Lithuanian studies mentioned previously, where more cases were diagnosed in urban environments [11]. However, the studies of Brzozowska et al. shows that in 2008–2016, the number of cases of LD were similar in the cities and in the countryside [18]. This variance of results leaves room for a study to be conducted with same-sized research groups living in small towns and villages, as well as bigger cities.

Some of the respondents mentioned having a family member in a job-related at-risk group of having LD, including farmers, foresters, hunters and vets. Many of the students declared having a family member or a relative bitten by a tick, or even contracting LD. The studies by Acharya et al. revealed that about 8% of the foresters in South Korea have been diagnosed with seropositive LD [19]. According to the studies conducted by Pańczuk et al., about 63% of the examined foresters from eastern Poland had a positive outcome of an ELISA assay related with *B. burgdorferi* IgG antibodies, and 38% of the tests were confirmed using a Western-blot [20]. Furthermore, research conducted in eastern Slovakia by Zakutna et al. showed that in a group of 277 countryside workers, about 25% tested positive with the related IgG antibodies [21].

The majority of the respondents showed a basic knowledge about Lyme disease. Information about the type of vector (ticks) or pathognomonic signs of the sickness (erythema migrans), were known to most of the students. There are speculations whether one can be infected with *B. burgdorferi* only due to a tick bite. Some research indicates speculations about other methods of transmission; Middelveen et al., suggest the presence of the same type *Borrelia* spirochaetes in human vaginal and seminal secretions, but further research is needed to confirm this thesis [22].

B. burgdorferi sensu lato (s.l.) is a microaerophilic bacteria belonging to the Spirochete phylum. The *B. burgdorferi* s.l. complex covers around 20 known genospecies, such as *B. bavariensis*, *B. spielmanii*, *B. garinii*, *B. afzelii* and *B. burgdorferi* sensu stricto (s.s.) [23]. In Europe, most LD

cases are caused by *B. afzelii* and *B. garinii*, and in the USA by *B. burgdorferi* s.s. [24]. The latter possesses many virulence factors, such as OspE, OspA, OspC or CspA lipoproteins, which allow it to bind the complement system, and thus avoid human immunological response [25]. In the current study, some of the respondents did not know that the pathogen responsible for borreliosis is a bacteria. They also did not know that the disappearance of the lesion did not mean that the illness had been cured. It is important to know that in some cases Lyme disease erupts without any skin lesion. According to *Enkelmann et al.*, in 94% cases of LD in Germany in 2013 – 2017, erythema migrans was the only sign of the infection [26]. In the USA, the rate of skin lesion related to LD amounted to about 80% [27].

Clinical tests are being conducted to develop an LD vaccine. In the 1990s, two companies produced vaccines, and sought the approval of the US Food and Drugs Administration (FDA) for their public use. The vaccines were based on the earlier-mentioned OspA lipoprotein, which caused its inactivation, and preventing the bacteria from spreading from ticks to humans. The two vaccines were clinically tested, but only one – LYMERix – was eventually approved by the FDA. However, it was withdrawn from the market a few years later because of low demand, and complaints by some vaccine recipients about their health after vaccination, and because of lack of knowledge regarding possible long-term complications [28].

In the current study, knowledge about whether an LD vaccine is available, was uneven. This confusion might result from the fact that very often young people do not remember the reason for being vaccinated in the past. The research to develop an effective, well-tested LD vaccine is continuing, and such a vaccine is crucial for reducing the number of borreliosis cases worldwide. The best-yet candidate seems to be the VLA15 vaccine [29]. It is worth underlining that in order to mitigate the spread of the sickness people should also undertake actions that will reduce the number of ticks residing near their households, such as using tick repellents, or keeping the grass on lawns short [30].

The respondents selected various symptoms that could occur in LD, which is the correct approach as the sickness can manifest with many different signs and symptoms. The most commonly selected symptom was ‘the bull’s eye’ – another name for EM, the clinical manifestation that appears the most often [27]. Other popular choices were fatigue, high body temperature, fever, flu-like symptoms and articular pains. The study by *Rogerson et al.* shows that within a group of examined patients with LD, fatigue, muscle and back pain were the most often occurring symptoms of the illness [31].

It is worth mentioning that in the current study, some respondents mentioned gastrointestinal symptoms, such as bloody vomiting and diarrhoea, as being symptoms of LD. Although these symptoms are rare, they sometimes can occur, but not in Europe. *Zaidi and Singer* speculate that gastrointestinal signs such as anorexia, nausea, vomiting, diarrhoea, hepato- and splenomegaly, can be present in the early stage of disease [32]. Another study, conducted by *Baig et al.*, shows that in very rare cases, the sickness can manifest itself with hyperbilirubinaemia [33].

It is important to remember that there are some differences between symptoms of borreliosis in populations in the USA and European patients. For example, Lyme disease-associated

arthritis seems to occur more commonly in the USA, while some skin conditions that might be present in European populations, such as acrodermatitis chronica atrophicans (ACA), have not yet been diagnosed in American patients [24].

Neuroborreliosis is diagnosed in Lyme disease patients evincing neurological symptoms. Some studies show that early neurological symptoms, such as facial nerve palsy, may be present in 10–15% of cases [34]. According to *Raurer et al.*, within the adult population the most common symptom is polyradiculitis, but there may also be manifestations of Bannwarth syndrome, polyneuropathy, or even stroke [35]. In some cases, neuroborreliosis may lead to life-threatening conditions, owing to the occurrence of complications such as diaphragm paresis [36]. An interesting symptom of the illness is vertigo. Although it is present very often in elderly, it cannot be ignored as a symptom, as it can also indicate that the LD has spread to the nervous system. In studies by *Sowula et al.*, vertigo was presented by 76% of the examined LD patients [37]. In the current study, the students responded that the systems or organs most often affected by disease are the nervous system, skin, and the osteoarticular and cardiovascular systems. It is worth mentioning that Lyme disease can also affect mental health. *Hündersen et al.*, proved that compared to their control group, people with borreliosis complained about a worse quality of life, sleeping problems, lack of concentration and signs of depression [38].

Another possible complication of LD is Lyme carditis, which usually manifests with electrical conduction blocks in the heart, especially atrioventricular blocks (of any degree). Patients with this condition can manifest such symptoms as shortness of breath, palpitations or chest pains [39]. According to *Paim et al.*, about 4–10% of the patients who did not treat Lyme disease developed endocarditis [40]. In rare cases, Lyme carditis causes sudden cardiac death or myocardial infarction [41].

There are multiple ways to remove a tick from the skin. The life cycle of a tick consists of three phases: larva, nymph and adult tick. People can contract LD from an infected nymph, which is small, or an adult, which is normally bigger [3] and therefore easier to remove. Nowadays, there are special tick-removal devices available in pharmacies, which make easy the procedure for the removal of both tick forms, as it has different parts designated to get rid of various forms of the parasite. The other correct removal technique involves grabbing a tick with tweezers just around its neck, and quickly pulling it out of the skin. If one cannot remove the Ixodes by itself, a doctor should help with the procedure. The study of *Şahin et al.* shows that about 77% of the bitten patients had their tick removed by healthcare workers [42]. In the current study, the respondents usually stated that the correct technique for tick-removal was to wring it off the skin clockwise. However, this method is no longer advised by the Centre for Disease Control and Prevention (CDC) as it provokes the tick, which can vomit into the blood of the host, releasing infectious agents. Also, while twisting the tick, parts of it can be ripped of the whole body and remain in the bite site. It is advisable not to remove ticks using the fingers, and not applying any kind of oil. After removal, the skin should be sanitised and then observed for about 4 weeks [43]. The most popular answer regarding dealing with the tick after removing it was to take it to a vet to test whether or not it is a bacterial reservoir. The latest CDC Lyme disease

guidelines do not encourage patients to test the ticks that bit them, as the test result may be misleading. If the test proves positive, patients often ask the doctor to prescribe antibiotics because they fear that they might be infected with LD. This treatment is not advised because the transmission of the spirochete normally happens within 48 hours after the bite, but it is also possible to happen after 24 hours, as stated in the guidelines by The French Scientific Society [43]. Some studies maintain that the probability of the pathogens' transmission after 48 hours is about 10%, while after 72 hours – 70% [44]. According to the CDC guidelines, the only reason to take antibiotic prophylaxis after a bite is living in an LD endemic region. The majority of respondents in the current study answered that there is a connection between the length of time that ticks spend in the skin, and the likelihood of being infected with Lyme disease.

The currently-endorsed CDC recommendations regarding the diagnosis of Lyme disease are made based on symptoms and serologic tests. If a patient is diagnosed with EM and lives in an LD endemic region, the diagnosis of LD can be made without serologic confirmation. In other cases, the golden standard of the serological tests is the standard 2-tier testing algorithm (STTT), which consists of immunoassay detecting the *B. burgdorferi* antibodies, e.g. ELISA test and Western Blot confirmation of the outcome of the first test. Another possibility is a modified 2-tiered testing (MTTT), consisting of 2 immunoassay tests, with the second one using another type of *Borrelia* antigens [45]. It is advised that the erythema migrans itself should be treated, without the serological confirmation of the disease. The positive test result is not sufficient to diagnose LD. According to Waddell et al., less than 12% of the tests conducted in the USA truly correlated with the illness [46]. This shows that there is still a need to improve specificity of the tests, and thus an LD diagnosis should not be made in patients with a positive serologic test, but without any clinical symptoms. A tendency of under-detection of the illness can also be observed, which can result in the morbidity rates being miscalculated. Lloyd et al. show that there is such a phenomenon in Canada, resulting from many factors, e.g. non-reporting of the disease by patients, false negative outcomes of the serologic tests, or not including the possibility of Lyme disease in the differential diagnosis [47]. In the current study, among a total 7 students diagnosed with the sickness, only 2 had their diagnosis determined with the use of serology.

The treatment of LD depends on its symptoms. The Guidelines of the Infectious Diseases Society of America, American Academy of Neurology, and American College of Rheumatology, issued in 2020, suggest that EM should be treated by a 10-day oral intake of doxycycline, or a 14-day intake of cefuroxime or amoxicillin. The neurologic manifestations of LD should be treated with intravenous ceftriaxone/cefotaxime/penicillin G, or a 14 – 21-day oral intake of doxycycline. Patients hospitalised with Lyme carditis should receive intravenous ceftriaxone therapy, with a duration of 14–21 days, whilst other patients can be treated with the same-duration of oral intake doxycycline/amoxicillin/cefuroxime/azithromycin [48].

However, in the current study, about 26% of respondents claimed that Lyme disease cannot be treated. Multiple medicines were also selected regarding treatment of the illness, which indicates that young adults lack knowledge in the field of treating borreliosis.

General practitioners should be aware of the spread of LD and its non-specific symptoms ('the great imitator') which can often be misleading in the course of diagnosis. The fact that patients sometimes do not remember being bitten by a tick also handicaps making of the diagnosis. In the earlier mentioned study of Hündersen et al., about 74% of patients recalled a tick bite that could have caused LD [38]. In the current study, 57% of the students diagnosed with the disease remembered being bitten, and 52.50% claimed to have been bitten by a tick in the past. A similar result was obtained by Pańczuk et al., with 57.6% of the examined students having been bitten [49]. In addition, about 80% of the respondents had family members who had been bitten by a tick, which shows that tick bites are common amongst adults.

CONCLUSIONS

The majority of the people living in LD-endemic regions, at some time in their lives will have to deal with tick bite(s). The outcome can be very different because sometimes such an encounter can result in serious physical and mental health complications. It is therefore very important to have at least some basic knowledge regarding ticks and tick-borne diseases, such as LD. The conducted research shows that first-year medical students must improve their knowledge regarding LD which is a major health problem. The results show that there should be more social campaigns, advertisements, or school happenings, in order to raise social awareness regarding the ever-increasing problem of LD.

In order to reduce the risk of bite, people should also use more protective measures, such as repellents or clothing, and should check themselves after forest or meadow trips. There is a space for further studies which should cover other aged, or at-risk groups, such as foresters, farmers or hunters, who are especially in danger of tick bite.

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