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Risk of tick-borne diseases in various categories of employment among forestry workers in eastern Poland

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Abstract

Among the zoonotic agents causing occupational diseases, those transmitted by ticks are very important, in particular the spirochetes *Borrelia burgdorferi* which are the common cause of occupational Lyme borreliosis in forestry and agricultural workers. The objective of this study was an evaluation of the exposure of forestry workers employed at individual workplaces to infection with tick-borne pathogens (especially *Borrelia burgdorferi* spirochetes), based on epidemiological investigation and serologic tests. Epidemiological studies covered 111 forestry employees from eastern Poland employed in 4 randomly-selected forest inspectorates which replied to questions in the area of epidemiology and prophylaxis of diseases transmitted by ticks. Eighty-two forestry workers employed in one forest inspectorate were examined for the presence of specific anti-*Borrelia burgdorferi* antibodies. The correlation between individual items of the questionnaire was assessed by Spearman's test. Results of serological tests were assessed by Mann-Whitney test. Statistical analysis of the results indicated that the workers performing manual jobs in the forest are at the greatest risk of tick bite and contraction of tick-borne disease. They are aware of the risk, but use the improper method of removal of ticks with the fingers. Comparisons of the relationship between job category and the results of serologic study, expressed in BBU/ml, revealed that the serologic response was significantly greater in manual workers than in administrative workers (p=0.019). All other comparisons did not produce significant results. Therefore, providing a simple tweezer-like device to forest inspectorates seems to be an effective mean of protection against Lyme borreliosis and other tick-borne diseases.

Key worlds

forestry workers, categories of employment, tick-transmitted diseases, borreliosis, epidemiological inquiry, serology, prophylaxis

INTRODUCTION

Diseases transmitted by ticks, called transmissive diseases, occur as natural foci and their range is equivalent to the geographical spread of certain species of ticks [1, 2, 3, 4, 5, 6, 7, 8].

In Europe, the main vector of pathogenic microorganisms causing contagious diseases is a common tick – *Ixodes ricinus,* which occurs widely in deciduous and mixed forests (more rarely in coniferous forests), also in municipal parks, on lawns and allotment gardens [1, 6, 9, 10, 11, 12, 13, 14].

Among the zoonotic agents causing occupational diseases, those transmitted by ticks, are very important, in particular the spirochetes *Borrelia burgdorferi* (*B. burgdorferi*) which are the common cause of occupational Lyme borreliosis in forestry and agricultural workers [3, 15, 16, 17, 18, 19, 20].

Among diseases transmitted by ticks, borreliosis (Lyme disease) is especially dangerous. At present, it is the most frequent occupational disease registered in Poland [21]. In 2009, a total number of 3,146 occupational diseases were registered in Poland, including 888 cases of contagious diseases, among which borreliosis – 664 cases – constituted 74.8% [21].

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OBJECTIVE

Taking into account the high risk of tick-transmitted pathogens infection in forestry workers, the objective of this study was evaluation of the exposure of forestry workers employed at individual workplaces to infection with tick-borne pathogens (especially *Borrelia burgdorferi* spirochetes), based on epidemiological investigation and serologic tests.

MATERIALS AND METHODS

Epidemiological studies. These studies covered 111 forestry employees (employed in 4 randomly-selected forest inspectorates subordinated to the Regional Board for National Forests in Lublin, eastern Poland, and in one forestry service enterprise), who provided replies to questions concerning epidemiology and prophylaxis of diseases transmitted by ticks (Appendix).

While elaborating the results of the examinations of forestry employees, the workplaces were divided into the following 3 categories of employment:

Category I – manual workers at workplaces: forest worker, lumberjack/saw operator (21 employees, 18.9% of respondents).

Category II – employees of forest service, performing mainly field work at workplaces: sub-forester, forester, supervisor, driver, owner of forestry service enterprise (63 employees, 56.8% of respondents).

Category III – employees of forestry service and administration, performing mainly office tasks at workplaces: forest inspector, deputy forest inspector, senior officer, specialist for the matters of forest protection, fire protection specialist, manager of business group, specialist for the matters of OSH, and work tasks coordinator (27 employees, i.e. 24.3% of respondents).

Serological examinations. Eighty-two forestry workers (14 workers in administration, 39 employees of forest service, and 29 manual workers) employed in one randomly-selected forest inspectorate were examined for the presence of specific IgM and IgG anti-*Borrelia burgdorferi* antibodies by the commercial immunoenzymatic test ELISA, according to the manufacturer's instructions.

Statistical methods. Correlation between individual items of the questionnaire was assessed by Spearman's test. Results of serological tests were assessed by Mann-Whitney test.

RESULTS

Results of epidemiological studies. Most of examined workers (56.8%) belonged to the middle job category (II): foresters, inspectors, and other educated workers performing their work mainly in the forest. The other workers belonged to the high (III) category, performing their work mainly in the office, and to a low (I) category, performing physical work in the forest. Most of the workers had been employed for more than 10 years in forestry, and a half of them spent over 6 hours each day in the forest (Tab. 1).

The majority of the examined workers reported a high probability of tick attack during work in the forest and the frequent presence of ticks on their body, usually 1-3 ticks. Most of the workers (65.1%) checked their body for the presence of ticks after return from their work shift in the forest. The majority of workers frequently removed attached ticks from the body, and nearly all of them believed they did so properly. However, although a half of the workers removed ticks with the use of tweezers or special hooks, a large proportion of them (43.6%) removed the ticks improperly – with fingers (Tab. 1).

Table 1. Response of forest exploitation workers to the questionnaire: frequency of answers to individual questions (see Appendix)

Question No.	Choice (No.,%)		
	a	b	c
N=111	25 (22.5%)	12 (10.8%)	74 (66.7%)
N=110	18 (16.4%)	37 (33.6%)	55 (50.0%)
N=111	17 (15.3%)	17 (15.3%)	77 (69.4%)
N=111	6 (5.4%)	43 (38.7%)	62 (55.9%)
N=97	90 (92.8%)	5 (5.1%)	2 (2.1%)
N=109	3 (2.8%)	35 (32.1%)	71 (65.1%)
N=111	2 (1.8%)	1 (0.9%)	108 (97.3%)
N=110	4 (3.6%)	32 (29.1%)	74 (67.3%)
N=110	48 (43.6%)	55 (50.0%)	7 (6.4%)
N=109	64 (58.7%)	45 (41.3%)	Not applied
N=98	56 (57.1%)	25 (25.5%)	17 (17.4%)
N=110	7 (6.4%)	46 (41.8%)	57 (51.8%)
N=111	30 (27.0%)	31 (27.9%)	50 (45.1%)
N=111	68 (61.3%)	39 (35.1%)	4 (3.6%)
N=111	27 (24.3%)	63 (56.8%)	21 (18.9%)

N – No. of examined workers.

A large proportion of workers (41.3%) had borreliosis diagnosed by doctors or were suspected to have this disease. The majority of workers (51.8%) always used repellents when working in the forest, but a large proportion of them (41.8%) did so only sporadically. Most of the workers perceived specially designed protective clothing and popular publications as important elements for prevention of tick-borne diseases. A large proportion of the examined workers knew the names of the microorganisms, other than those causing borreliosis, which may cause an occupational, tick-borne disease.

As seen in the Table 2, wood-cutters and other workers in the low job category spend daily most of their time in the forest ($p<0.001$) and are aware of the greatest risk to tick bite. Workers of this group also frequently noticed ticks on their bodies ($p<0.01$), checked the body for the presence of ticks after return from the forest more frequently than the others ($p<0.05$), and used repellents more frequently than the other workers. The workers identified themselves as mostly exposed to tick bite, frequently removed the ticks from their body ($p<0.01$), but did so mostly with the fingers ($p<0.05$), which may not assure avoidance of the risk of transmitting microbial pathogens. Workers with the diagnosis or suspicion of borreliosis had a longer job duration ($p<0.05$), noticed ticks more frequently than the others ($p<0.01$), and had proper ideas about removing ticks removing, and health education ($p<0.05$). The use of repellents by the workers was positively related to finding ticks on the body ($p<0.001$), checking the body after return from the forest ($p<0.01$), frequent removal of the ticks from the body ($p<0.01$), self-reporting great exposure to ticks ($p<0.05$), reporting of large number of ticks on the body ($p<0.05$), and knowledge of the pathogens transmitted by ticks ($p<0.05$). A negative correlation was found between the use of repellents and job duration ($p<0.05$) (Tab. 2).

Serologic study. The median values of BBU (Biomedica Borrelia Units) per ml in the groups of the administrative workers, employees of the forest service and manual workers were, respectively, 2.0, 4.0 and 5.0 for IgM antibodies and 2.0, 2.0, and 2.0 for IgG antibodies. The frequencies of positive results (≥11 BBU/ml) were, respectively, 0, 15.4%, and 19.2% for IgM antibodies, and 21.4%, 41.0%, and 31.0 for IgG antibodies.

Comparisons of the relationship between job category and results of serologic study expressed in BBU/ml revealed that the serologic response was significantly greater in manual workers than in administrative workers ($p=0.019$). All other comparisons did not produce significant results.

DISCUSSION

The presented study shows that the group most exposed to tick bite are employees of the lowest grade: forest workers (manual workers).

The results of the questionnaire study clearly indicate that the wood-cutters and other workers of low job category are at the greatest risk of tick-bite and transmission of tick-borne pathogens. They are aware of the exposure, which is

Table 2. Response of forest exploitation workers to the questionnaire: Correlation between the answers to individual questions (1-15) (Spearman's test)

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1		(-) p=0.126	(-) p=0.859	(-) p=0.919	(-) p=0.670	(-) p=0.785	(-) p=0.568	(-) p=0.886	(-) p=0.324	+ p=0.0365	(-) p=0.259	+* p=0.043	(-) p=0.176	(-) p=0.324	(-) p=0.522
2			+++ p<0.00001	(-) p=0.058	(-) p=0.731	(-) 0.633	(-) p=0.510	(-) p=0.903	(-) p=0.367	(-) p=0.073	(-) p=0.432	(-) 0.701	(-) p=0.488	(-) p=0.881	+++ p<0.0001
3				+++ p<0.00001	(-) p=0.374	(-) p=0.767	(-) p=0.672	++ p=0.0048	+* p=0.018	(-) p=0.105	(-) p=0.919	+ p=0.0125	(-) p=0.434	(-) p=0.456	+++ p<0.0001
4					(-) p=0.308	+ p=0.0167	(-) p=0.136	+++ p<0.00001	+* p=0.039	++ p=0.006	(-) p=0.838	+++ p=0.00038	(-) p=0.100	(-) p=0.262	++ p=0.005
5						(-) p=0.054	+* p=0.022	(-) p=0.419	+* p=0.014	(-) p=0.125	(-) p=0.579	+ p=0.025	(-) p=0.393	(-) p=0.826	(-) p=0.154
6							(-) p=0.560	(-) p=0.258	(-) p=0.937	(-) p=0.216	(-) p=0.860	++ p=0.00147	(-) p=0.211	(-) p=0.961	+ 0.026
7								+++ p=0.00046	+ p=0.0254	(-) p=0.721	(-) p=0.379	(-) p=0.636	+ p=0.024	(-) p=0.537	(-) p=0.347
8									(-) p=0.128	(-) p=0.056	(-) p=0.737	++ p=0.0084	(-) p=0.291	(-) p=0.291	(-) p=0.473
9										+ p=0.0125	(-) p=0.170	(-) p=0.826	(-) p=0.713	(-) p=0.108	+* p=0.0187
10											+ p=0,032	(-) p=0.696	(-) p=0.418	(-) p=0.448	(-) p=0.672
11												(-) p=0.128	(-) p=0.055	(-) p=0.059	(-) p=0.164
12													+ p=0.0422	(-) p=0.982	+ p=0.0457
13														(-) p=0.270	(-) p=0.0632
14															(-) p=0.304
15															

(-) – lack of significant correlation; + – p<0.05, correlation positive; +* – p<0.05, correlation negative; ++ – p<0.01, correlation positive; +++ – p<0.001, correlation positive.

indicated by self-reported risk, significantly greater than in the other groups of the workers, as well as by a significantly greater inspection of the body after return from the forest, and by a significantly greater use of repellents. However, the results of the interview show that they remove ticks with the fingers, which may not assure full protection. Therefore, providing the forest administration units a sufficient amount of tweezers or special hacks for tick removal, accessible on the market, would certainly increase the protection of the forest exploitation workers against work-related tick-borne diseases.

According to Roupkarias et al. and Shen et al., no technique will completely remove every tick; and there is no appropriate or absolutely effective and/or safe tick removal technique. Regardless of the tick removal technique used, persons who have undergone tick removal should be monitored for up to 30 days for signs and symptoms [22, 23].

Piesman and Dolan showed that the removal of *Ixodes scapularis* nymphal ticks from humans with forceps via gentle pressure (26% transmission *Borrelia* spirochetes) or crushing the tick (30% transmission) caused a significant decrease in transmission, compared with the sham control (70% transmission). These authors also proved that the degree of protection provided via tick removal decreased steadily up to 60 h after attachment; between 60 – 66 h, a dramatic falloff in protection occurred to the point where no protection was observed at 66 h against nymphal stage of *Ixodes scapularis* tick [24].

Studies concerning the methods of preventing tick-borne diseases among individuals from the group at occupational risk were conducted in several scientific Polish and international centres. Connally et al, on the basis of a questionnaire research conducted among humans with Lyme disease from the state of Connecticut in the USA, suggest that practical activities, such as checking tor ticks and bathing after spending time in the yard, may reduce the risk of Lyme disease [25]. The research by Bartosik et al. on prevention of tick bites and protection of tick-borne diseases, which covered 300 inhabitants of south-eastern Poland, indicated that according to the questionnaire survey the most frequently applied method of prevention was the application of a repellent (38% of respondents). Apart from this, these researchers confirmed that individuals occupationally exposed to tick bites did not possess knowledge concerning the consequences resulting from contact with these arthropods. The authors also concluded that in contrast to individuals from rural areas, a relatively low percentage of urban inhabitants used simple methods for protecting themselves against tick bites (45% vs. 22%, respectively) [26]. In the study conducted by Adamek et al. among forestry employees, the percentage of respondents applying repellents and wearing proper clothing was less than 30% [27]. Zielińska-Jankiewicz and Kozajda evaluated knowledge concerning biological occupational hazards (BOH) among medical staff, forestry employees, and administration staff, and found that the workers employed in forestry possessed the highest level of

knowledge concerning these hazards [28]. Also, Kozajda et al. observed that the workers engaged in forest exploitation could protect their health against biological occupational hazards; however, the scope of their knowledge of the risk associated with BOH was low [29]. Own studies conducted in 2010 among 157 employees of forest exploitation indicated that the vast majority of respondents (87.3%) possessed basic knowledge concerning tick-borne diseases. The most frequent prophylactic actions were: prophylactic health check-ups (over 90%) and application of repellents on the skin (75%). In their answers, the respondents suggested a higher frequency of prophylactic examinations (37%), as well as the publication of educational materials and organization of educational meetings [30]. Thorin et al., in a survey of nearly 3,000 people of the group at risk, i.e. forestry workers from the areas of eastern France, confirmed the necessity to undertake actions associated with the dissemination of information concerning tick-borne diseases in this occupational group [19]. According to Patey, at present, the most effective prophylactic methods protecting against infection with *Borrelia burgdorferi* are as follows: protective clothes, application of repellents, checking body surface and removal of ticks after return from endemic areas, and if tick bites has occurred, observation of the site of bite for nearest weeks in order to begin therapy in the case of occurrence of erythema migrans [31].

In the USA, Eisen et al., while developing the principles for strategies and control concerning the improvement of borreliosis prophylaxis, tried to provide an answer to the question of how habitat diversity and forest fragmentation impacts acarological risk of exposure to *B. Burgdorferi,* and the ability of interventions to reduce risk. These authors refined knowledge of how human behaviour influences Lyme disease risk, and identified barriers for the adoption of personal protective measures and environmental tick management [32].

In the reports in the field of public health, the necessity is emphasized for the production and application of an effective vaccine against borreliosis which would be effective for humans [8, 23, 33]. The cited authors concluded that due to lack of an effective vaccine against borreliosis, at present, the methods of quick and correct removal of ticks from the body surface play a crucial role in the prophylaxis of this disease. According to Shen et al, current Lyme disease prevention efforts focus on a combination of methods and approaches, including area acaricides, landscape management, host-target interventions, management of deer populations, and personal protective measures, such as the use of insect repellents and tick checks. Although these methods are generally safe and relatively inexpensive, an effective human Lyme disease vaccine that has been adequately evaluated in the highest risk population groups could be very beneficial in preventing Lyme disease [23]. Piesman and Hojgaard evaluated a prophylactic antibiotic treatment of tick bite for Lyme disease prevention on the base of an animal model, and stated that such a treatment is more likely to be efficient if delivered promptly after potentially infectious ticks are removed from patients. They also concluded that there was only a very narrow window for prophylactic treatment to be effective for post-tick removal [34].

The results concerning the prevalence of specific anti-*Borrelia burgdorferi* antibodies obtained in the presented study was comparable with the results shown by other European authors [16-18, 20, 35]. The seroprevalence rates of antibodies to *B. burgdorferi* sensu lato in southwest German forestry workers ranged from 18%-52%, and in forestry rangers from northeastern Italy this percentage amounted 23.2% [17, 20]. The seropositivity in Italian forestry workers was associated with a history of yearly tick bites [20]. The seroepidemiological study of Buczek et al, carried out among forestry workers in southern Poland proved that in the studied region, considered to be non-endemic, borreliosis occurs as a health risk to forestry workers [15]. Bartosik et al, justifie the necessity of environmental monitoring of the threats posed by ticks in various habitats, especially in those frequently visited by humans [36,37,38].

CONCLUSION

In conclusion, the workers performing manual jobs in the forest are at the greatest risk of tick bite and contraction of tick-borne disease. They are aware of the risk, but use the improper method of removal ticks with the fingers. Therefore providing a simple tweezer-like device to forest inspectorate seems to be an effective means of protection against Lyme borreliosis and other tick-borne diseases.

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Appendix
Questions for forest exploitation workers concerning risk to tick-borne diseases

1. How long are you working in this forest district on the position (fill).....?
a) 1-5 years b) 6-10 years c) over 10 years

2. How many time do you spend in the forest during one work shift?
a) 1-3 hours b) 4-6 hours c) over 6 hours

3. Do you regard that on your position are you exposed to tick attack more than the people working on other positions?
a) no b) difficult to assess c) yes

4. Do you notice ticks on your body during performing work in the forest?
a) no b) yes, sporadically c) yes, frequently

5. If the answer is ”yes” how many ticks do you notice on your body during one work shift?
a). 1-3 ticks b) 4-6 ticks c) more than 6 ticks

6. Do you check your body after return from the forest for possible removing the ticks?
a) no b) yes, sporadically c) yes, always

7. Do you manage to remove a tick from your body?
a) no b) I do not know c) yes

8. Have you removed ticks from your body?
a). no b) yes, rarely c) yes, frequently

9. If the answer is “yes”, how do you remove ticks from your body?:
a) with fingers b) with tweezers or special hooks c) with other methods

10. Have you had borreliosis diagnosed by doctor, or were suspected to have this disease?
a) no b) yes

11. What are your expectations for health education from the area of tick-borne diseases?
a) more popular publications (brochures, leaflets) b) more lectures, educational meetings
c) other expectations, fill ……..
……..…….....

12. Are you using repellents during work in the forest?
a) no b) yes, sporadically c) yes, always

13. Do you know which microorganisms, apart from bacteria causing borreliosis, could be transmitted by common ticks?
a) no, I do not know b) presumably I know c) yes, I know

14. Which protection against ticks do you expect on your position?
a) effective repellents b) specially designed protective cloths c) other, list ……..
..…….

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15. Job category (establish on the basis of questionnaire and documents)

a) High: chief foresters, clerks and other educated people doing their work mainly in the office
b) Middle: foresters, inspectors and other educated people doing their work mainly in the forest
c) Low: wood-cutters and other workers doing physical work in the forest