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HUMAN BEHAVIOUR AND THE ROLE OF THE ENVIRONMENT FOR THE OUTBREAK OF PANDEMICS

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ABSTRACT

In the course of human civilization there have been diseases that changed the history of nations and the knowledge in medicine. Some have been transmitted from distant lands to other places under the appropriate conditions, others have originated as direct human interference in the ecosystems of the animal populations. A significant number of diseases caused by infectious and parasitic agents have the potential to spread with the nature of a pandemic. In a historical aspect human behaviour has played a important role in the spread of infectious and parasitic diseases. Migrations of large groups of people due to a many of causes - natural disasters and climatic changes, socio-economic distress, poverty and famine, riots and wars, disease and mass death, are some of the main driving forces of the spread of this kind of disease. Human invasion of nature and animal biotopes changes the ecological relationships and brings about new relationships not only between the animal species but also between the man and them. This subsequently creates the possibility of exchange of pathogens and the emergence of zoonoses, in which man often becomes a participant in the epidemic chain. Directly dependent on the climatic changes are vector-borne infectious diseases, which expand their ranges towards warmer climatic and geographic areas. With the expanded possibilities in our modern times for more and more intensive and distant travels, some diseases can circle the globe over a short period of time and appear at the other end of the world from their usual place of circulation. In a historical aspect the trajectory of infectious diseases has followed travellers and traders along the Silk Road. In the course of human aspiration to conquer new lands, people have often brought unknown and deadly diseases to non-immune local populations.

The purpose of this review is to trace the impact of some aspects of human behavior and the role of the environment in the occurrence of pandemics.

Key words: human behaviour, environment, infectious, parasitic, tropical diseases, epidemic, pandemic

There are conflicting views in science on the precise definition of the term 'pandemic' (from Greek: παν, pan, 'all' and δήμος, demos, 'people'). There is a debate as to whether it is appropriate to speak of a pandemic or an epidemic. The Dictionary of Epidemiology of the International Association of Epidemiology defines the concept of pandemic as “an epidemic occurring throughout the world, or over a very wide area, crossing international boundaries and usually affecting a large number of people” (1). A source of the World Health Organization (WHO) defines the pandemic as "the worldwide spread of a new disease" (2). Although WHO no longer officially uses the term “pandemic”, in March 2020 the

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Director-General of WHO, Dr. Tedros Adhanom Ghebreyesus, addressed the use of the term to describe the status of the COVID-19 outbreak and declared the COVID-19 disease caused by SARS-CoV2 a pandemic on March 11, 2020 (3). The wide spreading of infectious diseases in the ancient world brought about the need for healing and necessitated the emergence of medicine as a specific field in the human activities and the culture of behavior. Our ancestors have experienced terrible diseases which turned into pandemics and which, according to historians' calculations, have fatally reduced the human population many times. Malaria, typhus, tuberculosis, leprosy, influenza, smallpox were the first infections encountered by the people. The contemporary lifestyle creates preconditions for initiation of epidemics from old, known infectious and parasitic diseases, as well as the appearance of new and unknown once. They emerge as epidemic outbreaks or sporademics and can develop as epidemics and grow into pandemics. Since 1970 more than 1500 new pathogens have been discovered, 70% of which with animal origin. Not all of them had an impact on the public health but the diseases caused by some of them are horrifying with the scales of the human lives lost. These pathogens include the Ebola virus, identified in 1976, the human immunodeficiency virus (HIV), defined in 1983, and probably SARS-CoV2 – which appeared towards the end of 2019. Currently the mankind has been affected by two pandemics - AIDS and COVID-19 (4). One must always take into account the fact that infectious diseases are diseases in the ecosystem: pathogen - susceptible organism - environment. In the modern times the epidemic outbreaks are almost constant but not all of them develop into a pandemic. The preconditions for the development of infectious diseases into large-scale epidemics are diverse. Megacities and urbanization in the developing world attract more and more people from the rural areas, forming densely populated communities in the cities with a changed socio-economic profile. Social stratification and poverty are shaped by a number of factors, such as missing or inadequate education, living in poor sanitary conditions, malnutrition and chronic hunger, limited or even absent medical services, health care and adequate therapy. With the expansion of human activities and the encroachment of humans into wildlife biotopes and their proximity to and introduction into the places they inhabit, opportunities are created for zoonotic transmission of pathogens. The refugee waves, the migration of large groups of people from areas with existing and erupting military conflicts contribute to the spread of problems and diseases to places where they are unknown. The global climatic change creates opportunities for infectious and parasitic disease vectors to adapt and expand their ranges towards warmer climatic and geographic areas. The increase in the population in some regions and the scope of the human activities are putting increasing pressure on the environment, with the emergence of processes developing into ecological catastrophes. In the last decade the passenger air traffic has almost doubled. The introduction into daily operation of high-speed vehicles with the capacity to circle the globe within twenty-four hours makes it possible to transport not only passengers and cargo but also pathogens (5). Ancient and especially modern overseas trade, tourism and religious routes spread new and unknown infections over long distances, thus marking the dimensions of possible pandemics. These trends have a significant role on the spread of infectious diseases. For centuries the application of public health measures such as isolation, quarantine and border controls have resulted in limiting the spread of infectious diseases. Due to the absence of etiological therapy in many cases or the possibility of applying other curative interventions to control the pandemic, these methods of limiting the epidemic process in infectious diseases are still used today (6). Despite the invariable presence of certain pathogens in the human population and the devastating pandemics of diseases in a historical aspect, there is a definite trend in our modern times - the death rate from them is gradually decreasing. The improvements in health care and the understanding of the factors that potentiate the development of pandemics are the necessary tools to reduce the severity of their impact (5). The terms "endemic," "disease outbreak," "epidemic," and "pandemic" refer to the manifestations of an infectious/parasitic disease

over time in terms of the actual and projected health status of those infected and the magnitude of its manifestations in a given geographic area(s) (6, 7, 8). An "endemic state" defines the processes with predictable speed among the population. An "outbreak – outburst of a disease "corresponds to an unpredictable increase in the number of people with compromised health status due to a particular infectious/parasitic pathogen, or to the emergence of cases in another area. "An 'epidemic' is an outbreak that spreads over larger geographical areas, with a causal link between the infected. "A 'pandemic' is an epidemic spreading globally. An "emerging infection" is defined as a newly emerging disease in a defined population, or an infection that has the potential to spread out to new geographic areas (9). The transmission of animal pathogens to humans (zoonotic transmission) is a major mechanism by which emerging infections affect humans from ancient times to the present day (10). With human encroachment into wildlife ranges for hunting, logging, trade in animal foods, fur and exotic pets, the likelihood of interspecies transmission of pathogens has increased dramatically (11).

The process of interspecies transmission of pathogens goes through 5 stages (10): (1) the pathogen circulates in natural conditions and infects only animals; (2) the pathogen evolves and crosses the species barrier; can pass to people with relatively short transmissions in the human population; (3) the pathogen circulates briefly among humans and undergoes only a few cycles of secondary transmission between animals and humans; (4) the disease exists in animals, but long sequences of secondary human-to-human transmission without animal involvement have been observed; (5) the disease circulates exclusively among humans. Frequent transmission of the pathogen between animals and humans modulates the risk of zoonotic transmission. Humans with their activities in the environment, such as tillage, animal husbandry, logging and deforestation and other impacts, directly or indirectly lead to changes in biological diversity. Global climate change is another powerful factor in the transmission of wild-type pathogens to the human population (12, 13). Viral zoonoses pose a particularly serious threat to public health, as viruses have been at the root of the recent epidemics of Ebola, SARS, MERS, avian influenza, swine flu and COVID-19. Questions remain about the zoonotic origin of SARS-CoV-2. It is therefore important to constantly assess the risk and potential for cross-transmission of viruses from animals to humans.

Another aspect of the impact of some infectious agents - Yersinia pestis, Variola virus, Bacillus anthracis, - is that they can be used as biological weapons and thus pose a threat to humanity (14). These weapons are based on naturally occurring microorganisms or modeled microorganisms that are designed to be highly transmissible, more virulent, or resistant to therapy (15). The commissioning of these biological weapons is intended to cause disease in humans or even death. Bioterrorism poses a serious threat to global security and its consequences can be detrimental to the public health system. The advancement in genetic engineering and the synthetic biology techniques allow the creation of new pathogenic microorganisms through genetic manipulation. Bioterrorism is a form of terrorism in which biological agents - bacteria, viruses or parasites or their toxins - are used as weapons of mass destruction to spread life-threatening diseases in order to devastate the population of given area. They deliberately (for terrorist purposes) cause disease or intoxication in the susceptible population (16). Bioterrorism is not a new phenomenon for humanity. Biological weapons have been well known since antiquity. The history of terrorism goes back to antiquity, to ancient Greece and Rome, and continues into the Middle Ages. In 1346, at the order of the Golden Horde's Khan, Taktamish, the corpses of warriors killed by the bubonic plague were thrown into the wells and other water sources in the besieged Genoese fortress of Kaffa in the Crimea. In the new millennium, the terrorist attacks against the World Trade Center in New York City and the Pentagon on 11 September 2001, and the subsequent anthrax spore mailings in New York, Florida, and Washington, D.C. have refocused our attention on biological weapons and the potential for biological organisms to be used for the purposes of modern terrorism. Today a large number of countries are introducing as their state policy a system of management procedures aimed at minimizing the risk of the entry and spread of

bioagents (biodefence), in which a significant place is designated to the use of disinfectants and decontamination. The documents define the main measures i18) case of bioterrorist actions and disasters (17, 18, 19, 20).

Expanding the ranges of new pathogens and climate as a factor in their dynamic spread

Climate change and related global changes are one of the most powerful drivers of the evolution of vector-borne diseases. (Leishmaniasis, American trypanosomiasis, Dengue, Chikungunya, Zika, Japanese encephalitis, West Nile viruses, Lyme disease) and their distribution to new and/or larger geographic regions. These processes are invariably associated with expanding of the ranges of zoonotic vectors: Aedes albopictus, Culex, sand flies, mosquitoes, ticks (21). The spread of some infectious diseases such as tuberculosis, malaria, and cholera in extended geographic areas raises health concerns for a significant part of the population (22). These infections show a wider spread as a result of a number of factors: the creation of drug resistance, the development of mosquito tolerance to insecticides, the existence of poor sanitary conditions, rough land use, climate change, intensification of human mobility and traveling (23). A prime example is the outbreak of cholera, malaria and other diseases in regions with preceding natural disasters such as earthquakes and floods (24, 25).

For four centuries, trade and long-distance travels set the stage for the spread of pathogens into new areas. In the period from the 7th to the 19th century the larvae of several species of mosquitoes were transported via ship traffic along with traded goods: Aedes aegypti (vector of dengue, yellow fever, chikungunya and others), Culex pipiens (vector of West Nile encephalitis) and Culex quinquefasciatus (vector of West Nile encephalitis and filariasis) (26, 27, 28). Some pathogens, such as Plasmodium vivax, the etiologic agent of three-day malaria, has been brought by Anopheles sp. to new continents. Malaria-infected mosquitoes, along with vectors of other diseases indigenous to these regions, maintain the background morbidity and humans become sources of vector-borne diseases weeks and months after their travel (29). The introduction of vector-borne disease-causing microorganisms into non-endemic regions often leads to epidemics of an explosive nature. In these epidemic outbreaks, the nonimmune population is at risk of infection for the first few years of the pathogen introduction. The West Nile virus and Chikungunya virus are among the best-studied zoonotic vector-borne diseases that emerged in the past decades, and they demonstrate how explosive epidemics can be among non-immune populations in new regions.

The warm and humid climate favours the increase in the number of turnovers of the life cycles of the vector insects. Some vectors, due to genetic and biological characteristics, have a low degree of adaptation in areas with climates with other characteristics. For example, Tse Tse fly, Glossina sp., the cyclic vectors of Trypanosoma brucei (causative agents of African sleeping sickness) have undergone evolutionary adaptations - they are viviparous and feed exclusively on blood from host vertebrates. These flies are critical to human health and agricultural development in sub-Saharan Africa (30). Unlike the Tse Tse fly, the vectors of Trypanosoma cruzy, the causative agents of Chagas disease, the triatomine bedbugs, belong to the family Reduviidae and are highly adaptable. Chagas disease is considered endemic in 21 Latin American countries. WHO estimates that, as of 2018, between 6 and 7 million people worldwide have been affected by the disease. American trypanosomiasis was once entirely confined to the region of the two Americas. In recent decades the epidemiological pattern of the disease has changed. From a disease prevalent mostly in rural areas, it has become predominantly urban, mainly due to population mobility, urbanization and emigration. Consequently, cases of Chagas disease have been detected in Canada and the USA, as well as in many European countries - Portugal, Spain, France, Greece, the Scandinavian countries, the UK and some African and Western Pacific countries, Australia and Japan (31-33). In Latin America between 10% and 30% of the cases have a clinical picture of varying degrees of cardiac (megacor), digestive (megaoesophagus, megacolon) or neurological systemic disorders (34-36).

Currently only a small number of people infected with T. cruzi, have been found in Europe (32).There are several reasons for this: most European health professionals have little or no experience with the detection and treatment of Chagas disease (37); the access to screening programmes for the communities at risk is very limited and only takes place in large urban areas; the diagnosis of the chronic phase is usually delayed as most patients remain asymptomatic for many years (38).

Adaptation of new endemic pathogens and dynamics of their spread under natural and controlled conditions

As the human population increases, so does the need to expand the areas of cultivated land. This is inevitably associated on the one hand with transformations in the environment, including changes in the ranges of disease transmitting vectors (39, 40) and on the other hand with adaptations in the socio-economic relationships. These two factors actively determine the dynamics of the emergence of new vector-borne diseases. In the transition to agrarian life 10,000 years ago, communities were created where there were real opportunities for emergence of epidemics. For endemic pathogens caused by the changed conditions of land use, the increase in the number of cases runs parallel to the changes in the abiotic and biotic environment of the pathogen. The dynamics of incidence increase in emerging endemic diseases caused by crises in the socio-economic life as a result of political turmoil, military conflicts or natural disasters, can be much sharper. For example, in East Africa and Amazonia, increased areas of stagnant water as a result of deforestation and intense sunlight potentiate the breeding of certain mosquito species, which can increase the risk of malaria. At the same time, rural depopulation and migration to urban areas often eliminates Anophelis mosquito habitat and reduces malaria cases (41). In the 1950s in Bulgaria, planned interventions were initiated to reduce the incidence and eliminate malaria in the country. In 1947 about 200,000 people fell ill annually from malaria and between 200 and 300 died. In 1948, after World War II, in accordance with the World Health Organization's global program, a National Malaria Elimination Program was initiated. After 1950, with the establishment of the Sanitary Epidemiological Stations, planned anti-malarial measures began: rice field containment; hydromelioration works in rural and peri-urban areas; DDT treatment; larvicidal treatment (petrolization) and stocking of water bodies with gambusia fish; mass preventive malaria testing of the population of endemic areas was carried out and those who became ill were also treated with the administration of gametocidal drugs. In 1963 the last indigenous case of malaria patient was recorded and in July, 1965 Bulgaria was certified by WHO as a malaria-free country (42). This shows that in certain countries, with consistent and scientifically sound targeted actions, a deadly vector-borne disease such as malaria can be eliminated.

The driving factors for the spread of pandemics are the interactions between people, defined by their health, social and economic status and culture of behaviour. Individual and population immune responses to the pathogen and the characteristics of the pathogen itself are another group of driving factors. The dynamic or imperceptible changes in the environmental conditions occurring as a result of natural processes or directly or indirectly influenced by the human activity, are the third group of factors for the development of pandemics. Despite the subjective sense of superiority over nature demonstrated by the mankind, the shattering power of the infectious disease epidemics has repeatedly destroyed those illusions. The current pandemic of COVID-19 has ruthlessly shattered stereotypes and patterns of behaviour at the cost of millions of lives. Developing national pandemic preparedness strategies are an urgent current mission of the policy makers and experts in the global world.

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