A LITERATURE REVIEW ON VECTOR BORNE DISEASES

Zarema Obradovic, Eldina Smjecanin, Ema Pindzo, Hana Omerovic and Nejra Cibo

Abstract

Vector-borne diseases occur in the chain pathogen-vector-host, with vectors playing the most prominent role. Vectors transmit pathogens between humans, and more often, from animals to humans so that many vector-borne diseases are categorized as zoonoses. Vector-borne diseases have become more important worldwide, and not exclusively in the tropics as in the past, by causing high morbidity and mortality every year. Out of all infectious diseases, more than 17% are vector-borne. The most significant and widespread vectors are mosquitoes and ticks, and the most significant diseases are West Nile fever, yellow fever, Zika virus fever, tick encephalitis, Lyme borreliosis, Crimean-Congo hemorrhagic fever and rickettsioses. Life and preservation of the vectors, and breakout and spread of vector-borne diseases are profoundly affected by climate change (rise in temperature and humidity, downfalls, extreme weather conditions), urbanization, deforestation, inadequate waste management, international travel, international commerce and social conditions, with poverty being the most important and directly linked to the rising incidence. In recent years, all factors mentioned above have favoured a rising number of the vectors and their spread, so that vector-borne diseases have become emergent or reemergent, meaning their high incidence have been registered in the countries with no previous breakouts; or they reoccurred in the areas where they had earlier been eradicated. Some extra reasons contributing to the increasing incidence are lowered investments and limited resources for monitoring vector-borne diseases. Most vector-borne diseases are zoonoses, making “One Health” the only appropriate approach, which implies integrated monitoring of the diseases in the sectors of both animal and human health. Prevention of vector-borne diseases should be aimed at raising public awareness on the importance of the vectors, education of the professionals and active involvement of the community as a whole.

Keywords

Vectors, diseases, prevention

Introduction

Vectors arthropods can transmit pathogens from humans to humans and animals to humans and cause vector-borne diseases (VBD). They are caused by different pathogens such as parasites, viruses, bacteria. The most important and common vectors are mosquitoes (Aedes, Anopheles, Culex), ticks, lice and flies. Vector-borne diseases account for more than 17% of infectious diseases, with the high incidence and mortality of more than one million people per year dying of malaria, dengue, schistosomiasis, African trypanosomiasis, leishmaniasis, Chagas diseases, yellow fever, Japanese encephalitis and onchocerciasis (WHO, 2018). Moreover, vector-borne diseases have become emergent or reemergent in different areas, posing an immense threat to health and causing economic losses (Barret et al., 1998). Therefore, the first step toward evaluating the importance of vector-borne diseases is precise diagnostics and collection of data on the prevalent diseases that have failed to be established in many countries (Kules J et al., 2017). The burden of vector-borne diseases varies worldwide, but terms are generally the highest in tropical and subtropical areas. Even though every person can acquire a vector-borne disease, people mostly live in poverty under poor living conditions, which further deteriorate the issue (Wilson et al., 2020).

Narladkar (2018) speaks about the consequences of vector-borne infections, emphasizing human-affecting diseases and animal health and the costs of vector-borne disease control. Emphasis was placed on the comprehensive approach, where envi-
enronmental protection from the harmful influences of the chemi-
cals used in their control plays a significant role.

**History of vector-borne diseases**

Despite a long history of the scientifically proven connection between insects and human and animal diseases, the exact transmission mode has not been known for a long time. At the end of the 19th century, vector-borne diseases were recognized to be very complex and transmitted in the interactions between the pathogens, insects-vectors and hosts (animals or humans), with environmental factors significantly impacting the occurrence and spread of diseases (Tabachnick, 2010).

The most known disease from this group was the plague (The Black Death), which devastated Europe in the 14th century. The epidemics of yellow fever also significantly affected the so-called "New World" development. In the 20th century, vector-borne diseases were considered important public health and veterinary issues, and their elimination was approached seriously. Mid-century introduced new insecticides, most known as dichlorodiphenyltrichloroethane (DDT). The use of DDT and other control measures significantly reduced morbidity and even eradicated some vector-borne diseases in some areas (Gubler, 2009). However, the beginning of the 21st century witnessed the increase in morbidity of vector-borne diseases appearing as emergent or reemergent, pending the numerous factors, most notably climate changes, urbanization, global commerce and travel. The increase in morbidity of vector-borne diseases has been significantly influenced by global environmental changes, the development of resistance to existing insecticides and the lack of adequate monitoring and control (Wilson et al. 2020). Despite the vector-borne diseases’ predominant mode of transmission by bites and stings of the insects, the possibility of transmission via blood transfusion must not be neglected, as indicated by Nordin et al. (2015).

**Current distribution of vector-borne diseases**

In the past, vector-borne diseases were considered tropical because they occurred in tropical climate areas almost exclusively. Lately, their geographical distribution significantly changed, and they emerged almost worldwide, sometimes even in the areas with no earlier breakouts registered. In some ways, vector-borne diseases must be imported into such areas, either via intermediary vectors or hosts infected with the pathogens further transmissible. Due to the widespread vectors (mostly mosquitoes), extensive travel to the endemic areas, and commercial exchanges with endemic countries, the risks of emergence or re-emergence of vector-borne diseases worldwide, including European countries, have been evident (Brugueras et al., 2020; Monge-Maillo et al., 2015; Sonden et al., 2014).

The most significant vectors are mosquitoes, transmitters of different diseases with high morbidity and mortality every year. Data on morbidity and mortality are changed on an annual basis, together with the significance of each vector-borne disease. Among mosquito-borne diseases, dengue and malaria have been associated with the highest morbidity and mortality. Malaria was a big global problem, but dengue fever has become the most widespread mosquito-borne disease in recent years. A causative agent is the dengue virus, and transmitters are *Aedes* mosquitoes. It is estimated that about 40% of the world’s population live in areas under the risk of dengue fever breakout (Semenza and Zeller, 2014, Sharifi Mood B, Mardani M, 2017).

Malaria was prevalent in many parts of the world that are free of malaria today.

**Figure 1:** Source: Hay et al. (2004). The global distribution and population at risk of malaria: past, present and future. In The Lancet Infection diseases

**Figure 2:** World map of dengue evidence consensus with some publications reviewed in respective countries. The geographic scale (municipality, district, state/province, country) of studies is given in grey boxes. (Luiset)

Saahak (2020) described the epidemiological characteristics and clinical features of the first cases of dengue fever in Afghanistan in the provinces bordering Pakistan. In Bangladesh, the epidemic of dengue fever happened in 2019, and Rahman et al. (2021) investigated students’ knowledge, attitudes, and practice on the factors affecting dengue fever and possible preventive measures concerning climate changes.

Malaria affects about 300 million people annually, with a death rate of 400 000 people. Most alarming is that children under five years are the most prevalent deceased category. The burden of malaria is greatest in Eastern and Southern Africa, where the climate is adequate for *Anopheles* mosquitoes and the parasite *Plasmodium* (Ryan et al., 2020). Another vector, *Aedes albopictus* (Asian tiger mosquito), changes rapidly due to climate change. This type of mosquito transmits various diseases such as Zika viral infection, dengue fever and chikungunya.

Another important vector is *Phlebotomus*, which transmits leishmaniasis and Phapathaci fever (Tabachnick, 2010).

Vector diseases appear as emergent or re-emergent in many countries, and the factors that affect them are air temperature, precipitations and population density. The distribution of vector-borne diseases also depends on complex demographic, environmental and social factors. The globalization of world commerce has significantly impacted the spreading of vector-borne diseases and travel and urbanization of the land, especially unplanned (Brugueras et al., 2020, Woolhouse ME., Gowtage-Sequeria S., 2005).

**Vector-borne diseases in the American continent and Canada**

Four mosquito-borne diseases: West Nile fever, dengue, Zika, and yellow fever, have a public health impact on the American
continent in the 21st century. Rising temperatures, accelerated urbanisation, and travel are the main factors that created the conditions for the vector’s contacts with potential hosts and the appearance of diseases with no previous outbreaks recorded—the growing number of hosts, people with weakened immunity (Guarner et al., 2019). In North America, mosquito-borne infections have become significant, posing a threat to global health, primarily the West Nile virus and dengue fever, recognized as a public health issue since 2009. Ticks are also important, and they transfer rickettsial diseases in North America. Due to their increasing incidence, the strategies to avoid contact with vectors have been considered fundamental in prevention (Hutington et al., 2016).

Since 2016, Aedes albopictus has been detected in Canada, posing a potential risk for the appearance of Aedes albopictus-borne diseases (chikungunya, dengue, yellow Zika and West Nile fever). The presence of this mosquito was investigated through the seasons, and it was noticed that their number is the highest in September. This is important epidemiological information helpful in defining preventive measures to prevent breakouts and the spread of related vector-borne diseases (Gior-dano et al., 2019). Researches indicate that in Canada, about 80 types of mosquitoes have been endemic nowadays, but, fortunately, only a few transmit the pathogens that can cause diseases in humans. Nevertheless, some diseases in the area have already become endemic. It is estimated that the incidence of endemic mosquito-borne diseases has increased about 10% in Canada over the last 20 years. Climate changes, most prominently rise in temperature, precipitation, and extreme weather conditions, significantly impact the mosquito population. In addition, previously mentioned factors prolong the transmission of the infection, which may result in a breakout of the epidemics of vector-borne diseases (Ludvig et al., 2019).

Vector-borne diseases are imported to the territory of Canada by international travelling or directly from the US endemic territories. The most important diseases in this group are West Nile fever and Lyme disease. The current situation indicates the need for improved surveillance of vector-borne diseases, including early detection and timely public health response (Kulkarni et al., 2015).

West Nile virus was first detected in North America in 1999, and the first case of human disease in Canada was in 2002. Since then, the virus has become endemic in Canada. From 2002-to 2017, West Nile fever was registered every year, with the lowest incidence in 2010 and the highest in 2007. Moreover, Canada has established strict monitoring of mosquitoes and mosquito-borne diseases (Wijayasri et al., 2017).

**Vector-borne diseases in Africa**

Vector-borne diseases are very widespread in Africa, and more recently, authors have drawn attention to a dry part of Africa that accounts for three-fourths of the African continent. In this area, all living conditions are minimal, with the significant issues being vector-borne diseases, food unsafety, environment degradations, population vulnerability and climate changes. Consequently, it is necessary to strengthen local capacities to deal with the issues and create programs adjusted to local ecological conditions (Wilcox et al., 2019).

**Vector-borne diseases in Europe**

Semenza and Zeller (2014) speak about vector-borne diseases, which have lately become a severe public health threat in Europe, be them of emerging or reemerging nature. For example, malaria was common in southern Europe in the 20th century but eradicated after implementing various measures. However, in the last years, malaria cases have been imported to Europe from the endemic countries, creating risks for local transmission and reappearance of the autochthonous cases. Such an example is Greece, where malaria was eradicated in 1974 but was once again registered in the summer of 2009 as locally-transmitted, inducing the state activities toward suppressing the spreading of malaria.

A similar situation is faced by Bosnia and Herzegovina, where the autochthonous form of malaria had been in existence until the ‘70s of the last century but was later eradicated. Still, there is a risk of its reappearance due to the presence of vectors and extensive travel to and from the endemic countries, international commerce, and climate changes (Obradovic et al., 2019).

Vector-borne disease caused by the West Nile virus was recognized in Europe in the 1950s for the first time and then reemerged in Bucurest (Romania) in 1996 and Volgodgrad (Russia) in 1999. The epidemics caused by this virus were registered in Europe from 2010-to 2013. West Nile virus is now endemic in many European countries, causing disease in hundreds of people every year, with high spatial and time heterogeneity. Studies demonstrate the significance of the spring temperatures in the transmission of the West Nile virus, i.e. a direct connection between higher temperatures in April-May with an intensified circulation of WNV, which directly reflects on the increased risk of transmission to humans (Marini et al., 2021).

West Nile virus (WNV) and Usutu virus (USUV) circulate in several countries of the European Union, thus allowing the risk of their transmission via a blood transfusion to be recognized and preventive measures related to blood safety to be recognized (Domanovic et al., 2017).

**Figure 3**: Source: Vector control practices and strategies against West Nile virus, ECDC, 2020.

Semenza and Zeller (2014) indicate that pathogens and vectors disseminate quickly due to the globalisation of transportation. For example, estimates are that over 100 million passengers arrive in Europe by airplanes every year, which poses a significant risk for disease. That is why it is essential to monitor the importation of the specific pathogens and vectors and plan the preventive measures accordingly.

It is similar to Aedes albopictus (Asian tiger mosquito), whose presence was registered for the first time in Albania in the 70s and in Italy in the 90s of the 20th century. Mosquitoes were imported to Italy from the US in the car tires (to Genova and Venice), spreading afterwards to another countries. Active monitoring detected the autochthonous cases of transmission of chikun-
gunya and dengue fever. *Aedes aegypti* mosquito is the primary vector for transmission of dengue that was detected in Portugal (Madeira Island) in 2005. The epidemic of dengue fever appeared on the island from September 2012–to January 2013 when more than 2000 people got sick (Semenza and Zeller, 2014).

Dujardin et al. (2008) indicated the risk of importation of the “exotic” vector-borne diseases to Europe with special emphasis on leishmaniasis, which has been endemically preserved in the countries of Southern Europe. The number of autochthonous symptomatic cases is about 700, while the asymptomatic ones are triple the number. Most cases of leishmaniasis are linked to Leishmania infantum. However, other strains such as *L. donovani* and *L. tropica* have also gained importance. Furthermore, a risk of exportation of leishmaniasis has been linked to the exportation of infected dogs. That is why monitoring and control of leishmaniasis in Europe should be raised at a higher level. Due to favourable ecological life conditions for the other vector *Phlebotomus*, leishmaniasis cases are sometimes also registered in BiH. *Phlebotomus* favours higher air temperature, higher humidity, and waste as the habitat (Obradovic, 2010).

**Tick-borne diseases**

These diseases are significant in the northern hemisphere, and ticks are the most important vector of the pathogens that cause human diseases. They have increased in importance from the worldwide public health view. Ticks transmit viruses (most important being the causative agent of tick-borne encephalitis), bacteria (borrelia–Lyme disease) and rickettsioses. In the last years, there has been an expansion of ticks, encephalitis and hemorrhagic fever in Europe and Asia (Rochlin and Toledo, 2020). In Bosnia and Herzegovina, the most significant diseases caused by the reservoir of the pathogen and transmitted by ticks are Q fever and Lyme borreliosis. The incidence of these diseases has had a rising trend over the years (Obradovic, 2019).

Mysterud et al. (2017) speak about the relation among the pathogen-vector-host and the conditions required for the vector-borne disease to become emergent. A study carried out in Norway concludes that the appearance of vector-borne diseases in cattle depends on their exposure and contact with ticks. Europe has witnessed an increasing incidence of bacterial tick-borne diseases in the last years due to changing environmental conditions and human behaviour. Therefore, special attention should be paid to tick-borne rickettsioses, the disease with potential for emergence and reemergence in many European countries (Socolovschi et al., 2009).

Tick-borne diseases present a significant public health issue in Eastern and Central Europe and the Baltic states. One of the most significant diseases is tick-borne encephalitis, which is transmitted by the Europe-wise widely distributed tick *Ixodes ricinus*. Therefore, to establish adequate preventive measures (including vaccination), it is necessary to precisely localize the active transmission of disease (Semenza and Zeller, 2014). Incidence of tick-borne encephalitis is connected with climate and socio-demographic factors, with considerable risks such as the duration of stay in the woods collecting forest fruits, mushrooms and blueberries as well as the professional exposure to ticks by the forest workers.

Lyme borreliosis and other tick-borne diseases have been very important Europe-wise, with transmission linked to the territorial expansion of the tick habitat to higher altitudes (Semenza and Zeller, 2014).

Coipan et al. (2013) emphasized the importance of *Ixodes ricinus* as the primary vector of pathogens for humans in many European countries, including the Netherlands. Researches demonstrate that the ticks (density) numbers differ, varying from 1-179/100 m2; over 37% of the ticks are infected with different pathogens, and 6,3% are infected with more pathogens simultaneously. Infection of the ticks causes the increase in tick-borne diseases, dominantly Lyme borreliosis and erythema migrans.

**Climate changes and vector-borne diseases**

From the mid-19th century, there has been a constant rise in temperature, most prominently in the last years of the 21st century. Climate changes impact a complete ecosystem, agriculture, social conditions, migration, and the modes of transmission of infectious diseases, including vector-borne ones. In the epidemiology of vector-borne diseases, tremendously important are the changes related to ecology and host behaviour, ecology and vector behaviour, and density and immunity of the population (Rosati et al., 2014). Hope et al. (2009) emphasize the importance of environmental factors’ influence on the development of malaria vectors, *Anopheles gambiae* and *Anopheles funestus*, main transmitters of *Plasmodium falciparum* in Sub-Saharan Africa, including Kenya.

Climate changes create favourable conditions for new vectors and their spread as a prerequisite for the appearance of new diseases. In addition, scarce resources allocated for vector control and prevention of vector-borne diseases create an objective risk for the appearance of such diseases as emergent and reemergent (Tabachnick W.J., 2009).

Rossati et al. (2014) indicate the importance of climate changes in Europe that facilitate the appearance of new vectors such as *Aedes albopictus*, which caused the autochthonous transmission of some diseases and even the epidemics. Examples are the epidemic of Chinkungunya in northern Italy in 2007 and registered cases of autochthonous dengue in southern France and Croatia in 2010.

Appearances of leishmaniasis in northern Italy and Germany are connected to the climate changes favouring the development of vector *Phlebotomus papatasi*. However, besides the climate changes, the break out of visceral leishmaniasis was also influenced by the population characteristics, i.e. the increasing number of people with weak immunity, such as HIV-positive or diagnosed with AIDS, and people with heavy comorbidities and patients on immunosuppressive treatments.

Tabachnick (2010) indicates a complex influence on vector-borne diseases and emphasizes the direct influence climate factors exert on the pathogens, vectors and hosts and their interaction. The climate also influences population economic status, while poverty and high population density influence the transmission of vector-borne diseases positively. However, poverty has different ways of favouring vector-borne diseases, especially inadequate infrastructure and insufficient allocation of funds for monitoring and controlling vector-borne diseases.

Tabachnick (2010) points at “vector competence”–the vectorial ability to be infected by a pathogen and transmit it to a new host. It is emphasized that so-called “vector competence” is a key component in the vectorial cycle of pathogen transmission. Ogden (2006) analyzes the impact of climate change on vectors and concludes that they are very sensitive to climate change, especially temperature and humidity, which affect the developmental stages of vectors and the availability of food and
their activities. Temperature and humidity significantly affect a pathogen’s entry into a vector body, all the way to the salivary glands when a vector becomes ready to enter the pathogen into a host during the blood meal.

Climate changes are characterized by extreme weather conditions that favour mosquito-borne diseases and even cause epidemics. An example is a very fast spread of the West Nile virus and the breakout of epidemics after heavy rains and temperature rise. Climate changes in the summer of 2010 caused a significant rise in temperature and the epidemics of West Nile viral diseases in Southeast Europe. Due to the significant interconnectedness of the climate changes and distribution of vectors, and the potential risk for the disease breakout, it is recommended to follow weather conditions and weather forecasts within the early warning system to reduce the risks of vector-borne diseases (Semenza and Suk, 2018).

Climate changes significantly impact the spread of different types of ticks and, consequently, tick-borne diseases. During the climate changes, ticks spread to higher altitudes, and different latitudes, especially *Ixodes ricinus* transmits Lyme borreliosis and tick-borne encephalitis. Still, tick-borne diseases spread much slower than mosquito-borne diseases, and their morbidity does not show a drastic rise (Ogdjen, 2006).

### Occurrence of vector diseases

Vector-borne diseases can cause disease in every human, regardless of residence. However, the majority of diseases are registered in urban and semi-urban areas. Current knowledge supports the need for strengthening monitoring of the transmission of the disease and risk assessment in the households and at labour sites. The mobile population has been characterized as a special risk group (Eder et al., 2018, Lemos et al., 2020).

It is estimated that over 6 million people populate urban areas with the constant risk of transmission of vector-borne diseases. The occurrence of vector-borne diseases in populated areas is particularly favoured by inadequate disposal of solid waste suitable habitat for vectors. *Aedes* mosquitoes favour solid waste, and numerous researches indicate a direct link between inadequate plastic waste disposal and the occurrence of mosquito-borne diseases because *Aedes aegypti* requires small water quantities retained in the plastic waste, empty bottles and mixed garbage for life and reproduction. Inadequately disposed waste is a particularly big problem during rainy seasons, and increased morbidity of vector-borne diseases is usually noted afterwards. Furthermore, Malaria-transmitted *Anopheles* mosquitoes grow and develop in disposed containers, and leishmania-transmitting sand flies in the mixed garbage (Krystosik et al., 2020).

Solid waste also presents an important habitat for ticks to grow and develop. Ticks favour the garbage made of old furniture, mattresses and unselective garbage. Due to the significant role of garbage in preserving vectors and the occurrence of vector-borne diseases, it is paramount for decision-makers to pay attention to adequate waste disposal as one of the most important preventive measures against vector-borne diseases. It is also important to educate the population about the importance of adequate waste disposal (Krystosik et al., 2020).

### Hosts for vector-borne diseases

Some vector-borne diseases may be linked to specific jobs and professions, where workers are exposed to more frequent contact with vectors and increased risks of vector-borne diseases. Vector-borne diseases are connected with international traveling, international commerce, deforestation and urbanization, and the workforce within these sectors is exposed to increased risks of vector-borne diseases. That is why it is necessary to include preventive measures against vector-borne diseases in planning preventive measures for the protection of the workforce (Vonesch et al., 2016). Tomassone et al. (2018) remind on the transmission of vector-borne diseases from the wild animals and the related breakouts in persons who contact them, either at work or leisure. Contacts with the wild animals are often enabled by urbanization, unplanned in particular, climate changes and adaptation of vectors that usually live in the wilderness to humans. Higher exposure of humans to wild animals has been associated with the risk of tick-borne diseases. It is important to emphasize the role of rodents and other wild animals in the breakouts and spread of vector-borne diseases. For this reason, monitoring of the health status of wild animals needs to be included in the surveillance system of vector-borne diseases.

### Prevention of vector-borne diseases

Despite vector-borne diseases becoming a more serious threat to the entire world and their appearance as emergent or reemergent, encouraging is that such diseases are preventable by applying specific measures and mobilization and inclusion of the entire community. Accordingly, in 2017 the World Health Organization adopted The Global Vector Control Response 2017-2030. This document provides strategies for strengthening vector control globally and Zinsstag and Scheling (2003) speak about the need for the countries to self-assess the risks of vector-borne diseases; such was the case in Switzerland, the country with an ever-increasing incidence of vector-borne diseases and intensified activities on their prevention. As many vector-borne diseases are zoonoses, their surveillance requires a public health aspect and surveillance of animal health (cattle and pets). That is why it is necessary to establish close cooperation between human and veterinary medicine and public health and veterinary institutions at all levels. Like other zoonoses, the “One Health” concept is the only adequate and complete approach to zoonotic vector-borne diseases, like other zoonoses, is the “One Health” concept (Obradovic, 2019). Savić et al. (2014) also emphasize the need for the “One Health” concept, a comprehensive approach to fighting vector-borne diseases in close cooperation and coordination between the veterinary and human medicine sectors. The authors give an example of leishmaniasis, the disease transferred from dogs to humans, which is difficult to control without surveillance of canine diseases, environment and vectors.

Braks et al. (2011) mention the importance of a comprehensive approach to vector-borne diseases due to their complexity and dependency on the interaction pathogen-vector-host. They indicate that surveillance of any individual factor does not suffice. Instead, an interdisciplinary and integrated approach is necessary. Adequate risk assessment is essential as well as early detection of disease because of implementing the measures and establishing a disease control system. Kuleš et al. (2017) speak about the significance of introducing new diagnostic procedures as prerequisites for the surveillance of vector-borne diseases. The authors indicate that diagnostic capacities for diagnosing vector-borne diseases have not been adequate in many countries, even non-existent in some, causing a lack of information on vector-borne diseases. That is why establishing surveillance requires adequate diagnostic capacities in entomology, human, and veterinary medicine. Wilson et al. (2020) speak about vector...
control as a long-standing activity worldwide and emphasize that it exceeds medicines and vaccines. First organized vector control programs were implemented at the end of the 19th century. They achieved tremendous success in the 20th century because of joining professionals from different fields: entomology, ecology, epidemiology and microbiology. Vector control programs should address concrete measures specific to each vector type and harmonize with its ecology and behaviour at the local level. One problem in controlling vectors is their increasing resistance to available insecticides. Another problem is the connection between vector control and global environmental changes, particularly climate changes, which are hardly controllable and modifiable, especially locally. Despite all problems, it is necessary to gain vector control to create prerequisites for the prevention and elimination of vector-borne diseases.

Research on vector-borne diseases and presentation of the results are prerequisites for introducing preventive campaigns and creating vector control programs against vector-borne diseases, where adequate communication strategies play an essential role (Scalway et al., 2019).

A significant segment of the control of all diseases, including vector diseases, is the sufficient knowledge of health professionals at the primary level. Patients’ first encounters determine the disease’s diagnosis, treatment, and follow-up. Lugo-Caballero et al. (2017) surveyed the knowledge of doctors working in rural Yucatan about vector-borne diseases. Their results demonstrated that 62.5% of doctors had a moderate knowledge level, while even 37.5% had very poor knowledge of vector-borne diseases. Based on such results, it can be concluded that besides the campaigns for the general population, it is necessary to refresh knowledge and further educate doctors on vector-borne diseases.

Vector-borne diseases, especially their epidemics, are common in developing countries without sufficient resources to establish an adequate surveillance system. That is why the local population should be included in the vector control programs, eliminating the sites suitable for life and preservation of vectors. Through their active role, the population can significantly solve the problem. Prerequisites for active population participation are raising their awareness, reaching correct attitudes, and implementing acceptable practices, according to Alobuia et al. (2015). Braks et al. (2014) propose three strategies: surveillance based on following the changes in population, surveillance based on the following disease in animals, and surveillance based on ecological and social factors in a specific area. In order to implement such strategies as prerequisites for appropriate epidemiological measures, all institutions and individuals from the field must cooperate. In the last years, great attention to the vector-borne disease issue has been paid to air traffic, investigated by Huang et al. (2012). This mode of transportation has been intensifying, so the estimates are that about 29.6 million flights take place annually, transporting about 2.7 billion people. Moreover, many flights originate from the endemic vector-borne disease areas creating a potential mode of transmission of vector-borne diseases and their importation to the new areas. For this reason, as a significant tool in the surveillance of vector diseases, a database through GIS is proposed to enable the visualization of risks for vector-borne diseases and their connection to air travel. Nordin et al. (2015) propose that, apart from the measures mentioned above, blood screening on some vector-borne diseases is included in preventive strategies due to the potential risk of transmission by blood.

African experiences show that to initiate the implementation of preventive strategies for vector-borne diseases, communicating relevant results about the vectors, environment, and the best preventive practices have tremendous importance. Therefore, Scalway et al. (2019) emphasize the importance of cooperation between the decision-makers and local researchers to create the best communication plan adjusted to the local requirements.

Vector control program requires strengthening of the technical capacities, infrastructure, monitoring and monitoring system, and more extensive community mobilisation. That program has several segments: the creation of evidence-based guidelines for vector control and human protection from infections, technical support to the countries in order for them to efficiently manage sporadic cases and the epidemics of vector-borne diseases, support to the countries to improve their reporting systems and to calculate burden with specific vector-borne diseases, strengthen capacities by offering training in clinical management, diagnostics and vector control and support and strengthen the methods of evaluation. Experiences from the countries with established vector control programs and vector-borne diseases indicate that the most significant are behavioural changes in population and unfavourable living conditions for vectors. That is why health education and raising public awareness about the role of vectors and the protection measures for vector-borne diseases are of special importance (WHO, 2017).

Conclusion

Vector-borne diseases have become a serious threat worldwide. For this reason, it is necessary to establish organized and systematic disease control with the participation of all relevant institutions and individuals in a joint effort toward the prevention and suppression of the spread of vector-borne diseases.

Declarations

Ethics approval and consent to participate
All consents have been taken.

Consent for publication
Informed consent has been taken.

Competing interests
The authors declare that they have no competing interests.

Funding
This work did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

References