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Original article

Implementation of preventive measures against tick-borne infections in a non-endemic area for tick-borne encephalitis—Results from a population-based survey in Lower Saxony, Germany

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ABSTRACT

Lyme borreliosis (LB) and tick-borne encephalitis (TBE) are the most common tick-borne diseases in Germany. While for LB only non-specific prevention strategies exist, TBE can be additionally prevented by vaccination. It is unclear to which extent non-specific prevention strategies are applied by individuals living in non-endemic areas for TBE in Germany, and whether TBE vaccination status affects their implementation. Participants of the HaBIDS panel (Hygiene and Behavior Infectious Diseases Study) from four counties of Lower Saxony were invited to fill out a questionnaire on their TBE vaccination status, their LB diagnoses as well as their knowledge, attitudes, and practice related to prevention measures for tick-borne diseases. Based on self-reported data we estimated cumulative lifetime incidence (CUM) and incidence of LB as well as TBE vaccination coverage. One year later, participants received a supplementary questionnaire focusing on reasons for vaccination against TBE and compliance with the vaccination schedule.

1,573 (74.2% of those invited) panel members aged 18–69 years participated in this study. Of these, 22.8% reported to have ever been vaccinated against TBE. The estimated CUM of LB was 5.1% (95%-CI: 4.1%–6.4%), and the incidence was 1.09 per 1,000 person years (95%-CI: 0.87–1.36). 98% of participants knew that LB is transmitted by the bite of an infected tick, but about 50% didn't know that TBE vaccination does not protect against LB. Even though about 80% of study participants were convinced that recommended non-specific prevention strategies were indeed protective, a much lower proportion implemented them. TBE-vaccinated participants were better informed about tick-borne diseases compared to non-vaccinated participants, whereby being vaccinated did not negatively affect implementation of non-specific prevention strategies. Based on data from the supplementary questionnaire, traveling to endemic areas (75.3%) was the main reason for TBE vaccination; 33.0% of those vaccinated had a complete vaccination schedule with three doses.

Our study in a TBE non-endemic area revealed deficits in knowledge about which pathogens are covered by TBE vaccination, and a lack in the implementation of non-specific prevention measures. TBE vaccination was not associated with a reduced uptake of non-specific prevention measures.

1. Introduction

Lyme borreliosis (LB) and tick-borne encephalitis (TBE) are the most common tick-borne diseases in Europe (Alpers et al., 2004; Frank et al., 2014; Wilking et al., 2015). Germany is one of the 20 European countries with an existing comprehensive national surveillance system for TBE (European Centre for Disease Prevention and Control, 2012); in 2017, 485 TBE cases were reported, which corresponds to an increase of

Abbreviations: CI, confidence interval; CUM, cumulative lifetime incidence; DEGS1, The German Health Interview and Examination Survey for adults; HaBIDS, Hygiene and Behavior Infectious Diseases Study; LB, Lyme borreliosis; PY, person years; TBE, tick-borne encephalitis

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40% compared to the previous year (Robert Koch-Institut, 2018). Currently, 156 administrative districts are classified as endemic areas for TBE in Germany; they are predominately located in Southern Germany (Amicizia et al., 2013; Robert Koch-Institut, 2018; Süss et al., 2004). However, the number of these areas has increased in recent years. About thirteen TBE cases per year have occurred outside endemic areas between 2002 and 2017 (Frank et al., 2014; Robert Koch-Institut, 2018), which corresponds to 4.8% of all cases in Germany in this period. Since treatment strategies for TBE are limited (Kaaijk and Luytjes, 2018; Kaiser, 1999), the implementation of preventive measures is crucial for a reduction of the burden of disease. In addition to non-specific prevention measures, the German Standing Committee on Vaccination (STIKO) recommends vaccination against TBE for individuals who are exposed to ticks in endemic areas for TBE, individuals who are occupationally exposed to TBE (e.g. hunters, forest workers, laboratory personnel) and individuals traveling to endemic areas for TBE (Ständige Impfkommission, 2017). For a temporary immunization against TBE two doses, while for a longer protection three doses are recommended. The first re-vaccination (booster) is recommended after three years, further re-vaccinations are recommended after three to five years, dependent on the vaccinee's age and the type of vaccine. Despite this recommendation, the compliance with vaccination schedules for TBE in Germany seems to be low and varies geographically dependent on TBE risk (Erber and Schmitt, 2018; Jacob and Kostev, 2017). No nationwide mandatory notification system for LB exists in Germany (Wilking and Stark, 2014); moreover, data on the distribution and burden of disease are scarce. In contrast to TBE, only non-specific prevention strategies exist for LB. General preventive measures for reducing the overall risk of tick-bites are recommended, such as wearing light, closed clothing, avoiding undergrowth and high grasses, or using tick repellents (Rizzoli et al., 2001). Given the possibility that individuals falsely assume that TBE vaccination also offers protection against LB, being vaccinated could negatively influence the implementation of non-specific prevention measures. Accordingly, information and education regarding protection, risks, and transmission of LB are seen as the most effective preventive measures (Frank et al., 2014; Robert Koch-Institut, 2018). Since LB incidence shows no clear geographical pattern and is considerably higher than the one of TBE, non-specific prevention strategies against tick-borne diseases play an important role inside and outside endemic areas for TBE. To date, it is unknown to which extent such prevention strategies are implemented in non-endemic areas for TBE in Germany, and whether the uptake of such strategies is hampered by individual TBE vaccination status. While TBE vaccination status could also affect the prevention measures in endemic areas for TBE, there is likely a lower level of information about tick-borne diseases in non-endemic areas for TBE, which can reinforce the confusion. We therefore investigated how well non-specific prevention strategies against tick-borne diseases are implemented in a non-endemic area for TBE in Germany (using a knowledge, attitude and practice (KAP) survey) and how these are affected by TBE vaccination status. Furthermore, we determined vaccination coverage against TBE, as well as incidence and cumulative incidence of LB based on self-reported data in this area.

2. Methods

2.1. Study population

This study was performed within the population-based longitudinal HaBIDS (Hygiene and Behavior Infectious Diseases Study) panel, which is described in detail elsewhere (Rübsamen et al., 2017a, 2017b). 26,895 men and women between 15 and 69 years of age from four counties in Lower Saxony in Germany (Braunschweig, Vechta, Salzgitter and Wolfenbüttel), comprising about 600,000 inhabitants (Statistische Ämter des Bundes und der Länder, 2014), were invited to participate in the HaBIDS panel. Lower Saxony has a population of 8 million inhabitants, and consists of 45 counties. In total, 2,379 (8.9% of those initially invited) individuals accepted the invitation to participate in the HaBIDS panel. In the initial phase, all HaBIDS panel members received eleven questionnaires between January 2014 and July 2015 covering different topics on knowledge, attitudes, and practice related to infectious diseases. In autumn 2014, a questionnaire (online or pen and paper) focusing on prevention strategies against tick-borne infections was sent to the panel members (main questionnaire). At the end of the initial HaBIDS phase all panel members were invited to participate in an extended phase of HaBIDS, which was carried out online only. Half of the panel members (n = 1,037) agreed to continue participation and received eight additional questionnaires between August 2015 and June 2017. In autumn 2015 an additional supplementary online questionnaire focusing on reasons for vaccination against TBE and completeness of vaccination schedule was sent to the participants. Based on the data from this supplementary questionnaire, we analyzed reasons for self-reported TBE vaccination status and checked for reliability of LB diagnoses data reported in the main questionnaire.

2.2. Questionnaire

The main questionnaire consisted of closed questions related to tick-borne diseases (see Supplement) covering four main topics: (i) information on previous diagnosis of LB ("Have you ever been diagnosed with Lyme borreliosis by a doctor?") and vaccination status against TBE ("Have you ever received an "anti-tick vaccination"?"), with the response options "Yes", "No", and "Don´t know". Study participants, who reported to have ever been diagnosed with LB were asked to specify the year of diagnosis. (ii) Knowledge about transmission and vaccination was assessed by four items, with response options "Agree", "Somewhat agree", "Somewhat disagree", "Disagree", and "Don´t know". (iii) Seven items covered attitudes towards non-specific prevention strategies against tick-borne diseases with responses on a scale "Protects very well", "Protects well", "Doesn´t protect well", "Doesn´t protect at all", and "Don´t know". In addition, we asked the panel members to rate seven statements related to what to do after having been bitten by a tick ("Very important", "Rather important", "Rather not important", "Unimportant"). (iiii) The practice of seven specified non-specific prevention strategies was assessed by asking about the frequency of their implementation ("Always", "Often", "Sometimes", "Never" and "Don´t know"). The supplementary questionnaire obtained information on the frequency ("How many times have you been vaccinated against ticks in your life?") and date of received vaccinations as well as the reasons for receiving vaccination against TBE, and the symptoms and circumstances leading to LB diagnoses. Sociodemographic data (age, sex, and school education; the latter defined as "Still at upper secondary school", "Lower secondary education or apprenticeship", "University entrance qualification", and "University degree") of all panel members were added from the baseline questionnaire of the HaBIDS study.

2.3. Data management and analysis

For our study we only included panel members who filled in the main questionnaire; we excluded individuals with missing data on age and sex. In addition, in order to compare our findings with published data from the German Health Interview and Examination Survey for Adults (DEGS1) (Poethko-Müller and Schmitz, 2013), we restricted the age spectrum of respondents in our analysis to the age range 18 to 69 years. In a first step, we calculated TBE vaccination coverage with the corresponding 95% confidence interval (95%-CI). Secondly, we estimated the cumulative lifetime incidence (CUM) of LB in different age groups in order to compare it to the age-specific seroprevalence reported in another German study based on DEGS1 (Wilking et al., 2015). Reliability of LB status and TBE vaccination status reported in the main questionnaire was investigated based on data of the supplementary questionnaire using Cohen's kappa (Landis and Koch, 1977). To allow comparability in the calculation of Cohen´s kappa, we excluded events reported to have happened between both questionnaires. For all other analyses, however, these events were included. We also estimated the age-specific incidence of LB by calculating the time at risk retrospectively based on participants' self-reported year or age of LB diagnosis. In addition to data from DEGS1, we also used self-reported data on TBE vaccination coverage from a household survey in the German population (stratified by federal state, and including Lower Saxony) to check if vaccination coverage results in our study are comparable to other studies in the same source population (Erber and Schmitt, 2018). For the estimated CUM and incidence of LB, we used for comparison data from a population-based study conducted in the Würzburg region of Germany (Huppertz et al., 1999). Data regarding knowledge, attitude and practice were reported as proportions. To assess the association between TBE vaccination status on the one hand and baseline characteristics as well as the implementation of prevention strategies on the other hand, chi-square tests were used. All analyses were performed using Stata IC 12 (StataCorp, US) based on a complete case analysis.

The study was approved by the Ethics Committee of Hannover Medical School, and the Federal Commissioner for Data Protection and Freedom of Information in Germany. All participants provided written informed consent.

3. Results

3.1. Study population

After application of exclusion criteria, 1,573 (66.1%) participants aged between 18 and 69 years were included in this study. About 40% of the participants were male (Table 1); median age was 48 years (IQR: 36–58 years). The majority of the participants were married (61.2%), and a high proportion had a university degree (40.7%). We found no evidence for an association between TBE vaccination status and sociodemographic characteristics (Table 1). Of the 1,037 individuals who continued in the online panel, 77.8% (n = 807) filled in the supplementary questionnaire.

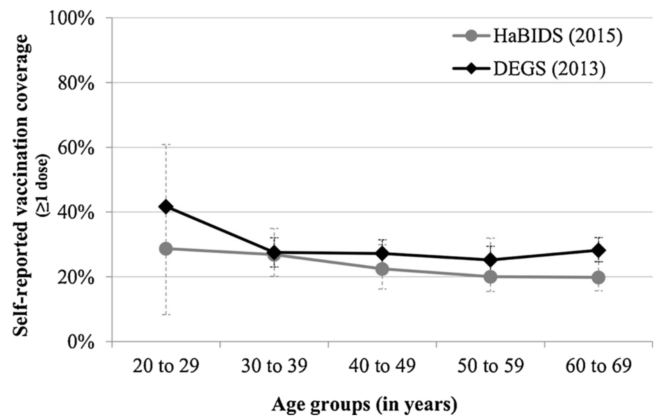

Fig. 1. Self-reported vaccination coverage for TBE in the HaBIDS population (n = 1,559*) in percentage stratified by age group and compared to data from the DEGS1 study (2013).
TBE: tick-borne encephalitis. Vertical lines represent 95%-CI.
*Out of 1,573 participants 14 did not report the vaccination status.

3.2. Vaccination against tick-borne encephalitis

In the main questionnaire, 22.8% (95%-CI: 20.5%–25.3%) of the participants reported to have been vaccinated against TBE at least once. When comparing the answers in the main and the supplementary questionnaire we found an agreement of 92.3% and a kappa of 0.78 (0.72–0.83) (when excluding the response option "Don't know" an agreement of 94.5% with a kappa of 0.83 (0.78–0.88)). Six individuals who received a vaccination between both questionnaires (due to travelling (n = 3) or moving (n = 3) to endemic areas), were excluded from this comparison. The German Health Interview and Examination Survey for Adults (DEGS1, comparable age distribution to the present study) study reported a vaccination coverage of 29.4% (95%-CI: 24.4%–34.4%) for Germany in 2013, but combined data from endemic and non-endemic areas (Poethko-Müller and Schmitz, 2013). Based on

Table 1
Characteristics of study participants (n = 1,573) by TBE vaccination status.

Characteristics	Received vaccination against TBE[a]			
	No, n (%)	Yes, n (%)	Don´t know, n (%)	p-value[b]
Sex				0.077
Male	469 (40.1)	124 (34.8)	15 (46.9)	
Female	702 (59.9)	232 (65.2)	17 (53.1)	
Age. mean (sd)				
Male	49.4 (13.5)	45.0 (14.1)	33.1 (14.1)	
Female	46.8 (13.1)	44.4 (14.2)	36.5 (16.0)	
Marital status				0.218
Single	289 (24.8)	107 (30.3)	22 (71.0)	
Married	745 (60.0)	209 (59.2)	8 (25.8)	
Divorced	103 (8.8)	28 (7.9)	0	
Widowed	27 (2.3)	9 (2.5)	1 (3.2)	
Missing	*7*	*3*	*1*	
Education				0.207
Still at upper secondary school	5 (0.4)	5 (1.4)	2 (6.5)	
Lower secondary education or apprenticeship	364 (31.3)	103 (29.1)	9 (29.0)	
University entrance qualification[c]	313 (26.9)	94 (26.6)	15 (48.4)	
University degree	482 (41.4)	152 (42.9)	5 (16.1)	
Missing	7	2	1	
Self-reported LB diagnosis				0.537
No	1106 (95,0)	335 (94,1)	32 (100)	
Yes	59 (5,0)	21 (5,9)	0	
Missing	*6*	*0*	*0*	

sd: standard deviation.
[a] 14 participants did not answer.
[b] Chi-square test, not including response option "Don´t know" and missing data.
[c] Including upper secondary education or vocational school.

the data from the main questionnaire, vaccination coverage was somewhat higher in DEGS1 across most age groups compared to our study (Fig. 1). In a cross-sectional household survey performed in 2015, vaccination coverage based on self-reported data was estimated to be 27% in Germany, with the highest proportion in Bavaria (40%, endemic area) and the lowest in Bremen (5%, non-endemic area), Saarland (10%, non-endemic area) and Lower Saxony (14%, non-endemic area) (Erber and Schmitt, 2018).

3.3. Reasons for and completeness of vaccination against tick-borne encephalitis

Since Lower Saxony is a non-endemic area for TBE, we investigated the motivation for vaccination against TBE in the supplementary questionnaire. In total, 194 (24.0%) individuals reported in the supplementary questionnaire to have received a vaccination against TBE at least once. Most of the study participants named travelling to endemic areas (75.3%) as the reason for vaccination; 14.4% of participants reported to live in an endemic area (contrary to the fact that they lived in Lower Saxony), while 2.6% reported to have an occupational hazard. Those indicating travelling as main reason for vaccination were further asked about their travel destination. In 94.3% of cases, the destination was indeed deemed an endemic area. The information on the number of received doses was reported by all 194 vaccinated individuals, of which 154 specified the year of the first vaccination. When evaluating the completeness of baseline immunization, 33.0% of those who reported in the supplementary questionnaire to have been vaccinated against TBE at least once (n = 194) had a completed schedule with three doses within the recommended time period. Of these, 34.4% received a first boost within five years after the third dose.

3.4. Cumulative lifetime incidence and estimated incidence of Lyme borreliosis

Based on self-reported LB diagnosis in the main questionnaire, we estimated an overall CUM for LB of 5.1% (n = 80) (95%-CI: 4.1%–6.4%). In the supplementary questionnaire, 49 (6.1%) participants reported to be diagnosed with LB. This corresponds to an agreement of 98.0% and a kappa of 0.83 (95%-CI: 0.74–0.91), which is classified as "almost perfect" by Landis and Koch (1977). Using data from the main questionnaire, we compared the age-specific CUM of LB with seroprevalence data from the population-based DEGS1 study (Wilking et al., 2015); DEGS1 data showed higher estimates across all age groups with an overall seroprevalence of 9.4% (95%-CI: 8.4%–10.0%) (Fig. 2A). The modeled overall incidence based on self-reported data in our study was 1.09 per 1,000 person years (PY) (95%-CI: 0.87–1.36). No major age trends could be detected; however, in younger age groups (< 39 years of age) the incidence of male participants was higher than those of female ones, while above the age of 40 the incidence of women was considerably higher than the one of men (Fig. 2B). A population-based study in the Würzburg region of Germany in 1996/1997 reported an incidence of 1.1 per 1000 PY (n = 279,000) which is compatible with the results of this study (Huppertz et al., 1999).

3.5. Knowledge, attitude and practice regarding (non-)specific prevention strategies

3.5.1. Knowledge

Ninety-eight percent of participants knew ("(Somewhat) agree") that LB is transmitted by the bite of an infected tick, while a lower proportion of participants (81.2%) stated that the same is true for TBE (Fig. 3). About 25% erroneously assumed that vaccination against TBE does also protect against LB while nearly one third wasn't sure about it. Sixty-two percent reported correctly that the "tick" vaccine prevents against TBE, whereby 32.6% were uncertain ("Don´t know"). A significantly higher proportion of those who were vaccinated with at least one dose (compared to those who were never vaccinated) answered correctly that TBE vaccination prevents TBE (86.2% vs. 55.5%, $p < 0.001$) but not LB (68.5% vs. 41.5%, $p < 0.001$).

3.5.2. Attitudes towards (non-) specific prevention strategies

Study participants considered the presented recommended non-specific prevention strategies to be highly protective against tick bites. The highest rated non-specific prevention strategy was "checking body" (protects (very) well: 96.4%) followed by "wearing long clothes" (92.2%) (Fig. 4A); in contrast, "using anti-tick agents" was considered only by 52.2% as an effective prevention measure. A large majority (96.8%) rated "removing the tick immediately" as a (very and rather) important prevention strategy. The participants displayed some uncertainty about how to remove ticks (Fig. 4B); 52.8% stated that "a tick must be unscrewed" is (very and rather) important (which is against the recommendations), while almost the same proportion (46.0%) had the opinion that pulling the tick straight out is the best way to do it; more than half of the participants selected the answer that "the tick should be removed by a physician" (50.4%). Only a small percentage of participants felt that using toothpaste, oil, or alcoholic-based solutions before removing a tick is a suitable procedure.

3.5.3. Practices related to (non-) specific prevention strategies

Even if prevention strategies were deemed protective, this did not necessarily mean that individuals also implemented these strategies (Fig. 4C). Only 75.8% of the participants who stated "checking body" protects (very) well, reported to implement it always/often. About 50%

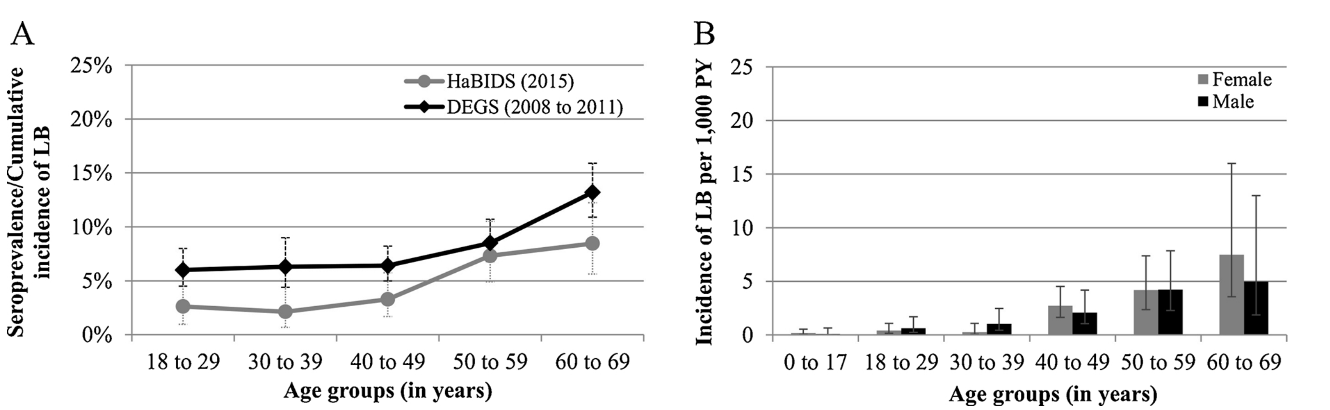

Fig. 2. Comparison of age-specific estimated cumulative lifetime incidence (CUM) of LB in the HaBIDS population with seroprevalence data from the DEGS1 study; (A)); age-specific modeled incidence of LB of the HaBIDS population, stratified by sex (B).
LB: Lyme borreliosis. PY: person years.

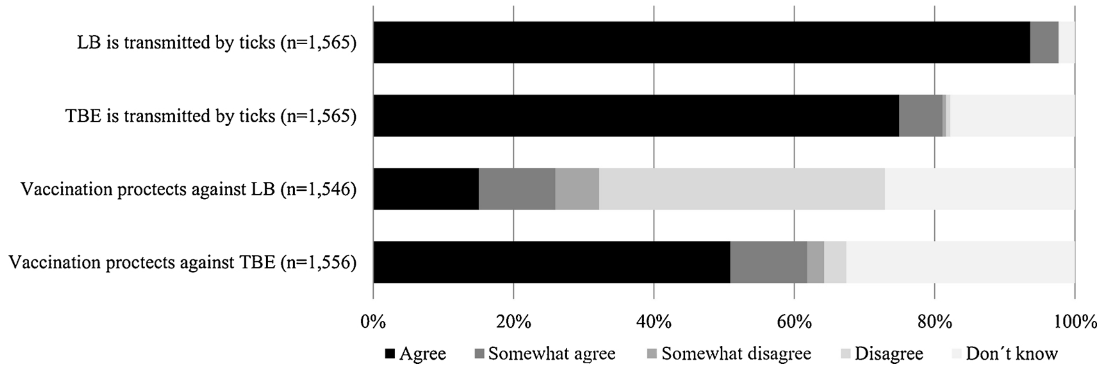

Fig. 3. Knowledge of HaBIDS participants regarding vaccination against TBE and transmission of causative agents of tick-borne diseases.
LB: Lyme borreliosis; TBE: tick-borne encephalitis; Total number (n) of observations mentioned in brackets. The statement "LB/TBE is transmitted by ticks" was intentionally used in this form although not diseases but infectious agents are transmitted.

would always/often wear long clothes or ankle-high boots when exposed to ticks. Tucking pans in the socks or using anti-tick agents would always/often be implemented by about 30% of participants. Less than 15% would always/often avoid forests or meadows. To investigate differences in practices dependent on TBE vaccination status, we dichotomized the response options regarding implementation of prevention measure (always/often vs. sometimes/never) and found that the implementation of non-specific preventive measures was at least as good among those vaccinated against TBE compared to those without vaccination history (Fig. 4D).

4. Discussion

We analyzed the knowledge, attitude and practice regarding preventive measures against tick-borne infections in a non-endemic area for TBE. Knowledge of study participants showed some major shortcomings with respect to the target pathogens for TBE vaccination. Although established non-specific prevention strategies were deemed protective by the majority of study participants, this attitude was not necessarily transferred into daily practice. In our survey in a non-endemic area for TBE, we found a vaccination coverage comparable to endemic areas. However, our results indicate that TBE vaccination status was not associated with a reduced uptake of preventive behavior towards tick-borne diseases. To ensure that the self-reported data collection provided valid results, we compared TBE vaccination coverage to external German data sources. Although vaccination coverage in DEGS1 was slightly higher across all age groups, results were still comparable to our study since DEGS1 also included endemic areas. Furthermore, our data was in line with the results from Erber and Schmitt (2018) based on self-reported data, showing as well a slight age-dependent decrease of vaccination coverage (Erber and Schmitt, 2018). Nevertheless, the reported vaccination coverage is comparably high for a non-endemic area for TBE. In order to ensure that vaccinations were reported appropriately, we examined the motivation of vaccination for each participant. Receiving vaccination against TBE in our study was to a large extent associated with high risk exposure to tick-borne diseases, such as traveling to an endemic area. The observed high vaccination coverage in our sample could be attributed to a higher level of health-consciousness of the study participants. Since the majority of the panel members is highly educated and all respondents opted to participate in a study on hygiene and behaviour regarding infectious diseases, it is fair to assume that our study population is generally more interested and better informed than the overall general population. Nonetheless, study participants showed, if vaccinated at least once, low overall compliance with TBE vaccination recommendations; only 33% received three injections within the recommended time frame. Within the framework of a household study, it has been shown that about 30% of 897 surveyed participants with TBE vaccination in Germany received all three injections (Erber and Schmitt, 2018). This is in line with the findings of Jacob and Kostev (2017) showing that 28% of patients receiving the first dose also received the second and third dose (Jacob and Kostev, 2017). The low vaccination compliance could be attributed to the lack of knowledge regarding the vaccination schedule/recommendations as well as to lower risk awareness.

We used self-reported data on LB diagnosis for estimating CUM and for modeling the incidence of LB in a non-endemic area for TBE. We compared our data to external sources, and found that DEGS1 data yielded higher estimates. In contrast to our study, DEGS1 data were, however, calculated based on antibody detection in blood samples (seroprevalence). Since not all encounters with bacteria leading to a humoral immune response cause clinical disease, the observed differences seem reasonable. This is further supported by our modeled incidence being in line with data from a prospective population-based surveillance study from Würzburg (Huppertz et al., 1999).

When looking at knowledge towards tick-borne diseases we observed a mixed picture. In total, 50% of the participants did not know that TBE vaccination does not protect against LB, reflecting a considerable knowledge gap. Since we could not find differences in the implementation of non-specific preventive measures against tick-borne diseases between those vaccinated and those non-vaccinated, there is no evidence that this knowledge gap leads to changes in risk behaviour (which as a consequence could indirectly increase the risk of acquiring LB). Knowledge about tick-borne diseases was higher in our study when compared to a survey performed in the District of Columbia in the US (Herrington, 2004); 97% of HaBIDS participants knew that LB is a tick-borne disease versus 77% in the US study, indicating that the awareness for LB is higher in our study population. This could also be explained by self-selection of participants in our study. Generally, we could show a high consent to the protective effect of prevention strategies against tick-borne diseases. In terms of checking for ticks after being exposed, 80% of participants from Connecticut reported to perform tick checks after being outdoor (Gould et al., 2008), which is in line with the 76% ("checking body") in our study. Unscrewing ticks or pulling them straight out were both perceived by about 50% of the participants as the way to remove ticks after tick bites, indicating a substantial level of uncertainty. Moreover, about half of the participants agreed that ticks should be removed by physicians only, which could potentially lead to a relevant delay in tick removal and an increased risk for transmission of tick-borne infections. However, over 95% of participants in our study knew that removing the tick immediately after a bite is an important prevention strategy recommended by the RKI (Robert Koch-Institut, 2018). Since deficits in the process of removing a tick after a bite may be associated with an increased risk of acquiring an infection, comprehensive information and education regarding post-tick bite behavior is crucial. The use of alcohol, toothpaste or oil was correctly considered

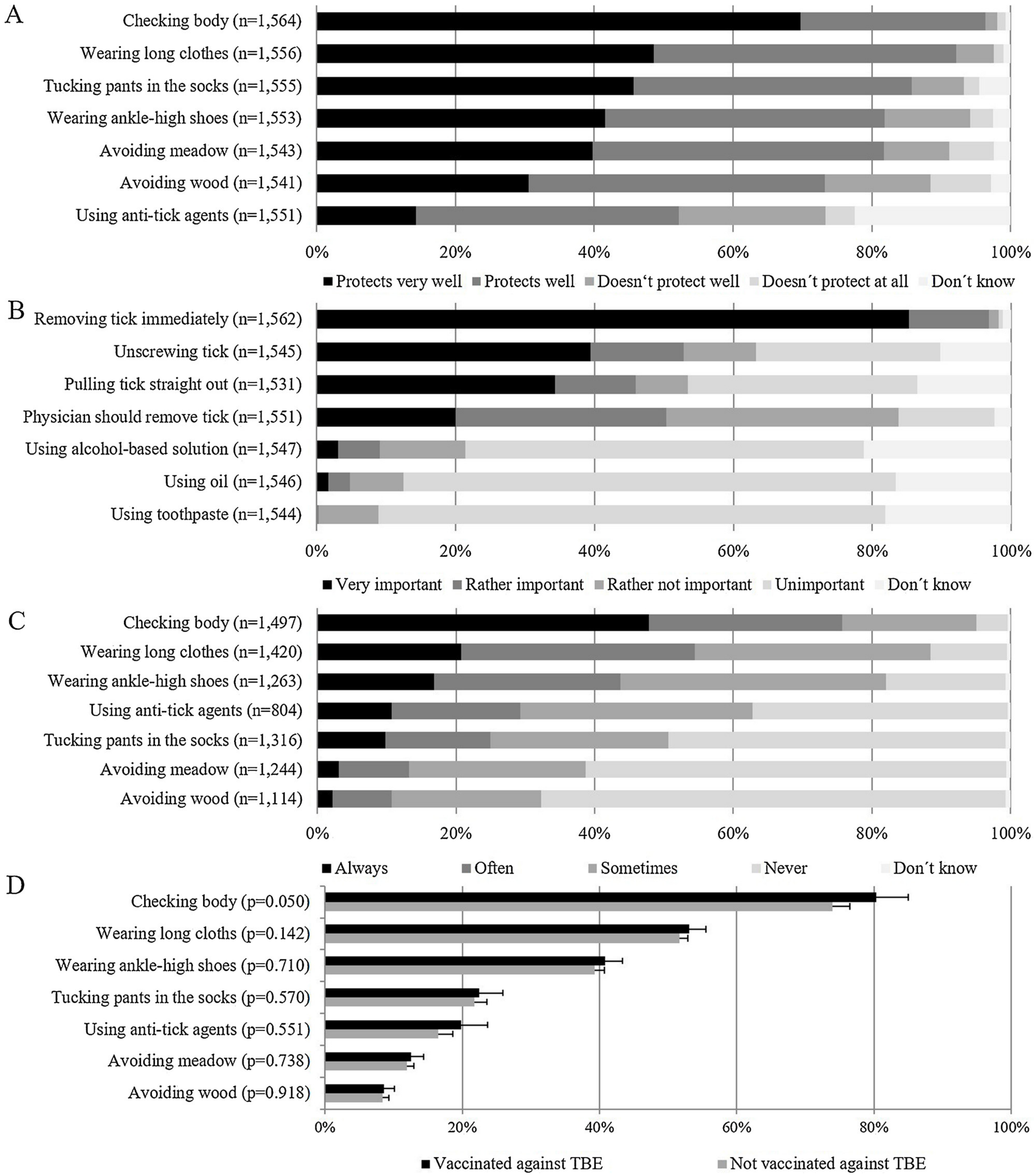

Fig. 4. Attitude of HaBIDS participants with respect to protection provided by non-specific strategies against tick-borne diseases (A) and on importance of various measures used while removing ticks (B). Implementation of non-specific prevention strategies of HaBIDS participants among those who stated that the respective strategies are (very) protective (C). Comparison of prevention strategies implemented depending on TBE vaccination status (D).
Total number (n) of observations for Figure A and B mentioned in brackets.
P-values in Figure D presented in brackets based on chi2-tests without considering "Don't know"-response and missing data for prevention strategies and TBE vaccination status.
*$p < 0.05$.

as not important by the majority of the participants. However, a proper rating of the prevention methods does not necessarily translate into the regular implementation of personal prevention measures. In comparison to surveyed individuals in a recent cross-sectional study in Delaware (Gupta et al., 2018), a state with one of the highest incidences of Lyme disease in the United States (Schwartz et al., 2017), a higher proportion of HaBIDS participants implemented personal preventive measures (always/often "checking body": 75.8% vs. 22.2%; always/often using "tick repellent": 29.2% vs. 22.4%; always/often "tucking pants into sock": 24.9% vs. 6.6%). Particularly in the view of changing climatic conditions in the future, which could lead to expanding geographic risk areas for vector-borne viral diseases (Kaaijk and Luytjes, 2018; Rubel et al., 2018), a comprehensive education of individuals about personal preventive measures against vector-borne infections is necessary.

4.1. Limitation and strengths

We observed a high vaccination coverage for a TBE non-endemic area (22.8%). Given that our results indicate that most obtained vaccinations were in line with STIKO recommendations, the high coverage might be explained by self-selection of health-conscious individuals in our study population; as mentioned above, our study participants likely represent a population with higher awareness and better information in the field of infectious diseases compared to the German general population. We used self-reported data on past diagnoses of LB and vaccination against TBE, which come with inherent limitations. We tried to minimize misclassification by recording vaccination status and LD diagnosis twice, in the main as well as in the supplementary questionnaire; moreover, we went into more detail about the circumstances of vaccination, and about clinical symptoms of LB to estimate the validity of self-reports. The proportion of participants, who reported in both questionnaires to have ever been vaccinated against TBE, was 86.2% (kappa: 0.79). Even though we excluded vaccinations performed between both questionnaires, there remains disagreement. One potential explanation might be, that the supplementary questionnaire focused mainly on various dimensions of TBE vaccination so that study participants were more likely to consult their vaccination card than in the main questionnaire which had a much broader spectrum of questions. We found a larger agreement for self-reported LB history between the supplementary and the main questionnaire. Within the supplementary questionnaire we only recorded LB diagnosis status again, but not the date of diagnosis. Accordingly, some of the differences could be explained by diagnoses in the period between the two questionnaires. In addition, we compared our findings with aggregated data of different population samples; estimated LB CUM, modeled incidences and vaccination coverages were generally in line with data from surveillance systems and population-based cohort studies.

5. Conclusion

Our study showed deficits in the knowledge about TBE vaccination in a non-endemic area for TBE; participants with a TBE vaccination history were better informed about what TBE vaccination protects against, compared to not-vaccinated ones. We observed a considerably higher TBE vaccination coverage than expected for a non-endemic area for TBE. TBE vaccination was, however, not associated with a reduced uptake of non-specific prevention strategies, which apply to TBE as well as LB.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ttbdis.2019.02.005.

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