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Climate Change Impacts on the Prevalence of Tick-Borne Diseases in Europe †

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Abstract: Climate change (changes in temperature and weather patterns) plays a significant role in the outbreak of tick-borne diseases such as Lyme borreliosis (LB) disease and tick-borne encephalitis (TBE) in Europe. The prevalence of LB disease has increased lately and TBE, one of the most serious infections of the central nervous system, significantly affects public health. Changes in abiotic factors are the main determinants affecting their vectors. The warmer weather during winter has prolonged the extension of the period in which ticks are most active. Therefore, the increased risk of transmission of tick-borne diseases influenced by the climate conditions could be determined by advanced climate models.

Keywords: Europe; climate change; temperature; tick-borne diseases

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1. Introduction

Climate change is currently one of the major challenges, since factors like significant increases in temperature, heavy precipitation, and severe droughts can affect human health by aggravating the incidence of pathogenic diseases [1]. According to the European Centre for Disease Prevention and Control (ECDC), 1510 new reports for *Ixodes ricinus* were submitted the last year (2022), increasing the rate of its distribution [2]. *Ixodes ricinus* is the most common hard species with wide geographical distribution across Europe [3]. Abiotic factors have a direct impact and biotic factors have an indirect impact on the seasonal population dynamics of the tick [4]. During the growing season, there is a greater total of abiotic factors such as relative humidity, mean air temperature, and precipitation that are related to higher *Ixodes ricinus* occurrence [5]. Relative humidity impacts the mortality rate and temperature affects the development rate, although they do not necessarily correlate. Thus, it is difficult to predict the *Ixodes ricinus* density and activity patterns [6]. Human tick exposure has been linked to changes in the geographic distribution of tick populations, the seasonal activity of questing ticks, and other biotic factors including host populations and habitats (both density and behaviours) [6].

In general, the phenological patterns of *Ixodes ricinus* depend on the climate type (freezing, intermediate, warm). In cold climates, for instance, there is a unimodal pattern, with a summer peak and a winter pause, whereas in warmer climates a late winter peak is observed. However, in many countries *Ixodes ricinus* populations have different phenological patterns due to local adaptation or phenotypic plasticity [6].

Tick-borne diseases such as Lyme borreliosis (LB) disease and tick-borne encephalitis (TBE) are widely affected by numerous climatic hazards, and thus they are characterized as climate-sensitive diseases [7]. However, the extent of human vulnerability to these diseases affected by climate change is poorly quantified. In this regard, many climate models can be used in order to make robust predictions for LB disease and TBE incidence. The aim of the current study is to provide current evidence regarding how climate changes affect the prevalence of tick-borne diseases.

2. How Climate Affects the Prevalence of LB

LB disease is the most prevalent tick-borne disease in Europe [8]. Changes in abiotic variables like relative humidity and air temperature, as well as saturation deficit, are the main determinants affecting LB vectors. Also, transmission by *Ixodes ricinus* ticks is also determined by factors such as host populations and habitats [9]. The prevalence of LB disease, especially in Western Europe, has increased lately and more than 65,000 new cases are recorded each year in endemic regions. Of note, this number may not reflect the reality since many countries in Europe do not report tick-borne case numbers [10]. For example, in Greece, limitations in the cases that are diagnosed and in the surveillance system render the true rate of LB disease undetermined [11]. On the other hand, in Lithuania, due to high prevalence rates of the disease in Europe, health authorities have decided on a mandatory registry of the disease [12]. Climate models have advanced our knowledge on how changes in climate and tick-borne diseases are related. Some countries, such as Slovenia, are using a combination of different global climate models in order to predict the prevalence of LB disease in the future. This approach has revealed that the possibility for infection could rise up to 10% by the 21st century's end, pointing out the demand for establishing prevention and alleviation strategies in order to reduce the risk [13].

Similarly, in Germany, research groups are providing robust data to better understand the LB disease epidemiology since LB remains an important public health concern with marked regional variation [14]. A recent study in south Germany suggests extreme changes in tick behaviour, e.g., that the nymphal questing peak would shift towards early seasons of the year. For the investigation of tick activity, they developed a cohort-based population model influenced by 15 different climate models [4]. This shift in nymphal questing may affect the disease onset, the peak of which is in July [14].

Temperature changes are the main determinant that influences LB prevalence. Health authorities should be aware of the risk of its prevalence in order to develop strategies such as quick tick removal, the prevention of tick bites, and medical advice in order to protect the general population [9]. For this reason, accurate predictive models (climate models) can be used. For example, in Slovenia, a country which has a high level of reported confirmed cases of LB disease, uses five significantly different models of the world climate according to the RCP 8.5 climate scenario in order to calculation the infection risk of LB disease. It is emphasized that the risk of infection could rise by up to 10% by the end of the century, underscoring the necessity for better mitigation plans and the adoption of preventive measures [13,15].

3. How Climate Affects the Prevalence of TB

TBE is one of the most potentially serious neuroinfections widely distributed in Eastern, Central, and Northern Europe [16]. The aetiological factor of TBE is the tick-borne encephalitis virus (TBEV). Humans are infected if they are bitten by an infected tick and, infrequently, by consuming unpasteurised milk and cheese from domestic ruminants [9,17]. Milder winters and an early occurrence of spring due to climate change has accelerated tick development and may cause an augmentation in hosts' populations to maintain greater tick populations [18]. Consequently, humans are exposed to TBEV for a longer period, beyond July and August, and this may explain the increasing prevalence of TBE in the last years. Indeed, since 2015, a growing number of confirmed cases have been observed, with the involvement of countries in which TBE has been reported for the first time [19]. In Greece, during the last 10 years, eight cases of TBE have been recorded for the first time, a phenomenon which is associated with economic, environmental and climatic factors [20,21]. Moreover, the increased number of TBE cases in the era of COVID-19 is a paradoxical phenomenon. Two hypotheses can explain this increase: (a) changes in human behaviour, such as an increase in dangerous outdoor activities, put more people at risk of contracting TBE, and (b) there is limited access to specialized diagnostic tests for the disease due to overburdened healthcare resources [18]. Interestingly, this increase may be under-estimated since there are limited clear-cut and specific diagnostic methods and inadequate training of professionals [19]. Mathematical models for the risk assessment of TBE prevalence could become useful tools for countries concerning the identification of high-risk areas of TBE transmission. Scientists in Hungary have developed a useful method for calculating the transmission risk of TBE using climate data. They have observed a gradual increase of the temperature, resulting in an enhanced transmission potential of TBEV [22]. In Finland, researchers have used eight different predictive modelling methods and have provided a new distribution map that contains high-risk areas for TBE transmission [23]. Although these models are really important for the implementation of mitigation plans, they have some limitations in their use. For example, the research mentioned above omits information on microclimatic circumstances (land use/cover change), which could significantly impact tick and host animal habitat compatibility [13].

4. Conclusions

In conclusion, changes in temperature and weather conditions significantly affect the transmission of tick-borne diseases, and advanced climate models have to be used by European countries in order to reduce the threat of the high prevalence of the tick-borne diseases.

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