DOI: 10.2478/fv-2023-0031

FOLIA VETERINARIA, 67, 4: 1—9, 2023

BACTERIAL VECTOR-BORNE ZOONOTIC DISEASES AND ONE HEALTH APPROACH. A REVIEW

Frida L. Aasegg[1, 2], Maroš Kostičák[1], Anna Ondrejková[1], Ľuboš Korytár[1], Monika Drážovská[1], Boris Vojtek[1], Andrea Pelegrinová[1], Marián Prokeš[1]

[1]Department of Epizootiology, Parasitology and Protection of One Health, University of Veterinary Medicine and Pharmacy in Košice, Komenského 73, 041 81 Košice
Slovakia

[2]Faculty of Biosciences and Aquaculture, Nord University, Post Box 1490, 8049, Bodø
Norway

maros.kosticak@uvlf.sk

ABSTRACT

One Health is a collaborative, multisectoral, and transdisciplinary approach with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environments. The main goal of this paper is to highlight the significance of the One Health concept in relation to the large group of diseases that transmits through arthropods and their worldwide distribution, with a closer look at the zoonoses. The importance of knowledge increases as the globalization and climate changes increases the likelihood of transmission, as both cause favourable conditions for transmission of bacteria and viruses. The increase in reservoir abundance, climate change, changing habitat structure, socio-political changes, and import of animals for welfare reasons, trade and traveling are considered to be potential factors for the pathogen and vector introductions to new areas. This article highlights the selected agents of bacterial zoonoses as sources of human and animal diseases and shows the number of cases of Lyme disease, which is the most common bacterial tick-borne disease in humans in Slovakia and Norway, and the trend in incidence over the past twelve years.

Key words: One Health, Slovakia; Norway; vector-borne diseases; zoonoses

INTRODUCTION

Veterinary and human medicine differed only slightly in the early days. The same healers would take care of both humans and animals. During the middle age, human medicine became part of the medieval universities, while veterinary medicine did not. After the first veterinary school was established in 1762, it wasn't until the 19th century that scientists started considering the link between veterinary medicine and human medicine again, owing to the observation of the same diseases in both species [54].

A One Health approach describes cooperation between different disciplines that together develop strategies for better human, animal and environmental health. Collaboration between disciplines is now recognized as being critical to addressing potential pandemics due to zoonotic agents and the spread of diseases as a result of climate change [5, 45]. As there isn't currently a single, widely accepted definition for One Health, there are many distinct definitions of the concept. The most common definition, shared by the Centers for Disease Control and Prevention is "One Health is defined as a collaborative, multisectoral, and transdisciplinary approach – working at the local, regional, national and global levels - with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants and their shared environments" [21].

The concept of One Health was proven essential when facing pandemics such as SARS in 2003, and Coronavirus in 2020, as both viruses were zoonotic, spreading from animals, and caused a threat for human health and the world economy. The control of antimicrobial resistance, food and water safety, preventing zoonotic disease transmission, managing pollution and preventing pandemics are all important components of One Health.

The COVID-19 pandemic has caused massive damage to the world economy and imperiled human lives everywhere. The ignorance of the principles of One Health approach in the current health care system has proved to be the Achilles heel of our health policy. Social distancing, lockdown, and hand hygiene are short-term preventive measures imposed by nations worldwide; but are difficult to sustain in the long run. Thus, it is long overdue that we change our unidimensional approach regarding the control and prevention of diseases [18].

One Health – sectors cooperation

As the One Health approach works towards better health for animals, humans and the environments and ecosystems, there is a need for both veterinarians, medical doctors, and researchers with expertise in all three aspects. The three key components in One Health concept are shown in the Fig. 1. In 2010, a tripartite collaboration was formed between the Food and Agriculture Organization of the United Nations, the World Organization for Animal Health and the World Health Organization. The goal of this tripartite collaboration was to provide the multi-disciplinary perspective for an efficient and better management and coordination of the One Health approach [15].

The aim of One Health

The goal of One Health concept is to be able to implement programs, politics, laws and science where more sectors cooperate and communicate to achieve a better public health. The One Health approach aims to improve global food and water safety, reduce disease transmission risks, and ensure that all living beings have sufficient resources of nutrition. Preventing zoonotic diseases from evolving into endemics or pandemics is one of the key goals. When it comes to reaching the Sustainable Development Goals (SDGs), the One Health concept is particularly crucial [26]. The 17 SDGs were jointly developed by the United Nations to strive toward a collaboration in enhancing global health and education, promoting greater equality, protecting wildlife, oceans, and forests. All member nations were required to adopt the goals by 2015, and the aim is for the goals to be reached by 2030 [40].

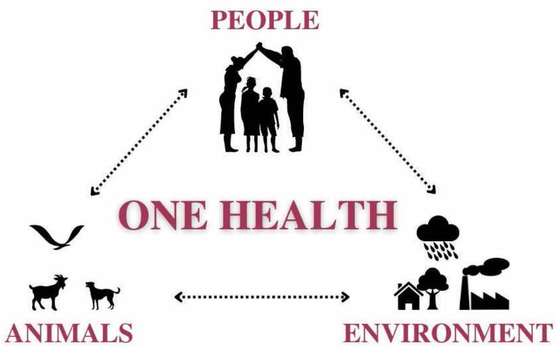

Fig. 1. Three key components in the One Health concept

Ticks as vectors

Ticks are found globally, in various habitats. There are 900 species identified, which are mainly divided into two groups, the hard ticks, Ixodidae, and soft ticks, Argasidae. Ixodidae are the biggest family, with close to 700 species, and is divided into 7 genera, where the main genera are: *Amblyomma*, *Dermacentor*, *Haemaphysalis*, *Hyalomma*, *Ixodes* and *Rhipicephalus* [3]. Ticks are the most important vectors of human pathogens, leading to increased public health burdens worldwide. The tick-borne pathogens include viruses (e.g. tick-borne encephalitis); bacteria, such as the causative agents of Lyme disease, spotted fever rickettsiosis and human anaplasmosis; and malaria-like protozoan parasites causing babesiosis. Tick-borne diseases are emerging due to the geographical expansion of their tick vectors, especially in the northern hemisphere [34, 52]. Given ongoing climate change, it is desirable to intensify efforts to prevent and control the spread of vectors capable of transmitting infectious disease agents, especially zoonoses [33].

Climate change and zoonotic diseases

Climate change can have a complex impact that also influences human and animal health. For example, climate change alters the conditions for pathogens and vectors of zoonotic diseases. With these changes come new challenges for maintaining human and animal health [20]. Climate change has improved the living conditions of ticks substantially. One of the consequences is an increased distribution of ticks and a rise of the Lyme borreliosis incidence [46].

The influence of global warming and geoclimatic variations on zoonotic disease epidemiology is evident by alterations in the host, vector, and pathogen dynamics and their interactions [14, 37].

The Intergovernmental Panel on Climate Change reported with a high confidence that the prevalence of vector-borne diseases has increased in recent decades and that the prevalences of malaria, dengue, Lyme disease, and West Nile virus infection in particular are expected to further increase during the next 80 years, if measures are not taken to adapt and strengthen the control strategies [16].

Climate change has a major impact on seasonal weather patterns, resulting in marked phenological changes in a wide range of taxa. However, empirical studies of how changes in seasonality impact the emergence and seasonal dynamics of vector-borne diseases have been limited [11].

Lyme borreliosis has an increasing prevalence of infections, as the summers in certain regions are getting longer, and therefore increasing the most active time for the ticks transmitting the disease. The disease is spreading further north, as the weather is getting warmer, with the association of the expansion of ticks for example in Norway and Canada. [48].

Vector-borne diseases

Vector-borne diseases have been the scourge of man and animals since the beginning of time. Historically, these are the diseases that caused the great plagues such as the ‘Black Death’ in Europe in the 14th Century and the epidemics of Yellow Fever that plagued the development of the New World. Others, such as Nagana, contributed to the lack of development in Africa for many years. At the turn of the 20th Century, vector-borne diseases were among the most serious public and animal health problems in the world [7, 13].

Estimates show that as much as 75 % of emerging diseases affecting human health are due to zoonoses, responsible for 2.7 million deaths annually [9]. Vector-borne diseases account for 17 % of all infectious diseases in humans on a global scale, causing more than 700 000 deaths yearly. The highest occurrence is seen in tropical and sub-tropical regions, where there is a rich biodiversity. The typical vectors for human vector-borne diseases are mosquitoes, ticks, sand-flies, triatomine bugs, tsetse flies, fleas, black flies, aquatic snails, and lice.

The two major vector-borne diseases of the northern temperate regions, tick-borne encephalitis and Lyme borreliosis (LB), show very different epidemiological patterns, but both have increased significantly in incidence since the 1980s [30].

Although there is a summary of all known vector-borne diseases that affect humans, there is still no such list for diseases affecting animals as of 2016. Given that many vector-borne diseases have the ability to infect and inflict disease in a variety of animals, as well as several types of vectors can transmit the same disease, there is a significant potential extent of harm. Reducing the risk of transmission in free range domestic animals as well as domestic animals on pasture can be challenging, as several of the vector-borne diseases can infect and transmit both domestic and wild animals [45].

Bacterial vector-borne diseases

Infections with vector-borne pathogens are a major source of emerging diseases. The ability of vectors to bridge spatial and ecologic gaps between animals and humans increases opportunities for emergence. Small adaptations of a pathogen to a vector can have profound effects on the rate of transmission to humans [35].

Relapsing fever is a zoonotic disease caused by different spp. of the bacteria Borrelia and the main vector is the soft-bodied tick, *Ornithodorus turicata*. The soft-bodied thick differs from the thick-bodied tick with living close to mammalian hosts, and feeding for only 15-90 minutes, causing a risk of not getting detected while biting. Reports of ticks carrying the bacteria has been reported worldwide, with Australia and Antarctica as the only exceptions. The bacteria are naturally found in ticks and a variety of animals, often small rodents. The only distinction between Relapsing Fever and Louse-borne Relapsing Fever is that the latter is exclusively caused by *Borrelia recurrentis*; aside from that, the two illnesses are clinically and microscopically identical. Relapsing Fever was first reported in 1904 in Africa and has since then spread to all regions except Antarctica and Australia. It is now considered an important public health problem in Western and East Africa, and causes a high mortality among children [17]. Mediterranean Spotted Fever is a zoonotic vector-borne disease of the Spotted Fever group, caused by *Rickettsia conorii conorii*, with the brown dog tick *Rhipicephalus sanguineus* as vector. Typical symptoms in humans are fever followed by a rash. The disease was first recognized in Tunisia in 1910, then detected in the Mediterranean countries in 1927. Today the disease is endemic in the Mediterranean, as well as being present in surrounding countries. The main mammalian hosts for Mediterranean Spotted Fever are dogs, hedgehogs and small rodents. There is still no vaccine to protect humans or animals from the infection. Preventive measures to avoid further spread of the disease are tick-controlling programs, and individual prevention of insect bites [42].

Q-fever is caused by the bacterium *Coxiella burnetii* and was first recognized causing disease in humans in Brisbane, Australia, then shortly after in Montana, USA and in military personnel in Balkan countries. The disease is zoonotic, tick-borne and causes symptoms like the flu in humans. In chronic cases in humans, Q-fever is potentially life-threatening. Infected animals may suffer from infertility, abortions and stillbirths; however, most animals are asymptomatic. There are a diverse range of hosts for the bacteria including humans, ticks, reptiles, birds, fish and ruminants. The bacteria transmit through airborne transmission, consumption of contaminated raw food, direct mucosal contact of contaminated products and ticks as vectors. Preventive measures to prevent outbreaks are vaccination of production animals, strict hygiene on farms, and surveillance programs. As most animals are asymptomatic, the potential for human infection when working at farms, veterinary work etc. is hard to control in endemic areas [50].

Lyme borreliosis (LB) is a multisystemic tick-borne disease that can affect many organs and have various clinical manifestations in animals [8, 24]. LB is the most common vector-borne disease in the Northern Hemisphere, transmitted to humans by the bite of *Ixodes* ticks [10, 23, 29]. Many mammalian and avian species become infected but do not develop overt clinical signs. Humans are at high risk of infection in regions where highly competent reservoirs are the primary hosts for the subadult stages of the tick, in contrast to regions where less competent or refractory animals feed ticks. Human infections are also most frequently associated with spring and summer months when the nymph stage of the tick is active [39]. Lyme borreliosis is primarily caused by the bacterium *Borrelia burgdorferi* in North America and *Borrelia afzelii* or *Borrelia garinii* in Europe and Asia. Infection usually begins with an expanding skin lesion, known as erythema migrans (referred to as stage 1), which, if untreated, can be followed by early disseminated infection, particularly neurological abnormalities (stage 2), and by late infection, especially arthritis in North America or acrodermatitis chronica atrophicans in Europe (stage 3). However, the disease can present with any of these manifestations. During infection, the bacteria migrate through the host tissues, adhere to certain cells and can evade immune clearance. Yet, these organisms are eventually killed by both innate and adaptive immune responses and most inflammatory manifestations of the infection resolve. Except for patients with erythema migrans, LB is diagnosed based on a characteristic clinical constellation of signs and symptoms with serological confirmation of infection [43]. The diagnosis is not always easy, as many patients are not able to recall a tick bite. However, in endemic areas, patients who have the typical rash can be started on treatment without waiting for serology [41]. Vaccination against LB is an effective way to prevent and reduce the number of diseases in endemic areas. Several vaccines have been developed and tested in the past, but no human LB vaccine is currently available on the market. Preventive measures to increase awareness of LB prevention should take place in regions with high LB morbidity [1, 2].

Tularemia is a zoonotic disease, infecting humans, wild animals and domestic animals. It is primarily seen in wild animals, where hares and small rodents are particularly vulnerable. Tularemia is caused by the bacteria *Francisella tularensis*, where the subspecies *Francisella tularensis holarctica* is found in Europe. The bacteria are highly contagious, and transmits directly through contact with infected or diseased animals, through contaminated water or meat, through inhaling of contaminated dust particles, or through blood-sucking midges as vectors. The bacteria are able to survive for a long time in the environment, and mosquito larvae can be infected during the development in contaminated water. Hares are especially sensitive to the disease and will usually die of sepsis a few days after being infected. Hares in the early phase of infection with no or little clinical signs causes a significant risk of transmission of disease for hunters during hunting [25]. The most recent incidences of tularemia have been reported from Scandinavia, northern America, Japan and Russia, without clear reason. Due to the easy transmission of the bacteria, Tularemia has been classified as a category A biological weapon by the Centres for Disease Control and Prevention [53].

Anaplasmosis is a vector-borne, infectious and non-contagious disease. The different species cause different types of anaplasmosis depending on which cells are infected in the mammalian host. Anaplasmosis has a wide host range, including humans, and it is distributed worldwide. The zoonotic potential of some species is of great importance in regards to public health concerns [19, 31]. Anaplasmosis is caused by bacteria of the genus *Anaplasma*, belonging to the order Rickettsiales, which emerged from the fusion of the families Anaplasmataceae and Rickettsiaceae [6]. Anaplasmas are obligatory intracellular microorganisms and Gram-negative bacteria. They can reside and multiply in vertebrate reservoirs for many years [38]. The main symptoms of anaplasmosis include fever, headache, myalgia, and malaise. Severe illness is more frequently reported in older and immunocompromised patients, but it can also affect immunocompetent individuals and may lead to hospitalization or death if appropriate treatment is not provided promptly. Generally, patients show significant improvement within 24-48 hours after starting antimicrobial treatment with doxycycline [28].

Ticks in Slovakia and Norway

Ticks are blood-sucking ectoparasites of vertebrates. *Ixodes ricinus*, *Dermacentor reticulatus*, *Dermacentor marginatus*, *Haemaphysalis concinna*, *Haemaphysalis inermis* and *Haemaphysalis punctata* are the most common ticks in Slovakia [47].

The most important tick-borne zoonotic pathogens causing disease in humans in Slovakia include *Borrelia burgdorferi* s.l., tick-borne encephalitis virus, *Anaplasma phagocytophilum*, various species of rickettsiae, bartonellae and babesiae.

The prevalence of different tick species in Norway is estimated to be 10–12 species established in the Norwegian fauna. *Ixodes ricinus* is responsible for the majority of spreading of disease. *I. ricinus, I. hexagonus, I. lividus, I. trianguliceps, I. uriae* and *Argas vespertilionis* are considered the most common established tick species. Several more species are observed in Norway, as a result of migrating birds, causing a risk of the establishment of several new tick species. The most important tick-borne zoonotic pathogens responsible for disease in humans in Norway are *Borrelia burgdorferi* s.l., Tick-borne encephalitis virus, *Rickettsia helvetica, Borrelia myiamotoi, Neonehrlichia mikurensis, Spiroplasma ixodetis* and *A. phagocytophilum* [44].

Lyme borreliosis in Europe

Lyme disease is the most common tick-borne disease in the United States and Europe [12, 22, 49]. In both locations, species of genus *Ixodes* ticks transmit the *Borrelia burgdorferi* sensu lato bacteria species responsible for causing the infection. The diversity of Borrelia species that cause human infection is greater in Europe; the 2 *B. burgdorferi* s. l. species is collectively responsible for most infections in Europe, *B. afzelii* and *B. garinii*, are not found in the United States, where most infections are caused by *B. burgdorferi* sensu stricto. Strain differences seem to explain some of the variation in the clinical manifestations of Lyme disease, which are both minor and substantive, between the United States and Europe [22].

Diagnosis of LB is on the rise in some Western European countries, mostly in the northern and central part. Better surveillance in the southern countries is necessary [51].

Despite improvements in prevention, diagnosis and treatment, LB is still the most common arthropod-borne disease in temperate regions of the northern hemisphere, with risk of infection associated with occupation (e.g. forestry work) and certain outdoor recreational activities (e.g. mushroom collecting). Recent surveys show that the overall prevalence of LB may be stabilising, but its geographical distribution is increasing. In addition, much remains to be discovered about the factors affecting gene-specific prevalence, transmission and virulence, although avoidance of tick bite still appears to be the most efficient preventive measure. Uniform, European-wide surveillance programmes (particularly on a local scale) and standardisation of diagnostic tests and treatments are still urgently needed, especially in the light of climate change scenarios and land-use and socio-economic changes. Improved epidemiological knowledge will also aid development of more accurate risk prediction models for LB. Studies on the effects of biodiversity loss and ecosystem changes on LB emergence may identify new paradigms for the prevention and control of LB and other tick-borne diseases [32].

Lyme disease in Slovakia and Norway

Data presented in review [4] indicate that the incidence of LB disease in Europe is substantial but geographically heterogeneous, both among and within countries. Data reported at the national level can often mask subnational differences, particularly in areas with substantially higher incidences.

During 2021, 621 human cases of Lyme disease were reported in Slovakia. This is 35 % less than in 2020 and 33.6 % less than the 5-year average. The presence of erythema migrans was reported in 551 cases. Arthritis in Lyme disease was reported in 51 patients. Disease was reported mostly in the Trnava region. Disease occurred throughout the year with a peak in June and July [36]. The overview of number of human cases of Lyme disease in Slovakia in years 2010–2021 is shown in Figure 2.

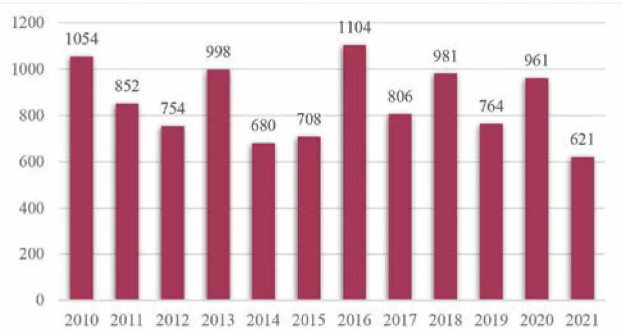

Fig. 2. Number of human cases of Lyme disease in Slovakia, 2010–2021
Source: RPHA, Annual Report, Public Health Authority of the Slovak Republic, 2010–2021

During 2021, 536 cases of Lyme borreliosis were reported in Norway, an increase of 5 % from 2020. The average for the last 5 years is 479, and 2021 represents an increase of 12 % from the 5-year average, and 30 % from the 10-year average. The trend for reported cases of Lyme borreliosis in Norway is on a steady increase. 75 % of the infected were infected in Norway, while 1 % were from other countries, and 24 % had unknown origin. Most cases were reported in August, October, and November, although disease was recorded throughout the year [27]. Figure 3 shows number of human cases of Lyme disease in Norway in years 2010–2021.

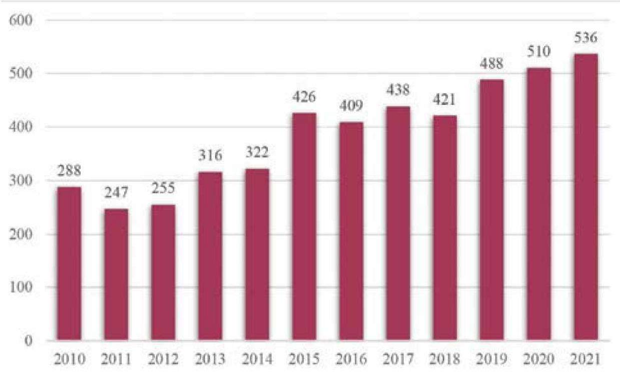

Fig. 3. Number of human cases of Lyme disease in Norway, 2010–2021
Source: Annual Report 2021, Norwegian Institute of Public Health, 2022

CONCLUSIONS

Climate change has a major impact on the transmission and spread of vector-borne diseases. Vectors represent a carrier of the pathogen between different species of organisms. A decrease in the number of cold and an increase in the number of warm days and nights, a reduction in snow cover, and an increase in extreme heat contribute to a significant increase and spread of vectors.

As climate change affects the temperature and humidity, the weather, and consequently changing the habitats of all living beings on earth, the importance of One Health approach is undeniable. A well-functioning cooperation between human health, animal health and environmental health is critical in facing the risk of new pandemics caused by vector-borne zoonotic diseases, to preserve the human and animal health as well as restrict the global economic impact from such pandemics.

LB is one of the major tick-borne diseases in Europe and still requires increased attention, especially due to problems with prevention, complicated diagnosis and treatment, and also due to a possible significant impact on the quality of life of these patients. Tick awareness, appropriate clothing in tick-infested areas, and early removal of attached ticks remain the most important prevention measures.

ACKNOWLEDGEMENTS

This article was supported by the project KEGA No. 005UVLF-4/2022 and VEGA No. 1/0316/23. The authors would like to thank David Idris Lewis, DVM, for the English language correction.

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Received August 23, 2023
Accepted September 27, 2023