# **Epidemiological Trends of Trans-Boundary Tick-Borne Encephalitis in Europe, 2000-2019**

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**Ethics Statement**

The authors confirm that the ethical policies of the journal, as noted on the journal’s author guidelines page, have been adhered to. No ethical approval was required as this is a review article with no original research data

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# **Summary**

Tick-borne encephalitis is a neuroinfection caused by the Tick-Borne Encephalitis Virus. It is transmitted primarily by tick bite and rarely because of consuming raw milk. It has been discovered in the 1930s. The disease covers the Euro-Asia region which also known as the tick-borne encephalitis belt. It is prevalent in most parts of Europe. The top affected parts of Europe include Southern Germany, Switzerland, the Czech Republic, Austria, Slovakia, Hungary, the Baltic countries, Slovenia, Poland, parts of Scandinavia, and European Russia. Since 2000, in Europe the total number of confirmed cases reported to the European CDC was 51,519.   There were signs of decreasing number of cases in 2014 and 2015 however after 2015 a steadily increasing number of cases with involvement of countries which had no history of tick-borne encephalitis. Within Europe, from 1950 to 2006 ticks were prevalent between 600 to 2000 meters above sea level of altitude. The determinant factors for the spread of tick-borne encephalitis are host population size, weather, movement of hosts, altitude, and local regulations on socio-economic dynamics of the local and travelling people around the foci areas. The mean incidence rate of tick-borne encephalitis since 2000 to 2019 in Europe was 3.27 while the age adjusted mean incidence rate was 2.19 per 100,000 population size. The recent increase is mainly associated with human activity as a dominant factor since there are new foci areas with no significant climate change. This review used several articles and data sources from the European Center for Diseases Prevention and Control and Polish National Public Health Institute to examine the trend of TBE across Europe and in Poland in particular.

Keywords: Tick-borne encephalitis; Tick-borne encephalitis virus; Trend; climate change; ticks

# **Introduction**

Tick-borne encephalitis (TBE) is a viral infectious disease that affects the central nervous system caused by the Tick-Borne Encephalitis Virus (TBEV). It appears as mild, moderate, and complicated features with the possibility of having long-lasting neurologic sequelae. Mainly, it is transmitted by a tick bite and rarely through the ingestion of raw milk (Deviatkin et al., 2020). The transmission is between ticks, rodents, and humans. Human is the dead-end host of TBEV (Lindquist & Vapalahti, 2008). *Ixodidae* ticks are vectors that transmit TBEV (*The Ecology of Ticks and Epidemiology of Tick-Borne Viral Diseases | Elsevier Enhanced Reader*, 2014). There are three common subtypes of TBEV known as European (TBEV\_Eu), Siberian (TBEV\_Sib), and Far-Eastern (TBEV\_FE). The three antigenically closely related subtypes are carried primarily by *Ixodes ricinus* (European subtype) and *Ixodes persulcatus* ticks (Siberian and Far-Eastern subtypes) (Lindquist & Vapalahti, 2008). Recently, two more subtypes called Baikalian (TBEV-Blk) and Himalayan (TBEV-Him) are also discovered (Dai et al., 2018; Holding et al., 2019). *Ixodes ricinus* ticks are prevalent throughout Europe, from Ireland in the west to the Urals in the east, and from northern Sweden to North Africa from north to south (Estrada-Peña et al., 2013). Birds, sheep, goats, horses, rodents, dogs, and other animals are also hosting the virus apart from humans (European Centre for Disease Prevention and Control., 2012). The Euro-Asia region is traditionally known for the prevalence of TBE with a varying degree of distribution (Deviatkin et al., 2020). TBEV\_Eu causes neurological sequelae in up to 10% of cases contracted by the virus with a mortality rate of <2% (Bogovic, 2015; Pulkkinen et al., 2018; Ruzek et al., 2019). TBEV-Sib causes prolonged infection compared to other sub-types while TBEV-FE patients show high rates of neurological sequelae outcomes (Bogovic, 2015).

The discovery of TBE goes back to 1930 by the former Union of Soviet Socialist Republics (USSR) scientists during a war between USSR and Japan after it has affected several army members. The first subtype discovered was the Siberian subtype. There was confusion between TBE and Japanese encephalitis until scientists conducted a study and confirm that they are different and the route of transmission of TBE is not airborne (Zlobin et al., 2017). The western subtype was reported as seasonal meningitis from lower Austria (Barrett et al., 2003). However, the discovery of TBEV is only in the 20th century, there are ancestral remaining evidence before 1632(814-4790), 722(401-1272), and 888(510-1395) years of most recent ancestral time (tMRCA) and (95% high probability density (HPD)) for European, Siberian, and Far-Eastern subtypes respectively (Deviatkin et al., 2020). Researches on vaccine development for TBEV have been initiated since 1970 (Barrett et al., 2003).

Ticks have a long-life cycle that the virus can survive throughout their developmental stages. Non-infected ticks get infected during co-feeding (Deviatkin et al., 2020). TBEV persists in the metamorphosis of ticks by staying non-infective (N. A. Hartemink et al., 2008). The life cycle of ticks is affected by microclimate, host factors, and seasonal variation. During colder seasons, the activity and development of ticks are limited while warmer seasons made them active. The modality of hosts also determines the spread of ticks (*The Ecology of Ticks and Epidemiology of Tick-Borne Viral Diseases | Elsevier Enhanced Reader*, 2014). Ticks become active during vegetation seasons with the adequacy of water and raised temperature. The access to increased water help ticks to ascend to the upper part of grasses then opportunities of attaching to their host are higher. During molting time, the size of ticks shrinks with the release of water and hardening of the skin. This is the time ticks get ready for winter seasons until the next spring (Kahl & Alidousti, 1997).

Globally, TBE covers the geographical areas of Japan, China, Russia, south Europe, central Europe, and north Europe. In Europe, the most strongly affected countries are southern Germany, Switzerland, the Czech Republic, Austria, Slovakia, Hungary, the Baltic countries, Slovenia, Poland, parts of Scandinavia, and European Russia (Lindquist & Vapalahti, 2008). New foci are being found in recent decades. The disease is spreading to countries that were not familiar with it like foci areas reported from northern Europe (Figure 1A) (Hrnjaković Cvjetković et al., 2016). The distribution of *Ixodes ricinus* is widely seen in most European countries (Figure 1B).

# **Factors affecting TBEV transmission**

Among others, factors including socioeconomic change, climate change, seasonal variations, and individual characteristics influence the risk of TBE spread. The extended and warmer summer and increased population size of hosts favor the survival of ticks and microbes out of their known habitats (*A Clear and Present Danger*, 2020.; Gray et al., 2009; S. E. Randolph, 2000). As there is an extended and warmer summer, the dynamics of the other seasons would also be changed in a way that is comfortable for ticks' life (Gray et al., 2009). Mild and shorter winters are followed by rainy summers. Rainy summer helps the grass to grow effectively so that ticks can climb and infest humans and other hosts. As it has been seen ticks remained active between March and December because of the climate change with shorter winters. The duration of the convenient season for tick's activity is getting longer after the year 2000 (Jaenson et al., 2012). Climate changes affect the survival, reproduction, interaction, and movement of ticks. The prevalence of TBE has been growing over time which also is true for climate change over the past century. However, cases are reported from new areas because of occupations related to increased human need and capability of accessing places that are hard to reach in the past regardless of the insignificant climate changes seen in some places (Ostfeld & Brunner, 2015). On the other hand, vector-borne diseases including TBE are expanding to the northern latitude due to the extension of the terrestrial range for relevant vector species and their vertebrate hosts (Omazic et al., 2019).

During the winter season, ticks hide into the soil and digest the blood ingested during their questing time. To become active, warmer temperatures and humidity are needed to exit from the soil and ascend into vegetation (Ogden et al., 2004; Ostfeld & Brunner, 2015). Ticks can be active in dry seasons looking for hosts and food however such condition limits their longevity (Nieto et al., 2010). Ticks become active at the temperature of 8ºC and humidity of 70-80%. European subtype (adult tick) is most active in the period of May-June and September-October (Hrnjaković Cvjetković et al., 2016).

Although climate change is known for the increased spread of several infectious diseases including TBE, socioeconomic changes also play a comparable role. The end of the Soviet era has caused a surge in the number of TBE cases among countries that had the influence of the planned economy. This is related to the change in the reaction of people to their environment. The land use and cover change and the increased leisure time make people interact more in the free economy (Sarah E. Randolph, 2010). Socioeconomic changes have a long-term effect on TBE distribution by changing the whole interaction of humans with the environment as it is seen in the free economy (S. E. Randolph & Team, 2010).

Despite the changing climate and its effect on the rise of TBEV, predictions show that the foci are spreading to the Northern part of Europe while the number of cases is shedding in central Europe. The spread is expected to be limited to Poland and the Baltic area in 2050 and the Southern part of Scandinavia by 2080. The changing climate will not be comfortable for the spread of TBEV in its human and enzootic hosts (S. Randolph, 2002; S E Randolph & Rogers, 2000).

The number of human cases reported to the European CDC has a seasonal variation with a bimodal distribution that pick number of cases reported between June and August followed by the second pick in October. The majority (95%) of cases are reported from May to November (*Tick-Borne Encephalitis - Annual Epidemiological Report for 2018*, 2019). The recent increased incidence rate is also associated with the advancement of diagnosis and establishment of mandatory reporting and surveillance systems, while in the past a considerable proportion of cases remained either undetected or unreported (Amicizia et al., 2013).

The population of ticks depends on the density of hosts though all hosts are not competent to transmit the virus. The composition of hosts in a specific area determines the impact of hosts on tick survival. The higher proportion of non-competent hosts reduces the transmission of TBEV by minimizing the number of tick bites (N. Hartemink & Takken, 2016). Conversely, the declined number of hosts like the deteriorating number of deer left humans to be the most available host for questing ticks and feeding nymphs (Jaenson et al., 2012). On the other hand, changing the land use and cover also facilitate the suitability of landscapes for human accessibility. Access to tick-populated areas by humans eventually leads to an increased chance of getting tick bites (N. Hartemink & Takken, 2016). Converting agricultural fields to forests creates a convenient environment for hosts and tick's survival yet the population of mammal hosts is reduced in agricultural fields (Knap & Avšič-Županc, 2015).

The exposure to ticks is also increased with the movement of people (Jaenson et al., 2012). The human movement to tick populated places is a potential factor for the enhanced spread of both ticks and TBE. People could move to forest areas for such activities as hiking and picking. In 2007 only, 78 Million people travelled to TBE endemic areas within Europe uninformed about the disease (Süss et al., 2010).

# **Migration of TBE sub-types**

In recent decades, the European strain of TBEV has spread into non-endemic areas. A phylogenetic analysis conducted in Hungary (2011-2016) has found that there were strains that have the contents of Finland, Germany, and Russia. Trans-boundary migratory birds were supposedly responsible for the movement of other countries’ strains (Egyed et al., 2018). Although subtypes were believed found in specific areas, evidence showed that variants were found out of their known endemic area. The Siberian was found in the northernmost part of Europe including Finland (Jääskeläinen et al., 2010), Estonia, and three of the subtypes were found in the Crimean Peninsula (Yurchenko et al., 2017).

Shreds of evidence are showing either the appearance of TBEV in new areas or re-emergency of TBE. In the United Kingdom, the first TBEV was reported in May 2019 found in ticks collected from deer (Holding et al., 2019). In Northern Germany, ticks were found positive for TBEV after 15 years of absence within the area either for low activity of ticks or absence of the virus and reappearance through the agent of migratory birds (Frimmel et al., 2014). The first autochthonous cases of TBE were reported in Moscow in 2016 along with detection of TBEV in ticks and small mammals (Makenov et al., 2019). Migrating birds of short distances migrated from southwest Europe and long-distance migratory birds from Africa carried TBEV infected ticks as reported from Northwest Europe (Kazarina et al., 2015).

The altitude limit is one of the dynamic factors that affect tick population which also principally affects climate, therefore, affects the threshold of ticks. The altitude convenient for ticks in the past was limited to the lower part of Europe. However, other conditions impact tick density regardless of the altitude level like proximity to the ocean, humidity level, and vegetation. In general, ticks can survive between 600-2000 meters above sea level altitude with other required elements for their survival (Table 1). With all the arguments that climate change impacts tick’s survival, there is no clarity of the direct relationship between climate change and tick population change (Sarah E. Randolph, 2010; S.e, 2008). Rather, multiple factors combined contribute to the risk of rising TBE. Recently peoples’ preference for climbing mountains is increasing as a way of recreation, at the same time ticks adapt to high altitudes as new foci because of climate change-induced wormer weather (Sarah E. Randolph, 2010; S.e, 2008; Süss et al., 2010).

Table 1. Tick availability with altitude change over time from 1950-2006

| Year | Country | Altitude (meter above sea level) | Condition |
| --- | --- | --- | --- |
| 1950 | Bosnia Herzegovina | <800 | (48) |
| 1957 | Scotland | 700 | (Daniel et al., 2003) |
| 1960 | Bosnia Herzegovina | 900 | (48) |
| 1980 | Poland | 700–750 | Krkonose mountainous area (*Tick-Borne Encephalitis Virus Expansion to Higher Altitudes Correlated with Climate Warming - ScienceDirect*, 2008) |
| 1997 | Italy | <1300 | presence of limestone and vegetation cover with thermophile deciduous forests and high densities of roe deer(Rizzoli et al., 2002) |
| 1990s | Scotland | >=700 | (Daniel et al., 2003) |
| 2001 | Scotland | 1100 | (Daniel et al., 2003) |
| 2002 | Poland | 1180 | Krkonose mountainous area (*Tick-Borne Encephalitis Virus Expansion to Higher Altitudes Correlated with Climate Warming - ScienceDirect*, 2008) |
| 2006 | Poland | 1250 | Krkonose mountainous area (*Tick-Borne Encephalitis Virus Expansion to Higher Altitudes Correlated with Climate Warming - ScienceDirect*, 2008) |
| 2008 | Austria | >1500 | Alpine pasture(Cagnacci et al., 2011) |
| 2008 | Greece | >600 | Arid parts of Europe typical of the Mediterranean |
| 2010 | Bosnia Herzegovina | 1190 | (Medlock et al., 2013) |
| 2013 | Spain | 2000 | Atlantic influence (i.e., greater humidity)(Medlock et al., 2013) |
| 2002-2006 | Czech Republic | 620–1270 | (Medlock et al., 2013) |
|  | Switzerland | 1450 | mountainside(Medlock et al., 2013) |

Controlling TBEV is extremely difficult because of the life cycle they passed through the arthropod vector and reservoir host without involving humans (Kaaijk & Luytjes, 2018). TBE has no definitive treatment other than supportive treatment and ICU support if complicated (Riccardi et al., 2019). Therefore, the vaccine has an irreplaceable role (Riccardi et al., 2019; Taba et al., 2017). In Austria, effective vaccination prevents TBE appearance from 96-99%. The vaccine coverage between 2000-2011, the number of cases has decreased by more than 4000 cases of TBE (Kaaijk & Luytjes, 2018). Two TBE vaccines are mainly available in Western Europe known as Encepur and FSME-IMMUN (Kollaritsch et al., 2012). The first vaccine utilized in Europe was FSME-IMMUN® (Pfizer, USA) in 1976 followed by Encepur®(GlaxoSmithKline) from Germany in 1991. Vaccines offer the best defense against TBEV. Vaccination against TBEV is highly recommended in areas with an annual incidence rate of greater than five per 100,000 populations. However, it is recommended for inhabitants in risky areas too. Travellers are also highly recommended taking the vaccine if they have a high engagement of outdoor activity in their stay in risky areas. Apparently, it is advisable to use post-exposure prophylaxis as one way of prevention (Taba et al., 2017). Specific anti-TBEV immunoglobulin is recommended taking in Russia and Europe. In Russia, it remained under use while Europe prohibited for its enhanced antibody diseases effect in naïve individuals (Ruzek et al., 2019). Apart from the preventive vaccines, the therapeutic anti-TBEV\_Si vaccine is also available for those who developed chronic outcomes (Ruzek et al., 2019).

## **Epidemiological Trends of TBE 2000-2019**

This review draws data from the European CDC collected from European Union/European Economic Area member countries. The number of countries with TBE report in the ECDC has been increased from 12 in 2000 to 25 in 2019. The data is part of the ECDC surveillance (Table 2). Data are used as per the data use protocol of ECDC. The database is classified into two parts as 2000-2010 and 2012-2019. The 2000-2010 part has a total number of reported cases, total number of confirmed cases, and classification per sex per country. The 2012-2019 report has a total number of cases, confirmed cases, confirmed cases per 100,000 populations, confirmed cases adjusted for age per 100,000 population. Map of each variable is included in the database although only selected maps are used in this review. To show the historical background of TBE, several pieces of literature from diverse sources have been included. Concerning the case of Poland’s TBE trend, Polish National Public Health Institute has been used as a source of data by compiling extracts of data from each year’s report from 1999-2019.

| Table 2. The number of confirmed cases reported to ECDC and the number of countries involved in each year 2000-2019 | | |
| --- | --- | --- |
| Year | Number of countries reported | Number of confirmed cases reported |
| 2000 | 12 | 2629 |
| 2001 | 14 | 2497 |
| 2002 | 14 | 1952 |
| 2003 | 14 | 3225 |
| 2004 | 14 | 2481 |
| 2005 | 15 | 2651 |
| 2006 | 15 | 3756 |
| 2007 | 15 | 2267 |
| 2008 | 16 | 2513 |
| 2009 | 16 | 3513 |
| 2010 | 16 | 3155 |
| 2012 | 21 | 2149 |
| 2013 | 22 | 2904 |
| 2014 | 24 | 1985 |
| 2015 | 24 | 1908 |
| 2016 | 25 | 2680 |
| 2017 | 25 | 2916 |
| 2018 | 26 | 3092 |
| 2019 | 25 | 3246 |
| Total |  | 51519 |
| *Source: Data from ECDC (https://register.ecdc.europa.eu/)* | | |

In the past nineteen years among European Union/ European Economic Area member countries listed in (Table 3) with a total number of 51,519 confirmed TBE cases reported to ECDC. The mean incidence rate per year within the region was 3.26 and the mean age-adjusted incidence rate of 2.19 per 100,000 populations per year. The number of countries enrolled in the report has been increasing over the years. Lithuania, Latvia, and the Czech Republic had 13.66, 9.95, and 6.14 cases per year respectively per 100,000 populations the highest incidence rate per year. This doesn’t mean that there are no places with a greater incidence rate (Figure 2).

Table 3. Number of TBE cases, number of years the country has reported, mean incidence rate 2000-2019 in Europe

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Country | Number of years | Confirmed cases reported | IR/100,000 | | Age-Adjusted IR/100,000(2012-2019) |
| Czechia | 19 | 12055 | 6.14 | | 5.50 |
| Lithuania | 19 | 8178 | 13.66 | | 15.64 |
| Germany | 19 | 6089 | 0.41 | | 0.43 |
| Latvia | 19 | 4184 | 9.95 | | 6.60 |
| Poland | 19 | 3933 | 0.54 | | 0.41 |
| Slovenia | 19 | 3877 | 10.12 | | 6.34 |
| Sweden | 19 | 3345 | 2.48 | | 2.85 |
| Estonia | 19 | 2761 | 10.86 | | 7.73 |
| Slovakia | 19 | 1734 | 1.69 | | 2.15 |
| Austria | 19 | 1562 | 0.97 | | 1.10 |
| Switzerland | 11 | 1302 | . | | . |
| Hungary | 19 | 878 | 0.46 | | 0.24 |
| Finland | 19 | 787 | 0.77 | | 1.07 |
| Italy | 18 | 312 | 0.03 | | 0.03 |
| Croatia | 8 | 189 | 0.56 | | 0.53 |
| Norway | 19 | 186 | 0.20 | | 0.30 |
| France | 8 | 67 | 0.01 | | 0.01 |
| Romania | 19 | 26 | 0.01 | | 0.01 |
| Netherlands | 4 | 16 | . | | . |
| Belgium | 8 | 14 | 0.02 | | 0.02 |
| United Kingdom | 8 | 9 | 0.00 | | 0.00 |
| Denmark | 1 | 4 | 0.07 | | 0.07 |
| Bulgaria | 6 | 4 | 0.01 | | 0.01 |
| Greece | 8 | 4 | 0.00 | | 0.01 |
| Luxembourg | 6 | 1 | 0.03 | | 0.03 |
| Ireland | 8 | 1 | 0.00 | | 0.00 |
| Spain | 8 | 1 | 0.00 | | 0.00 |
| Total |  | 51519 | 3.26†† | | 2.19†† |
| Source: Data from ECDC (https://register.ecdc.europa.eu/)  ††mean incidence rate; IR: Incidence Rate | | | |

The calculation is the national figure however in countries like Poland in its eastern and northeast regions the incidence rate is closer to the national incidence rate of Lithuania. The number of cases between 2000 and 2013 was variable that increased in some years and decrease in the other year; however, the number of confirmed cases is steadily increasing from 2015-2019. As it is mentioned above, vaccination is recommended in areas with >5 cases in the 100,000 population. The annual incidence of countries TBE in most European countries is <5 but the incidence rate in foci areas within one country is >5. Therefore, greater attention should be given to foci areas. For example, Poland has different incidence rates across regions, but the two regions had far more incidence rates than the other regions.

The annual number of cases in Europe is increasing between 2000 and 2019 though there is no linear relationship along with time. However, the number of cases is expected to increase with an increased number of countries conducting mandatory surveillance and reporting, the number has no significant increase. In some years, the possibility of the staggering incidence rate of TBE is highly possible because the ice burg effect visible and reported is small with enormous potential of zoonotic cases. TBE would spread while the invisible and epidemiologically undetermined zoonotic cases got exposures to its transmission pathways. Therefore, we cannot predict the number of human cases based on the available affected number of people since the virus could keep spreading as enzootic without showing up as human cases (S. Randolph & Sumilo, 2007).

Before the year 2010, the number of countries that reported their cases of TBE to ECDC was less than 15 while the most recent report included 25 countries. However, keeping that the increasing number of countries reporting, the 2019 number of cases (2977) is lesser as compared to 2006 (3776), 2009 (3513), and 2010 (4049). The declining incidence rate can be associated with prevention measures like vaccination. Vaccination is confirmed to be an important measure for the declined incidence of TBE as it has been seen in Austria (Barrett et al., 2003; Kollaritsch et al., 2012; S. Randolph & Sumilo, 2007). This has been also seen between the years 1993-2006 with a sharply increased number of cases with an amount of 200% in Germany and Switzerland and 60% increase reported in Poland. But afterward, the number has declined except for the expansion of the foci area to Northern Europe (Süss et al., 2010).

The number of cases reported varies with season. The number starts to rise in March and got its peak in August and decline in October (Figure 3).

As age rises the number of cases with TBE also rises that the likely reason for people with increased age is their vulnerability to infection because of either their declined immunity or vulnerability of being infested by ticks (Figure 4). People with age >50 years move across Europe without enough awareness about TBE and protecting themselves as compared to the other age group. People in this age group are promptly at higher risk of TBE (Süss et al., 2010).

# **TBE Trend in Poland**

According to the Polish National Public Health Institute, the total number of TBE cases reported from the 16 voivodships of Poland from 1999 to 2019 was 4791 (*Bulletins, Reports, Epidemiological Information*, 2021). Most of the cases were reported from the three eastern and northeastern regions. Podlaskie had the most with a 2263 total number of cases that encompasses 47.23% of the total cases reported in the past 21 years. The second most affected region that borders Podlaskie in the North is Warminisko-Mazurskie with a case number of 1246 from 1999-2019. Podlaskie and Warminisko-Mazurskie continued as the most affected regions above the national average rate of TBE per 100000 population size from 1999 to 2019.

Although most of the cases were reported from eastern and northeastern regions, Dolnoslaskie came to be the fourth affecter region with 188 cases situated in the western part of Poland. Mazowieckie had a lesser number of cases in the early 2000s, however, the number of cases made the third most affected region except in 2005 that Opolskie had dominated it. Since 2010 the curve of Dolnoslaskie had continuously increased except in 2015 that the number has slightly declined. Since 2015, Dolnoslaskie and Lubelskie have shown a persistently increasing record of cases (Figure 5) (*Bulletins, Reports, Epidemiological Information*, 2021).

However, Mazowieckie had the third most frequent number of cases, Opolskie and Swietokrzyskie had a greater average rate of 0.60 and 0.39 cases in 100,000 from 1999-2019 populations at risk respectively (Figure 5 and Figure 6). The 21 years national average rate was 0.6 while Podlaskie and Warminisko-Mazurskie had a far greater average rate of 9 and 4.13 cases per 100,000 populations, respectively. In recent years, the number of cases and rate of TBE in Dolnoslaskie and Lubelskie is rising although the curve of other regions is variable with time. This shows that TBE is spreading from eastern and north-eastern Poland to southeast and southwest Poland. This needs further investigation whether the number of reported cases emerging in these regions is associated with domestic expansion or migrated from neighbouring countries. From a poison's regression considering the number of cases against the changing time over the years, the national trend is statistically significantly increased with a 0.004 number of cases (P<0.001) per year (*Bulletins, Reports, Epidemiological Information*, 2021).

## **Conclusion**

TBE is a disease that has been known since the 1930s and persisted to have been one of the vector-borne diseases in the Euro-Asia region. The geographical distribution of TBE has been changing over time. It has expanded to places where it was impossible to find in the past. The subtypes are moving from their known endemic area to new places because of a multitude of factors despite the efforts made to deter the spread of the diseases like the use of vaccines and other public health risk preventive measures. A combination of climate change, socioeconomic changes, seasonal variation, and individual characteristics like increased age and occupation are key factors for the spread of TBE.

The number of confirmed cases is assumed to be far less than the expected number of cases. The under-identification of cases could be related to a lack of clear-cut and specific diagnostic methods and orientation of professionals. Dynamic identification of foci areas is also important that can help find the continuously changing expansion of TBE.

Socioeconomic changes are more important than climate change for the expansion of TBE. Effective vaccination has been proven as an effective measure to control the TBE spread. The trend of TBE is not consistent over the years. There was an increasing pattern in the second half of the 1990s and the beginning of 2000. It again declined for some years however since 2015 the pattern is increasing. However, predictions showed that the spread of TBE will be limited to specific areas like the Baltic area and Finland and 50 years-time. Generally, an integrated public health intervention is important to deter TBE within Europe including vaccination, disease detection, consider TBE as a travel health public health important disease.

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