Tick prevention in a population living in a highly endemic area

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Abstract

Aims: To describe environmental and personal tick preventive measures and their predictors, taken by a population living in a highly tick-endemic area.

Methods: Owing to the recent confirmation of human tick-borne encephalitis cases, vaccination against tick borne encephalitis was offered to the population living in the endemic area through the use of leaflets and media campaigns. At the time for the initial dose, information and enrollment to this cohort study was carried out. Participants´ characteristics, frequency of tick-bites and preventive measures were included in questionnaires. Logistic analysis was used to determine behavioural differences in activities taken in order to prevent tick-bites.

Conclusion: In total, 70% of the permanent residents had themselves vaccinated before the next tick-season. Of the studied participants 356/517 (69%) regularly took preventive measures in their environment and/or personally. Women in particular, and those previously treated for a tick-borne disease, took significantly more preventive measures. When analysing all variables together, spending less time in tick-endemic area and being tick-bitten the latest tick-season significantly increased the probability of taking preventive measures. After being tick-bitten, men were more inclined to start taking preventive measures than women. Awareness of the risks caused by living in a high endemic area to ticks influenced the participant's daily life through preventive activities. Public health action should be considered thus encouraging out-of-door activities for the population, without anxiety for risks for contracting tick-borne disease after being tick-bitten.

Key words:

Exposed, gender, Ixodes ricinus, Lyme borreliosis, prevention, risk, tick

Word count:

3236

Background

Diseases associated with tick-bites have increased world-wide and second only to mosquitoes ticks are currently considered as the most important vectors causing human diseases in the world (1, 2). Tick-borne diseases such as Lyme borreliosis (LB), ehrlichiosis, relapsing fever, tularaemia, tick-borne encephalitis (TBE) and babesiosis are caused by a variety of infectious pathogens, including different types of bacteria as well as viruses and protozoa (1-4).

It was not until the early 1980s the *Borrelia burgdorferi* (*B. burgdorferi*) spirochete was isolated and cultured by William Burgdorfer (5). The first human cases caused by *Anaplasma phagocytophilum* (formerly *Ehrlichia*) were described in the USA in 1994, and were documented in Europe in 1996 (2, 6, 7) . The incidence of TBE has substantially increased in Europe, in particular since the beginning of the 1990s (8). Public health efforts take place with the aim to increase the awareness of tick related diseases among populations living in tick-endemic areas. Preventive measures, both personally and in the environment are recommended, e.g. control of the vector by creating a less favourable environment for the tick and its reservoirs or to recommend avoidance of tick-infested areas (2, 9-12). Personal protection includes rapid removal of attached ticks by daily inspections, the use of repellents and/or wearing protective clothing that cover major parts of the body.

On the basis of the awareness of risks concerning tick-bites and tick-borne diseases, the aim of this study was to investigate and describe preventive measures, and their predictors taken by a population living in a tick-endemic area.

Methods

Study area and population

The study took place on Aspö, an island located in the south-eastern archipelago by the Baltic Sea in the county of Blekinge, Sweden. The area consist of 8 km^2 varied landscape with habitation mainly in the west and east seaside. Pine trees and deciduous forest with a rich undergrowth of fern and heather dominate the central part. Extensive fauna, small rodents, roe deer (*Capreolus capreolus*) and aquatic birds are common. The *Ixodes ricinus* (*I. ricinus*) tick is common and can be found over the entire island. Aspö is endemic to ehrlichiosis, TBE and LB and among studied *I. ricinus* ticks 15-25% have been found to be infested with *B. burgdorferi sensu lato* spirochetes (13, 14).

Aspö is one of the most extensively examined tick areas in Europe and also a region with one of the highest incidences of LB (13, 15-17). The island is inhabited by 210 households comprising 477 individuals, of whom 407 are ≥18 years. During the summer months the number of households increases to approximately 410.

Since children are most likely to be influenced and gain from the preventive measures their parents take, only permanent and part-time residents, ≥18 years, were included in this study. Also, the prevention of tick-bites is probably influenced by the length of time spent on the island. Therefore the participants were divided into two groups; those residing more or less than three months during the tick season each year for the last five years.

The entire population was well aware of ticks and tick-borne diseases and had repeatedly been instructed through the media, various campaigns and leaflets on how to prevent themselves through personal precautions from being tick-bitten.

Study design

The presence of TBE on Aspö was confirmed by one case diagnosed during the tick-season 1999, followed by two diagnosed in 2002 (unpublished findings). Consequently permanent and part-time residents were offered TBE vaccination in the autumn of 2002 through use of notice boards. At the time of the initial vaccination dose, which was offered on eight occasions within one month, the participants were informed and offered participation in this cohort study. All participants were given information and written informed consent was obtained. After filling in a questionnaire initially, another questionnaire was completed and submitted at the time for the second vaccination, 1-2 months after the first dose. The first questionnaire included questions about sex, age, if the person was permanent or part-time resident on the island of Aspö, earlier history of TBE and previous vaccination against TBE. The second questionnaire listed the following; if awareness of tick-exposure influenced leisure pursuit, environmental and personal preventive measures, residency less or more than three months/year during the last five years on Aspö, history of tick-bites, earlier history of LB and ehrlichiosis, animal/pets-owner and drug use.

Statistics

Descriptive statistics were computed to evaluate the data for sample characteristics. Chi-square test (four-fold table) was used to test significant differences in characteristics between:

-participants entering and fulfilling the study,

-regularly taken preventive measures; men versus women,

-regularly taken preventive measures and experience of limitation of leisure pursuit in their surroundings,

- taking preventive measures and ever being treated for a tick-borne disease,

-time spent on the island and being tick-bitten,

-time spent on the island and being treated for a tick-borne disease,

-ever being treated for a tick-borne disease and experience of tick-bites the latest tick-season.

Spearman's correlation coefficient was used to determine the impact of age and performing preventive measure. Age was treated as a continuous variable.

Binary logistic regression analysis was used to determine behavioural differences in measures performed to prevent tick-bites. The simultaneous relationship among the dependent variable and all independent variables were modelled using stepwise backward regression. Several models were tested. The relationship between each independent and the dependent variable controlling for all other variables were evaluated by determining odds ratios (ORs). The statistical significance of the variables was determined using 95% confidence interval (CI). Assessment of fit is based on the Cox and Snell R^2, which is based on likelihood.

We considered *p*-values less than 0.05 as significant.

All analyses were performed using the statistical software package SPSS (Version 11.5).

Ethics

The study was approved by the Research Ethics Committee of the University of Lund.

Results

Characteristics of included participants

During the study entry period, 642 participants, between 2 and 87 years (median 50), were vaccinated against TBE and also completed the first questionnaire.

Of the enrolled participants, 534 were ≥18 years and of these 517 (97%) completed the study and answered both questionnaires. They comprised 271 permanent residents and 246 part-time residents. Characteristics for the participants are seen in Table I.

After the enrolment period another 13 adult permanent residents were vaccinated in the study, thus 284/407 (70%) of the permanent residents ≥18 years had themselves vaccinated before the next tick-season. In comparison between the permanent residents who arranged to be vaccinated and those who did not, significantly more men did not have themselves vaccinated (four-fold table, p= 0.014). No significant differences were seen in the age distribution.

Preventive measures

Preventive measures were divided into activities of a personal preventive nature and those affecting the environment. In addition to vaccination against TBE, totally 356 of the 517 participants (69%) took one or more preventive measures (Table II). The number of preventive measures taken, differed significantly between the men, of whom 153/244 (63%) and women of whom 203/273 (74%), took preventive measures (four-fold table, p=0.004). Age did not have any impact in performing preventive measures (Spearman's correlation coefficient, p= 0.932)

Of those taking preventive measures, 162/356 (46%) said that their awareness of tick-exposure limited their leisure pursuit in the surroundings, compared to 7/161 (4%) of those not taking preventive measures (four-fold table, p=0.000).

Preventive measures in the environment

Among the participants, 174/517 (34%) regularly took preventive measures in their environment. The majority, 161/174 (91%) focused on checking the vegetation and keeping grass short in the nearby surroundings, i.e. within their gardens and/or outside in meadows and on paths. Preventive measures regarding animals included restraining host animals from entering gardens and nearby vicinity and the regular removal of ticks from the body of a pet.

Personal preventive measures

In all, 309/517 (60%) participants regularly took personal preventive measures. Several preventive strategies were reported (Table II). Participants, who took preventive measures with their clothing, used special clothes when entering known extensive tick-areas, or changed their clothes after leaving such areas. They also covered major parts of the body leaving as little visible skin as possible. The participants who examined their bodies or who took a shower or bath as a preventive measure expressed that they did so directly after leaving extensive tick-areas or before going to bed at night.

Those who avoided extensive tick-areas mentioned either that they took precautions when strolling in the woods or that they avoided entering woods or high grass or did not lie or sat directly on their lawns.

Believers in the use of naturopathic medicine as a way to reduce tick-bites consumed garlic and B-vitamin and applied tee-tree oil to their bodies.

The repellents used were those commercially advertised in Sweden today as protective agents against ticks, insects and mosquitoes (active ingredients;19% N-

dietyl-m-toluamid (DEET), perfume i.e.; terpene fraction of essential oils of e.g. lavender, geranium and roses or from the lemon eucalyptus plant)

Treated for tick-borne disease

In total, 129/517 (25%) of the participants had at least once been treated for a tick-borne disease, Table I. Significantly more of those treated for a tick-borne disease 99/129 (77%), versus those not treated 257/388 (66%), took preventive measures (four-fold table, p= 0.026). Also, compared with those tick-bitten but not treated 322/388 (83%), they were significantly more tick-bitten the latest tick-season 120/129 (93%) (four-fold table, p= 0.005).

Time spent on the island

Significantly more men and women, who had spent more than three months each year during the last five years, had been tick-bitten (men; four-fold table, p= 0.006, women; four-fold table, p= 0.001). However, there was no association between time spent on the island and being treated for tick-borne diseases (men; four-fold table, p= 0.363, women; four-fold table, p= 0.854).

Logistic Regression Analysis

Predictors for taking preventive measures

In the first model we included all possible independent variables summarized from the questionnaire. However, the final model was achieved after testing different alternatives resulting in categorizing binary variables. Of two variables giving almost the same information, we chose the one with the strongest association with taking preventive measures, excluding the other. Also, one by one we tested all possible

alternatives for interaction between the independent variables. In the final model we included only interaction variables with significant effect on the outcome. The exclusion criteria were based on the significance of the change in the log likelihood when the variable was excluded.

Dependent variable

The current study utilized one dependent variable, i.e. whether the participants took preventive measures to minimize the risk of being tick-bitten, or not. The variable was categorized binary (1= yes and 2= no). Questions included in the dependent variable were;

-if the participants regularly were using repellents as a preventive measure in order to prevent tick-bites,

-if they regularly took other personal preventive measures or

-if they regularly took preventive measures in their surroundings to minimize the presence of ticks (Table II).

Independent variables

The six independent variables used in this study were;

-1) sex, (0= men and 1= women),

-2) whether they had spent more (coded 0) or less (coded 1) than three months yearly on the island during the last five years,

-3) whether they had been tick-bitten during the latest tick-season (0= yes and 1= no),

-4) whether they had been treated for any tick-borne disease/s ever (0= yes and 1= no),

-5) whether they had owned animal/pets (0= yes and 1= no).

After testing the variables for interaction, one of these alternatives showed a significant result and was therefore included in the final model, i.e.

-6) gender and being tick-bitten during the latest tick-season (OR= 0.641, p=0.005, CI=0.469-0.876).

After processing, we found three variables that appeared to have a significant influence on the probability of taking preventive measures (Table III) i.e.:

-spending less time on the island than three months/year during the last five years,

-being tick-bitten during the latest tick-season and

-if the participant was a man and tick-bitten, he was more inclined to start taking preventive measures compared to a woman (interaction).

Discussion

Epidemiological studies, measuring the awareness of tick risks and its impact on performing preventive measures, has been reported earlier (18-23). This study provides further knowledge for the situation in Europe.

Since the 1990´s the population in this study has been instructed on how to take personal precautions to prevent themselves from being tick-bitten. Also, due to extensive and repeated tick studies on the island, the population is more aware and knowledgeable on how to prevent tick-borne diseases (13-17).

More than 2/3 of the participants took preventive measures against tick-bites. Nevertheless, almost everyone had been tick-bitten once or more and ¼ had been treated for a tick-borne disease, thus confirming this island to be an extremely tick-endemic area.

Participants taking preventive measures in their environment kept their grass short expressly for the purpose of preventing the occurrence of ticks.

The studied area has numerous free-roaming roe deer and several of the inhabitants tried to minimize presence of the animals in their gardens. A study performed by Ley et al., has showed a 2.5 times higher risk of developing LB with the observation of deer around the home and a history of exposure to ticks (22). Minimizing the number of deer in tick-endemic areas, or excluding them from residential areas by fencing, would probably minimize the population's anxiety and decrease the number of people being tick-bitten and contracting tick-borne diseases.

The majority of participants taking personal preventive measures used repellents and/or avoided extensive tick-endemic areas in order to protect themselves. The repellents mainly contained essential oils and DEET, which is a most effective substance for reducing the risk of tick-bites (24, 25). Using protective clothing/boots

was also a commonly taken preventive measure. However, Ley et al. found that the wearing of light coloured clothing and the use of insect repellent did not appear to be protective (22).

Individuals who had previously been treated for tick-borne diseases were more often tick-bitten the following tick-season despite taking more preventive measures than those who had not been treated. Those more often tick-bitten and who once or more had been afflicted with disease probably increased their awareness and took greater efforts in preventing them from occurring again.

From the regression model, owning a pet had the least influence on whether preventive measures were taken or not. Also this result may be related to the study performed by Ley et al., stating that dog ownership did not increase the risk of developing tick-borne diseases among humans (22). However, Jones et al. found dog owners more likely to report tick-bites (23).

During different stages in their life several of the participants have alternated between being permanent and part time residents. It would be expected that those residing a longer period of time on the island would become more aware of the risks connected with ticks and tick-borne diseases and consequently increase preventive measures. Instead our results indicate the opposite. In all probability the inhabitants either ignore the potential risks or have learnt to live with them and did not allow themselves to be influenced in their daily lives. Lengthy stays on the island together with few, if any preventive measures could be the cause of the increase in tick-bites. However, length of time spent on the island did not influence whether they had been treated for tick-borne diseases or not. Neither did the total time spent in tick-endemic areas influence the development of tick-borne disease according to the study carried out by Ley et al. (22). The awareness of preventive measures among these people might perhaps lead

to a more prompt removal of a skin-attached tick, minimizing the risk of developing tick-borne disease despite being tick-bitten.

Our results indicate no age-, but gender differences in taking preventive measures. However, these results could be biased since the non-participants mainly consisted of men, i.e. more men than women chose not to be vaccinated. When analysing the regression model, gender in itself did not have any influence whether the participants took preventive measures or not - only the combination of being a man and tick-bitten. When analysing the effect of being tick-bitten, women were not as affected as men in taking preventive measures. However, when analysing the relation between the sexes with taking preventive measures without consideration for other variables, we found that women took significantly more preventive measures in comparison with men. Thus, women took preventive measures independently if they had been tick-bitten or not, whereas men did not take as many preventive measures until they actually had been bitten. This is in accordance with other results showing an increased risk behaviour among men compared to women (26). In general, women seem to be more observant of their health status. In Jones's study, women reported more use of repellents and were checking their bodies for ticks more often than men (23). Also in a study of health behaviours Liang et al. found females more likely to report active health behaviours than males (27).

The attention the inhabitants have been exposed to from the media and campaigns from the medical service after TBE was established might be a confounding factor predicting the preventive actions. However, despite that this information reaches more or less the whole population on the island and that the whole study population lives in an endemic area to ticks and tick-borne diseases, we found that the performance of preventive measures varied within the population. The majority, 70%, of the

permanent residents ≥18 years, had themselves vaccinated and participated in this study. The number of part time residents during the tick-season is not known, not allowing an estimation of the proportion of those vaccinated. Non-participating permanent residents, who chose not to be vaccinated despite the recommendations given by the community health authorities, could be those that in general choose to expose themselves to a higher extent of risks. Thus, these results could be biased and overestimate preventive measures. The phenomenon that more men than women were non-participant further underlines the supposition that men in general could have a higher risk acceptance than women (26).

Another possible confounding factor, not examined here, could be the educational level of the participants and its influence on performing preventive measures.

Since this was a population voluntarily attending a vaccination campaign, prior to the time for study entry, we could assume that they were a group concerned for their health status.

The wish to prevent tick-bites reflects their anxiety for contracting tick-borne disease. Also, 46% of the participants taking preventive measures limited their time spent out of doors in carrying out leisure activities.

However, it is not clear that performed preventive strategies are efficacious (28). Valuable future research would be to measure time of exposure related to the outcome of taking preventive measures against tick-bites and tick-borne diseases.

Areas endemic to ticks and tick-borne diseases is clearly of public health concern and actions should be considered to minimize the population's experiences of not being able to move freely in their surroundings.

In conclusion, we found that, in addition to taking steps to vaccinate themselves against TBE, 69% of the participants regularly took preventive measures to minimize

tick-bites and tick-borne diseases. Measures taken were both personal and environmental. When analyzing gender and preventive measures solely, women took more preventive measures compared to men. When analyzing all variables together, spending less time in tick-endemic area and being tick-bitten during the same tick-season significantly increased the probability of taking any preventive measures. After being tick-bitten, men increased their performance of preventive measures more than women.

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Table I. Characteristics for participants, living in a tick-endemic area, in a study on tick prevention.

	No. of participants (%)		
	Men	Women	Total
	n= 244 (47)	*n*= 273 (53)	*n*= 517
Age (years)			
mean	53	53	53
median	56	54	55
range	18-86	18-87	18-87
Duration of stay on Aspö			
> 3 months/year/last 5 y	137 (56)	157 (58)	294 (57)
< 3 months/year/last 5 y	107 (44)	116 (42)	223 (43)
Previously treated for a tick-borne disease			
TBE	1 (0.5)	2 (0.7)	3 (0.6)
Lyme borreliosis	44 (18)	83 (30)	127 (25)
Ehrlichiosis	1 (0.5)	1 (0.3)	2 (0.4)
Tick-bitten during the latest tick-season			
no bites	43 (18)	32 (12)	75 (14)
1-5 bites	124 (51)	154 (56)	278 (54)
6-10 bites	41 (17)	39 (14)	80 (16)
>10 bites	36 (15)	48 (18)	84 (16)
total bitten latest season	201 (82)	241 (88)	439 (85)

Table II. Preventive measures against ticks, regularly taken by individuals living in a tick-endemic area.

	No. of participants (%)		
	Men *n*= 244	Women *n*= 273	Total *n*= 517
No preventive measure	91 (37)	70 (26)	161 (31)
Any preventive measures:	153 (63)	203 (74)	356 (69)
Environmental measures			
Affecting the surroundings	73 (30)	88 (32)	161 (31)
Towards animals	9 (4)	15 (5)	24 (5)
Any environmental preventive action	**80 (33)**	**94 (34)**	**174 (34)**
Personal preventive measures			
Avoidance of extensive tick-areas	42 (17)	66 (24)	108 (21)
Use of naturopathic medicine	14 (6)	25 (9)	39 (8)
Use of repellents	55 (22)	97 (36)	152 (29)
Clothing/boots	44 (18)	60 (22)	104 (20)
Body examination	32 (13)	39 (14)	71 (14)
Bath/shower	4 (2)	7 (3)	11 (2)
Any personal preventive action	**131 (54)**	**178 (65)**	**309 (60)**

Table III. Binary logistic regression (final model) predicting independent factors correlated with taking preventive measures to minimize tick-bites and tick-borne diseases in a population living in a highly endemic area to ticks.

Factor	Odds ratio	Confidence interval	P-value
[1]Time spent on the island	0.627	0.418-0.939	0.024
[2]Tick-bitten 2002	3.777	2.200-6.486	0.000
[3]Sex and tick-bitten 2002	0.640	0.468-0.877	0.005

[1]Spending > or < than three months/year during the last five years on Aspö

[2]Tick-bitten once or more during tick-season 2002

[3]Interaction variable measuring men and women, with or without experience of at least one tick-bite 2002