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ORIGINAL ARTICLE

Ecological prerequisites for the disease outbreaks

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The problematic situation in the world with the spread of COVID-19, the study of the origin, spread, management of biological risks, and the development of effective countermeasures has become one of the most relevant information topics in 2020. The pandemic caused by the SARS CoV-2 virus has sharpened the focus on all-natural foci of disease that have emerged in recent years with varying degrees of intensity in human and animal populations, creating epidemic epizootic emergencies in different countries. Under the influence of solid anthropogenic pressure, global climate change and natural disasters, migratory flows, and other socioeconomic and environmental factors, some of the previously unknown or known but controlled diseases (rabies, Lyme disease, Ebola) are gaining new importance. The manifestation of most natural focal infectious diseases is due to the population's response to environmental factors. It is manifested by expanding the range, overcoming the species barrier, increasing the pathogen's virulence, and forming atypical routes of transmission.

Classical mechanisms of population regulation, principles, and patterns of the structural and functional organization of natural ecosystems today are essential in forming a systematic approach to solving the problem of control and counteraction of socially significant emergent diseases.

Keywords: disease outbreaks, ecological factor, epidemic, pandemic, natural focal diseases.

Introduction

In today's world, environmental factors are playing an increasingly important role in shaping public health. The deterioration of the quality of environmental components, the transformation of natural ecological systems, global climate anomalies, and socioeconomic changes affect the health, duration, and quality of human life, features of the structure, and dynamics of various diseases etiologies.

Being under the constant pressure of anthropogenic factors, natural ecological systems respond to such changes by transforming the structural and functional organization of biocenoses, the disappearance or emergence of new species of organisms, the expansion of habitat, and changes in the life cycles of vectors, and others.

Since the evolution of parasitic systems and their activity are inextricably linked with the processes occurring in biocenoses, the response of the biological system at the population level can be manifested by epidemic outbreaks, and in some cases - powerful, sudden, and uncontrolled manifestations of diseases beyond the usual in natural ecosystems, the mechanism of regulation of the host population and significantly expand the natural nosoareal (Gorban, 2019).

The manifestation of infectious diseases with such symptoms is classified as emergent and re-emergent. The Terrestrial Animal Health Code of the World Organization for Animal Health (OIE) (2014) (OIE, 2013; Moutou, 2015) has identified criteria acceptable for emergent and re-emergent diseases, namely: previously unknown to science diseases of infectious origin or those occurring in atypical forms and their course carries new epidemiological stereotypes or is characterized by expansion of a nosoareal. Re-emergent infections are defined as already defeated and controlled diseases that have spread unexpectedly (tuberculosis, rabies).

The most critical policy setting of the World Health Organization (WHO) is to achieve health for all in the European region and, above all, to combat the coronavirus pandemic as a global threat to human life and health. Simultaneously, the urgency of emerging diseases in the world has increased significantly in recent years. It is difficult to control by health systems and international organizations, which actualizes the search for new approaches to analyzing epidemic and epizootic processes and ways to deal with emergencies.

Materials and Methods

We determined the ecological preconditions for the formation and manifestation of emergent infections in human and animal populations using a systematic approach. Traditional methods of analysis, synthesis, ecological, epidemiological, and epizootic research methods were used. A bibliographic review of classical and modern international and domestic literature sources was conducted (COVID-19 and Animals, 2019; Anthropozoonotic, 2020; WHO, 2020). The main provisions of international strategies and conventions are considered. Definitions, terms, and concepts are presented following the international practice.

Results and Discussion

Today, special attention is paid to biological pollution in the aspect of natural focal infections. In recent decades, pathogens of infectious and parasitic diseases have undergone significant pressure in an anthropogenically transformed environment, manifested in changes in their properties and the course of the epidemic process, which acquires emergent characteristics.

In the process of a long-term coevolution of the parasite and the host, mechanisms have been developed to ensure their stability in biocenoses through self-regulation at all levels of the biological system's organization. Besides, each biocenosis element, including the microorganism (pathogen), performs a specific function in it, forms different types of relationships, regulates quantitative and qualitative changes in the system. As the basis of the epidemic process, parasitic systems' stability and stability are supported by the processes of self-regulation in natural ecosystems. Here, they exist independently of humans and pets. Man in these processes is a random part of the epidemic process and, until recently, his role was scanty. Simultaneously, due to several socioeconomic and natural transformations in natural ecosystems, it is increasingly involved in the epidemic process as a host of a parasite or biological vector. Simultaneously, regardless of whether the human is an element of the epidemic chain, his role in transforming natural ecosystems and the disruption of critical functional connections is so powerful that it leads to loss of control and imbalance within the biological system. At the same time, there is a formation of ways of transmission uncharacteristic of specific types of parasitic organisms, increasing the role of socially significant pathogens transmitted by the short-chain "human-human", "animal-human," or with intermediate development in the environment (soil, water, food). Such processes lead to the destruction of evolutionarily formed relationships in biological systems and, consequently, to the uncontrolled manifestation of epidemics, epizootics, and epiphysis (Roitman, Beer, 2008; Andreychin, 2019).

These processes take place especially intensively in the conditions of technogenic and anthropogenically transformed territories, where the mechanisms of systemic self-regulation are violated and often destroyed by a person. In some parts of the parasite's area, the stages and speed of circulation of the infectious agent differ significantly, which causes spatial heterogeneity of the epidemic process concerning the zoonotic parasites - directly determines the different epizootic significance of these areas. The unevenness of the phase stages of the enzootic circulation of each subpopulation of a particular species is provided by some external factors (local density of hosts and vectors, small-station mismatch of conditions for the existence of carriers, etiological aspects) and the level of genetic heterogeneity.

Population reactions: behavioral, organizational, and socioeconomic are powerless in the face of epidemic and epizootic threats, and attempts to accelerate the formation of group immunity through mass vaccination are likely to lead to harsh and more aggressive effects by increasing the virulence of pathogens. Contagiousness and mutagenic adaptation of the pathogen, gaining the ability to respond quickly to changes in the environment. The reduction of typical reservoirs for the natural-focal pathogen due to the solid anthropogenic pressure on natural ecosystems will force it to search and adapt to new owners, especially domestic animals and humans (Fig. 1).

Disclosure of the interdependencies between the parasite, the host, the environment, and the whole ecosystem at all levels of their interaction allows identifying, trace, and preventing the influence of natural, geographical, and socioeconomic factors on the emergence and spread of infectious diseases. At the same time, causal relationships in natural ecosystems are rarely taken into account in everyday medical and veterinary practice, whose activities mainly aim to find ways to treat and prevent diseases, i.e., eliminating the consequences (Nakonechny, 2020).

Most emerging diseases during their manifestation in new populations are accompanied by high contagion, the rapid overcoming of the species barrier, increased virulence, duplication of pathogens. The expansion of the pathogen from natural foci into the human population has two stages:

- accidental or directed introduction of the pathogen into a new ecosystem;
- transmission and manifestation of the pathogen with its subsequent acquisition of emergent properties.

It has long been believed that the socioeconomic factor in the emergence and spread of emerging diseases in many cases was vital. At the same time, research in recent years requires a review of its significance, and the low economic standard of living does not play a significant role in the spread of socially significant infections. Climatic factors and emergencies are becoming more critical. Thus, natural disasters, local military conflicts, migration processes, urbanization, global climatic anomalies, and other external conditions affect the formation and functioning of new, non-pathogenic conditions and the emergence of foci of biological pollution. The WHO Global Emergency Preparedness Monitoring Annual Report for 2011-2018 tracked 1,483 events in 172 countries (WHO, 2020).

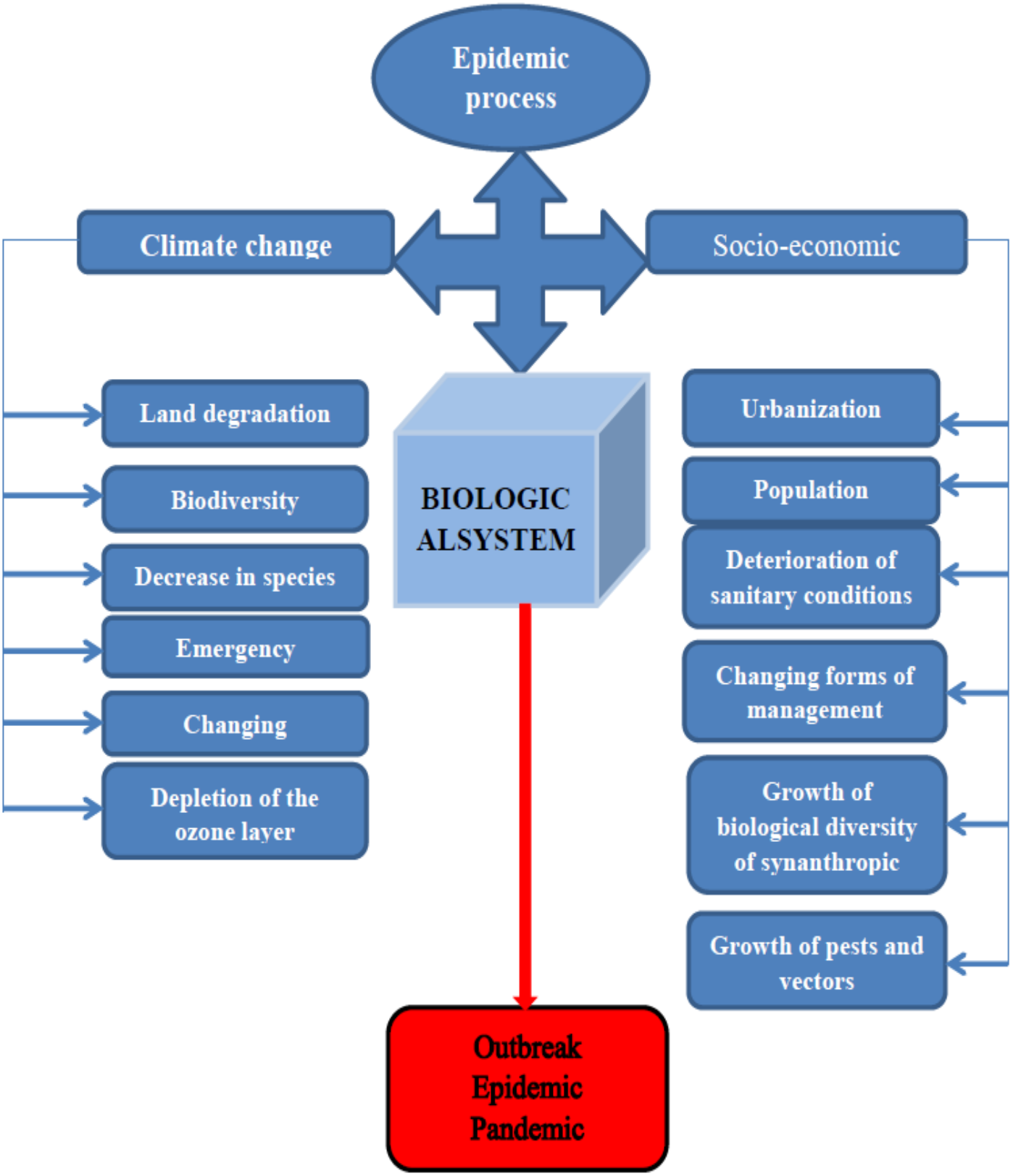

Fig. 1. Formation of the epidemic process under the influence of the environmental factors

Only in Ukraine for the last nine years (Fig. 2) analysis of hazards and threats of natural and human-made nature indicates an exacerbation of the situation and increasing risks of losses in all regions. In 2019, from 146 classified emergencies, 81 were promptly responded to untouched nature.

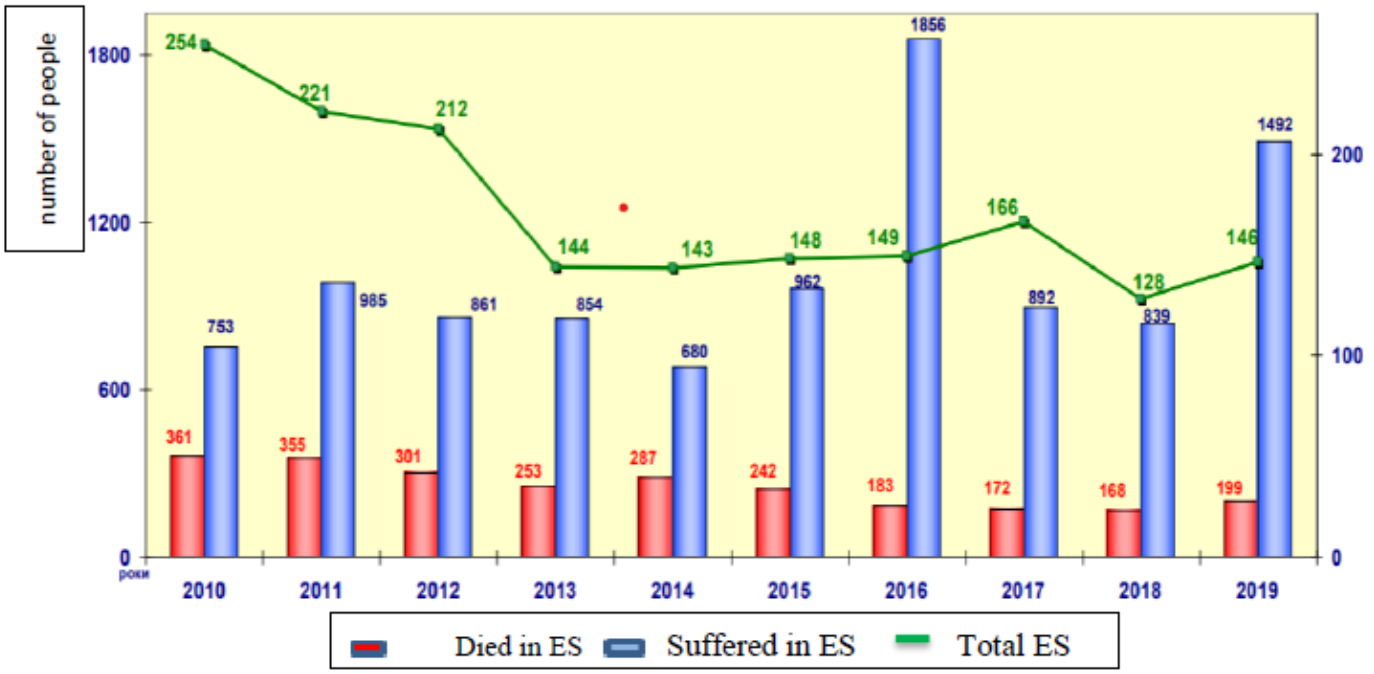

Fig. 2. Dynamics of emergencies and their consequences for 2010-2019

For the territory of Ukraine, the situation with emerging diseases is no exception. The most significant are nosoforms associated with natural habitats and wildlife-specific hosts and vectors of infectious agents.

Among domestic animals and humans, infectious and invasive etiology diseases remain the most common to this day. Thus, the average global mortality rate is 55-57 million people per year, of which the third die from parasites - 17-19 million people (https://www.who.int/gho/publications/world_health_statistics/2017).

The World Health Assembly adopted the document "Global measures to combat vectors for 2017-2030," designed to promote an integrated approach to achieving sustainable development's global goals by improving the technical capacity, monitoring system, and epidemic control with the active participation of local communities. This approach confirms the importance of focal infections, particularly with a transmissible transmission mechanism, which is only 20% in the structure of natural focal pathologies. Every year more than 700,000 people in the world suffer from malaria, dengue fever, schistosomiasis, leishmaniasis, Chagas' disease, tick-borne encephalitis, tick-borne borreliosis, Crimean-Congo fever, Japanese encephalitis, and others (https://www.who.int/ru/news-room/fact-sheets/detail/vector-borne-diseases).

The most relevant emergent diseases for Ukraine and their pathogens are presented in Table 1.

Table 1. Pathogens of some emerging diseases

№	The name of the disease	Year of discovery	The name of the pathogen
1.	Rabies	1931	*Rabies virus*
2.	Heartworm disease	1566	*Dirofilaria repens, Dirofilaria immitis*
3.	Lime borreliosis	1982	*Borrelia burgdorferi*
4.	Bird flu	1997	*Avian influenza A/H5N1*
5.	Atypical pneumonia	2002	*SARS-CoV*
6.	Pandemic California flu	2009	*Influenza A/ California/04/09 virus*
7.	Middle Eastern respiratory syndrome	2012	*MERS-CoV*
8.	Coronavirus disease	2019	*2019-nCoV*

Lyme disease (tick-borne borreliosis) is the only naturally occurring human helminthiasis in Ukraine with a transmissible route. Today the disease is registered in 25 regions of the country. The pathogen's nosorea is constantly expanding, which is associated with changes in natural and climatic conditions favorable for the vector - the mosquito. The disease has been registered in Ukraine since 2000 when 58 cases of the disease were detected among the population; over the past 20 years, the number of patients has increased 59 times. Only in the period from 2017 to 2018, the number of identified patients increased from 3986 (9.36 cases per 100 thousand population) to 5418 (12.77 cases per 100 thousand population) registered cases. Among pets (dogs, cats) susceptible to the disease, statistics are not kept but register a steady upward trend in morbidity (Analytical..., 2019).

No less alarming is the situation with the mass reproduction of certain xylophage species in coniferous forests, which has led to an ever-increasing volume of degraded pine plantations. The problem is becoming global on all continents, and the outlook is unfavorable. Thus, in Canada, for the last 15 years, about 180 thousand km^2 have been affected by wood-destroying insects; in North America, during the period of the highest concentration of pests, about 60% of pine forests are destroyed (Borodavka et al., 2017). In Ukraine, the risk zone is mainly in the north-western and central regions, the threat of bark beetle Carpathian virgin forests. Thus at the beginning of 2019, the total area of forests affected by bark beetles, subordinated to the State Forestry Agency of Ukraine, amounted to more than 413 thousand hectares, 222 thousand hectares - Scots pine and acquires signs of ecological catastrophe (Polishchuk, Voloshina, 2020).

Researchers have linked the explosion in the population of certain species of pests to an increase in average daily temperatures, which contributes to the formation of 2-3 cycles of reproduction and the availability of available fodder base in the form of weakened stands.

Manifestation cases of other emerging pathologies in Ukraine, such as rabies, African swine fever, bird flu, are also inextricably linked with natural foci, from which the infection spreads to agricultural species of animals and humans.
The outbreak of African swine fever (ASF) started in 2014 with 16 cases among wild and domestic pigs; in 2015, 40 cases were registered in 2016 – 91, 2017 - 119 with a predominant localization among wild pigs. Cross-border migration of wildlife populations, labor migration, and long-term persistence of the pathogen in the extensive pig sector, poaching, and relocation of contaminated products from disease outlets ensured the penetration of the disease from Georgia and Armenia through the Russian Federation to Ukraine (dominated by forest cycle 2014-2015).
Cases of ASF have been registered on the territory of the Dnieper-Oryol Reserve. Of particular concern with this situation is the lack of research on epizootological features in natural biological systems and the difficulty of localizing the wild infection source (Khomenko et al., 2016).
In each case, the formation of an epidemic outbreak is explained by a set of direct and indirect effects of various environmental factors (Table 2). Simultaneously, the leading (key, limiting) factor is defined, which determines the direction, speed, and possible ways to develop the epidemic process.

Table 2. The habitat of parasites is a system-forming factor.

Hierarchical levels of biological systems	System forming causes
Ecosystem	Factors influencing pathogens and hosts The host is the habitat of the infectious agent
Population	Factors influencing the host population and parasite population
Organic	Factors influencing the pathogen in the body of the host hosts
Cellular	Metabolism, cellular and humoral immunity. Factors of genetic transformations

One such factor is climate change, which occurs very quickly and affects land use, plant background changes, expansion or contraction of animal and plant species. The frequency of the extreme climatic phenomena causes the formation of a high level of uncertainty and conventionality.
In such conditions, there is a real danger of natural focal infections pathogens moving via domestic animals and livestock products to humans, and it requires environmentally sound approaches in all areas of economic management and environmental epidemic forecasting.
W.J. Martens (1998) proposed the epidemic models of the climate change impact on biological systems and public health related to:
- the spread of communicable diseases associated with thermally dependent pathogens;
- the influence of temperature;
- increased exposure to ultraviolet radiation.

The increasing and prevalence of infectious diseases reflect the negative processes occurring in natural ecosystems and society. On the one hand, this is due to the imbalance in the transformed ecosystems and radical social changes.
Interventions in the functioning of biological systems of influential anthropogenic factors "inhibit" coadaptation in the "parasite-host" system and trigger mechanisms to increase pathogenicity and virulence of the pathogen, reduce host resistance, which is inevitably reflected in the level of biological diversity and hierarchical population level.
Most researchers are inclined to think about the unpredictability of anthropogenic transformations of the natural environment and the "man-made evolution" of modern epidemics.
An example of such inconsistency is the current situation with counteraction to the COVID-19 pandemic, the source of which is the contact with representatives of natural ecosystems (https://apps.who.int/gb/gov/ru/index.html).
In the current conditions of a real pandemic, the circulation of the virus becomes ubiquitous with an unmistakable anthropogenic character and a new anthropogenic reservoir. The lightning transformation of a zoonotic parasite of viral origin with a long period of coevolution with their warm-blooded specific host into an active pandemic anthroponosis is paradoxical. Particularly unexpected was the demonstration of the ability of SARS-CoV-2 to self-initiate an epidemic process without a pronounced dependence of the latter on the primary natural reservoir or a spontaneous (enzootic) source of infection (Nakonechny, 2020).
The coronavirus pandemic situation dictates the urgent need to rethink approaches to studying the problems of emergent infections and the peculiarities of the epidemic process in natural conditions burdened by global climate change, anthropogenic pressure on natural ecosystems, population growth, and migration. At the end of 2019, a new 2019-nCo virus (or SARS-CoV-2) appeared in Wuhan (Hubei Province, China) and spread rapidly throughout the country and beyond. The first UN reports on the need for a rapid response to the emergency appeared only in early 2020 (https://www.who.int/csr/don/12-january-2020-novel-coronavirus-china/en).
The majority of the world's population remains susceptible to the COVID-19 virus. Since the beginning of the pandemic, the total number of registered cases from 2021 exceeds 80 million people — more than 1.7 million deaths since the beginning of the epidemic (https://www.who.int/publications/m/item/weekly-epidemiological-update-8-december-2020). In December 2020, a new strain of coronavirus appeared, estimated to be 70% more contagious. Like many other hazardous pathogens, it came to humans from a natural bat cell. Bats are among the most numerous mammals on the planet and count more than 1.4 thousand species. They are the second most diverse mammals group and are a "reservoir" of several zoogenic pathogens (Ebola virus, rabies). It has been proven that their bodies have evolved mechanisms to counteract the development of inflammatory processes caused by the viruses they carry. Parasitocenoses are regulated by the mechanisms of natural ecosystems and are aimed at maintaining the primary structural and functional organization of the biocenosis, and the ecological-evolutionary feature of bats, supported by their coevolution with a wide range of species-specific parasitic species, prevents mass outbreaks in the population (Komisarenko, 2020).
Entirely or partially destabilized natural ecosystems lose such mechanisms of biotic regulation, which leads to unpredictable and uncontrolled outbreaks of diseases initiated by pathogens of bat infections. Counteracting the pathological process's development and the pathogen's spread in such conditions is impossible because the population has no natural regulatory restraint mechanisms, and in a human-made environment, the situation generally becomes unpredictable.
Many questions regarding the transmission of COVID-19 in domestic animals and its species specificity remain unclear. It has been confirmed that in addition to humans, hamsters, ferrets, minks, dogs, cats, rabbits, monkeys, lions, and tigers are susceptible to

SARS-CoV-2 as a result of contact with a sick person. At the same time, pigs, chickens, and mice do not get sick and do not spread the pathogen. The pathogen is adapted to transmission both within the species and can overcome interspecific barriers and, in most cases, animals are infected by humans and efficiently transmit the infection (COVID-19…, 2019; Anthropozoonotic…, 2020).

Mass infections of minks with high mortality rates in the population on fur farms in the Netherlands, Spain, and Denmark have attracted researchers' attention. Genetic studies have confirmed that the SARS-CoV-2 virus entered minks from a sick farmworker and acquired new properties with high contagiousness rates. The mechanism of transmission of infection between farms has not yet been elucidated, despite enhanced biological protection measures (Anthropozoonotic…, 2020).

Frequent mutations lead to the emergence of new dominant variants of the virus, which are better adapted to environmental conditions than the original. Today, experts of the specialized working group within the global network of WHO laboratories study the evolution of the SARS-CoV-2 virus and quickly detect its new mutations, assess the possibility of an impact on the virus itself as a basis for developing effective methods of diagnosis, treatment, and specific prevention (https://doi.org/10.1101/2020.09.01.277152).

In current conditions, the biological system with its components, little-studied structural organization patterns, and functioning can implement unpredictable scenarios in response to anthropogenic and natural factors. The emergence of the pathologies is a clear example of such a reaction of the parasitic system. Simultaneously, the rapid spread of a particular type of pathogen in the population can act as a biological indicator of the processes occurring in the ecosystem and signal certain deviations in the ecosystem's homeostasis.

Considerable attention is paid to the study of biological indicators of anthropogenic impact levels, various pollutants. For example, over the last 20 years, the European Environment Agency (EEA) has presented more than 200 detailed reports on the analysis of the effectiveness of environmental bioindicators (https://www.euro.who.int/ru/home). Pathogens of infectious and parasitic diseases supplement a significant list of indicator species due to their narrow specialization, the complexity of the lifecycle, and confinement to specific ecosystems. Simultaneously, both the presence of the pathogen and its absence are indicative, which indicates the stability of the situation or vice versa. Given the role of hosts of parasitic species in energy flows through trophic chains, the interdependence of different types of ligaments in the biocenosis, the absence of the pathogen may indicate not only the absence of specific hosts or vectors but deeper processes of biological system self-regulation and possible changes in its structural and functional organization future.

Conclusion

Today there is an urgent need for accumulation, scientific analysis, and forecasting of the epidemic process in current conditions, rethinking tactics and approaches to solving real epidemic problems in the environmental aspect, one of which was the growing number and social importance of emerging diseases.

The appearance and manifestation of emergent pathologies is a complex problem that poses a real biological threat. Despite opposition from international organizations (the World Health Organization (WHO), the International Office of Epizootics (OIE) and the World Agriculture and Food Organization at the United Nations (FAO)) and the deep concern of governments around the world, the situation is difficult to control and control.

Thus, Ukraine's ecological and epizootic situation remains tense for many types of pathogens of natural focal diseases. The complexity of forecasting and eliminating their outbreaks are due to many socioeconomic factors. Simultaneously, the environmental services do not pay attention to environmental aspects, targeted impact, which may, in the long run, provide an effective solution to the problem of uncontrolled outbreaks.

The key to solving this problem is a systematic approach, which includes an extensive array of data on global climate change, endemic areas, preconditions and limiting factors for the formation of new disease foci, changes in the species structure of biocenoses, the emergence of new or known anthropogenic factors, spectrum susceptible organisms, mechanisms of pathogen transmission and features of life cycles. The unpredictable and difficult to control nature of the formation of emergent infections poses a real threat to human life's safety and has ceased to be the prerogative of medical and epidemic services.

The intensification and spread of socially dangerous infections, including emergent ones, are increasingly associated with the quality of the natural environment, human activities, and public health, which requires intersectional integration and improved training of specialists capable of solving applied environmental problems of health care. The environmental factors with epizootological consequences are the transformation of ecological systems, changes in the natural species composition of the fauna of regions, unreasonable faunal measures, socioeconomic processes associated with changes in management technologies, urbanization, trade, tourism.

Environmental programs and projects are scarce, and environmental measures often conflict with health canons, creating severe environmental problems.

Besides, ecologists do not often encounter issues of biomedical orientation, biological risks, in particular for endemic areas and nosoales of natural focal infections in their professional activities. Today's challenges require a significant revision of the content of training and response to requests for training in interdisciplinary, integrated programs and introducing a system of continuing professional development. The targeted orientation of the educational process's content in the training of environmentalists should focus on the rational use of natural resources in the context of life safety and human health.

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