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GLOBAL CLIMATE CHANGE AND ACCOMPANYING COVID-19 PANDEMIC: A PHYSIOLOGICAL PERSPECTIVE BY AVICENNA FROM 1000 YEARS AGO TO THE PRESENT

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ABSTRACT. The phenomenon of global climate change, which has been discussed for decades whether it is a possibility or a rumor, has revealed with tangible cases. By the end of 2019, it has become clear that this is a global scientific fact. First year of current decade '2020' has been engraved our memories with abnormal natural events; the most dramatics are the Australian bushfires and the coronavirus disease 2019 (COVID-19), which is caused by the new type of coronavirus (SARS-CoV-2). By the emergence of the COVID-19, it has been realized that humanity is helpless against epidemics, as it was in the middle ages, no matter how advanced the technology. Is there a relationship between the COVID-19 pandemic and global warming? It is interesting that this issue, which has been pondered in modern age, was actually addressed about 1000 years ago. Avicenna (Ibn-i Sina) drew attention to negative effects of climate change on health in his studies called the Canon of Medicine. In his corpus, he explained in detail that the changing climate can affect people's physiology and that people with impaired adaptation capacity may be exposed to diseases and epidemics. It is obvious that we have not learned a lesson from the past in our century, in which human beings have largely accepted global warming. Indeed, in such cases, history has the characteristic of repeating itself. For this reason, we have to reconsider Avicenna's determinations and find solutions to the problem of global warming beyond political or economic interests. We can counter possible future pandemics with vaccines, but we cannot end global warming with vaccines. In our review, today when we face global climate change and the COVID-19 pandemic, discussions and scientific data on the pandemic are presented, and Avicenna's physiological perspectives on the subject from 1000 years ago are evaluated.

Keywords: *Global climate change, COVID-19, Avicenna, The Canon of Medicine, Physiology*

KÜRESEL İKLİM DEĞİŞİKLİĞİ VE EŞLİK EDEN COVID-19 PANDEMİSİ: İBN-İ SİNA'DAN 1000 YIL ÖNCESİNDEN GÜNÜMÜZE FİZYOLOJİK BİR PERSPEKTİF

ÖZET. Geçtiğimiz yıllarda bir ihtimal ya da söylentiden ibaret olup olmadığı tartışılan küresel iklim değişikliği olgusu 2019 yılı sonlarına geldiğimizde küresel nitelikte bilimsel bir gerçek olduğunu somut vakalarla ortaya koymuştur. 2020 yılı pek çoğumuzun özellikle Avustralya orman yangını olmak üzere anormal tabiat olayları ve yeni tip koronavirüsün (SARS-CoV-2) neden olduğu koronavirüs hastalığı 2019 (COVİD-19) pandemisi ile belleğimizde yer edinen bir yıl olmuştur. Özellikle COVİD-19 pandemisinden

sonra teknoloji ne kadar gelişmiş olursa olsun, tıpkı orta çağ dönemlerinde olduğu gibi, insanlığın salgınlar karşısında aciz olduğu anlaşılmıştır. Peki, COVİD-19 pandemisiyle küresel ısınmanın bir ilişkisi var mıdır? Modern çağda kafa yorulan bu meselenin, aslında günümüzden yaklaşık 1000 yıl öncesinde ele alınmış olması ilginç bir durumdur. İbn-i Sina, El-kanun fi't tıbb adlı eserlerinde iklim değişikliğinin sağlık üzerine olumsuz etkilerine dikkat çekmiştir. Bu kitaplarda değişen iklimin insanların fizyolojilerini etkileyeceğini ve buna bağlı olarak adaptasyon kapasitesi bozulan insanların hastalıklara ve salgınlara maruz kalabileceği detaylı şekilde izah edilmiştir. Buna karşın, insanoğlunun küresel ısınmayı büyük oranda kabul ettiği yüzyılımızda geçmişten ders çıkartmadığımız da ortadadır. Nitekim bu tür durumlarda tarihin tekerrür etme gibi bir özelliği vardır. Bu sebeple İbn-i Sina'nın tespitlerini ve öğütlerini tekrar bir gözden geçirmek ve siyasi ya da ekonomik çıkarların ötesinde küresel ısınma meselesine çözümler üretmek zorundayız. COVİD-19 pandemisinde olduğu gibi ileride karşılaşmamız muhtemel pandemilere aşı ile karşı koyabiliriz, fakat aşı ile küresel ısınmayı sonlandıramayız. Ayrıca bilim ve teknoloji ne kadar gelişirse gelişsin, aşı veya çip kullanarak; küresel ısınmaya bağlı bozulan fizyolojik mekanizmaların ve azalan adaptasyon kapasitesinin düzeltilmesi mümkün değildir. Yazımızda, küresel iklim değişikliği ve COVİD-19 pandemisiyle yüzleştiğimiz günümüzde, pandemiye dair tartışmalar ve bilimsel veriler sunulmakta ve İbn-i Sina'nın 1000 yıl öncesinden konuya dair fizyolojik perspektifleri değerlendirilmektedir.

Anahtar kelimeler: *Küresel iklim değişikliği, COVİD-19, İbn-i Sina, El-kanun Fi't Tıbb, Fizyoloji*

INTRODUCTION

IS IT A COINCIDENCE THAT COVID-19 STARTED IN CHINA (ONE OF THE COUNTRIES WITH HIGH AIR POLLUTION AND GREENHOUSE GAS EMISSIONS)?

The coronavirus pandemic has started in China, one of the countries with high air pollution. The rapid growth of the Chinese economy in the last 30 years has increased the use of fossil fuels, especially coal, at the highest level. Chinese economy grew by about 10% per year between 1990 and 2017 and became responsible for about 1/4 of global energy consumption and carbon emissions [1]. China's fossil fuels energy-based growth strategy and increased coal dependency have caused country to be the country that emits the greenhouse gases that cause climate change the most, as well as being affected the most from air pollution. Particularly, fine particle (PM2,5) pollution, which is the most dangerous particle in China, is at a very high level and is above the limit value in 98.6% of the 210 cities where measurements were made [2]. Therefore, the number of preventable deaths due to air pollution in this country is also very high. According to the figures calculated for 2015, approximately 1.1 million people die every year in China due to PM2.5 pollution [3].

The Air Quality Index improved by about 20% in 322 of the 366 cities where data were reviewed during the lockdown period in China to prevent the pandemic. In same cities, reductions in nitrogen oxides (NOx) and sulfur dioxide (SO2) as well as PM2,5, particulate matter (PM10) and carbon monoxide (CO) levels were also observed. It can be said that the improvement in the Air Quality Index is related to the decrease in motor vehicle traffic and industrial emissions [1, 3]. Likewise, in Italy, Spain and France, where the pandemic was seen the earliest and most severe in Europe and therefore widespread quarantine measures were implemented, nitrogen dioxide (NO2) emissions decreased between 20% and 30%. According to this situation, the concentrations of pollutants in the atmosphere in these countries were also measured quite low compared to the previous years [4]. In this period, the decrease in greenhouse gas emissions that cause climate

change is also remarkable [5]. All these data are important indicators that nature tries to renew itself when mankind take a break from their harmful activities, even for a short time period. For this reason, it is necessary to take decisions to reduce or prevent the harmful actions of people both on a country basis and globally. These decisions must be supported by actions that will contribute positively to nature. Legal regulations must be strictly enforced in order to implement and supervise these actions. To maintain this struggle, lessons and practices should be given to children and young population and we need to practice them the ability to live in harmony with nature.

IS THE CORONAVIRUS PANDEMIC NATURAL?

Among all speculations perhaps the most striking of the links between COVID-19 and global warming is the prevalence of conspiracy theories in both areas. One of them is the claim that COVID-19 is a biological weapon developed by some countries. The number of people who think that the pandemic is not different from the seasonal flu that recurs every year is also quite high [6].

No matter how unrealistic and easily refuted they may seem, COVID-19 conspiracy theories have reached many people in a short time. Interestingly, these claims have been supported by a substantial number of people both in Turkey and worldwide. Unfortunately, the number of people who believe in this issue is not small at all, ignoring the point where global warming has come and the vital dangers awaiting humanity. Perhaps the most negative result of this situation is the formation of opposition to vaccines. For this reason, the end of the pandemic has prolonged, health problems, even serious numbers of deaths and economic deficits occurred. Of course, there are points of criticism regarding the way the vaccination policy is implemented. There is even the possibility of developing side effects related to vaccines, but these need to be dealt with on a scientific basis. The determinations of virologists, microbiologists, infectious diseases specialists and public health experts on this subject should be followed carefully. Of course, it is important for ordinary people to be aware of the pandemic and to follow current developments. However, this does not ensure that they are in a decision-making position. Believing in the claims of people with social media diplomas as broad as their imaginations without listening to the experts of the subject can lead people to make wrong decisions. It should not be forgotten that this kind of cursed decisions can result in permanent health problems or even deaths. Spreading such rumors and causing someone to do wrong and get hurt is a heavy burden of conscience.

IS GLOBAL WARMING REALITY EXAGGERATED?

Although it has been known for many years that the global climate has changed due to the accumulation of greenhouse gases in the atmosphere caused by human activities. It can be said that the issue came to the agenda of the world public opinion in the early 1990s [7]. Human activities such as the use of fossil fuels, the destruction of forests, industrial agriculture and animal husbandry, and engine industry increase the concentration of greenhouse gases such as carbon dioxide (CO2) and methane (CH4) in the atmosphere, thus increasing the greenhouse effect. So, these accumulations accelerate climate change and magnifies the crisis. The CO2 level has increased by about 26% compared to 1970. According to the scientific report prepared by the Intergovernmental

Panel on Climate Change, it is stated that the concentration of CO2 gas should be limited to 430 ppm in order to keep the global temperature increase in the atmosphere at 1.5°C in order to slow down climate change [8]. Among all indicators, temperature is just one of them. Other indicators include atmospheric CO2, Arctic and Antarctic glacial mass balance, seawater level, ocean temperature and acidification. According to the final report on Global Climate 2015-2019, all indicators show that climate change has accelerated in the last 5 years. Levels of CO2 and other important greenhouse gases in the atmosphere rose 18% more in 2015-2019 than in the previous 5 years. The risk of heat-related illness or death has climbed steadily since 1980, and around 30% of the world's population now lives in climate conditions that lead to potentially deadly temperatures at least 20 days a year [9].

More severe heat waves expected with climate change may trigger health problems for risky groups such as the elders, children and individuals with chronic diseases. Events such as floods can facilitate the spread of diseases transmitted through food and water, while increased temperatures can facilitate the spread of diseases transmitted by vectors. In addition, new infectious diseases specific to tropical climates may emerge. Globally, failure to eliminate greenhouse gas emissions can amplify the impact of air pollution, leading to respiratory system ailments or exacerbating existing problems. One of the situations associated with global warming is the increased risk of fire. The most typical example of this is the Australian bushfire in 2019-2020. In this fire, the area that effected from the fire is approximately 19 million hectares. This amount corresponds to approximately 14% of the total forested area of the Australian Continent [10, 11]. In addition, many irreversible losses of life were experienced. The negative effects of this fire disaster will continue for many years. In addition, regaining the natural habitat losses as a result of fire requires many years and perhaps it will not be possible to fully recover this expectation.

It is clear that reduction in emissions of harmful particles and gases will not be enough to deal with the climate crisis, even if some countries continue to take existing restrictive measures due to COVID-19. Since this temporary situation will be forgotten when the process returns to normal, countries should take action on the climate crisis and take measures to ensure that sustainable climate action plans are permanent and this should be very urgent. The IPCC, which was established by the joint initiative of the United Nations (UN) World Meteorological Organization and the Environment Program, has institutionalized the scientific consensus. Following this process, international climate negotiations and the process of creating global climate policies that have reached the present day have begun. The entry into force of the UN Framework Convention on Climate Change and the adoption of legally binding greenhouse gas reduction commitments with the Kyoto Protocol took place within 10 years of these developments. However, this process has not been successful in neither stopping nor slowing the emission of greenhouse gases into the atmosphere [6].

The last 30 years have been a period of both combating climate change and campaigns of doubt and denial [12]. These campaigns took various forms, from claiming that the increase in CO2 in the atmosphere is not something to be afraid of, to claiming that the climate does not change, that it does not change due to human influence, even if it does, because it is not global warming but cooling, even if there is warming, it is not negative. Despite the fact that scientists agreed on the vital importance of stopping climate change, the world public opinion was divided into two, causing the governments that had the biggest share in this problem to hold back from taking action for a long time. In the

intervening years, global greenhouse gas emissions and the amount of carbon dioxide accumulating in the atmosphere have doubled, and a significant part of the total global emissions and temperature increase compared to the pre-industrial period occurred after 1990. Climate change has turned into a global crisis since this time [6].

Even the European Union, which plays a leading role in international climate policies, had to wait until 2019 to adopt green order policies and begin to set a serious emission reduction target. Acting slowly and losing time seems to be one of the common points between the struggles against the climate crisis and the pandemic. When the epidemic first appeared in China, the countries of the could not realize the situation and even when the spread of the virus to Iran and Italy after the Far East countries made a global pandemic inevitable, countries outside the disease cluster were delayed in taking precautions. In this period, mostly unscientific views that can be seen as a symptom of denial psychology, such as that the disease is a simple flu, that well-nourished people will not get the disease, that the virus only affects the yellow race or the elderly, that the virus spread will stop in hot weather, that not the coronavirus infection but other underlying diseases cause death. There have been factors that reduced the chances of social acceptance of decisive measures that it could take. Especially in this period, when it was not understood what kind of treatment should be applied to severe patients and the health system was unprepared, deaths reached very high numbers [6].

THE COVID-19 PANDEMIC EMERGING AT THE TIME OF GLOBAL WARMING

In the wild animal market place in Wuhan, China, which is considered the place where the coronavirus pandemic started, animals that most people do not prefer to eat are kept together, in extremely uncomfortable and unhygienic conditions. It is suggested that consumption of bats or pangolins in this market place was responsible for the start of the pandemic among these animals. This situation necessitated considering the risk of epidemic diseases as a result of the invasion of the natural habitats of creatures that do not normally coexist and the trade of wild animals as a result of the mutation of microorganisms [13]. Its natural habitats are decreasing every year by the forest destruction of the mankind and open pastures and agricultural areas for settlements. Especially during the last 50 years, the logarithmic increase in human population and consumption has rapidly depleted the wildlife in its natural habitats, which are trapped between sprawling human settlements. According to the Living Planet Report of the World Wildlife Fund, the wild animal population has decreased by more than half since 1970 [14].

It is accepted by World Health Organization (WHO) that the increase of epidemic diseases caused by pathogens transmitted by water or carrier species is possible with the effect of climate change [7]. Microorganisms/pathogens, including viruses and bacteria, are the species that can rapidly take on new forms in changing conditions and can adapt to change the fastest. It is obvious that the adaptation of multicellular organisms to changing conditions will not be as fast as viral or bacterial species. The expansion of people's habitats towards nature, the removal of wild animals from their natural habitats and illegally bringing them to the city, human-induced air, soil and water pollution can also change the nature of microorganisms. The outbreak of the COVID-19 pandemic in the process of declining natural habitats is an important phenomenon that needs to be considered.

Wildlife areas are shrinking due to the continuous invasive movement of human beings. In relation to this situation, despite the decrease in wildlife due to decreasing habitats, the number of animals per unit area increases. Animal species that are natural enemies or are in competition with each other have to live in close contact. This situation is a serious threat to the continuity of the species. In addition, the contact of animals that cannot coexist in natural life is increasing, and accordingly, their habitats and microbial faunas of the species are changing. Changes in microorganisms in this direction lay the groundwork for the increase of mutations and the formation of new microorganism species. In relation to this situation, the immune systems of animals and humans have to cope with these newly encountered microorganisms. In cases where the necessary immune adaptation cannot be achieved, diseases and epidemics originating from microorganisms are inevitable.

GENERAL EFFECTS OF CLIMATE CHANGE ON HEALTH

All countries are under similar risks against the negative health effects of climate change on health. The risk index may vary according to the cultural organizations, geographical locations and socio-economic structures of the countries. Climate change especially affects social and environmental determinants of health such as clean air, fresh water, adequate food and safe shelter.

Climate change can have impact on health directly or indirectly. It is known that the frequency and intensity of extreme weather conditions have increased as a result of climate change. Diseases and deaths occur in proportion to the severity of extreme weather events such as hurricanes, floods, tornadoes, snow and wind storms and drought. Between 2000 and 2011, approximately 3.4 million people in Europe were affected by floods [15]. Extreme weather events can cause injuries, post-disaster epidemics and several problems such as malnutrition and psychiatric disorders [16]. The indirect effects of climate change are somewhat more complex than the direct effects. The environmental consequences of climate change include temperature rise, heavy rainfall in some places, drought in others, extreme weather events and rising sea levels [17]. Therefore, the quality and safety of air, soil, water and food are compromised. There is a two-way interaction between air pollution and climate change. Air pollution can cause climate change. Moreover, the level of air pollution due to climate change can also be affected. In particular, the gases that emerge as a result of the burning of fossil fuels are among the main pests in climate change with their atmospheric effects, and they also directly harm human health [18]. In general, the number of extreme hot days is increasing, while the number of cold days is decreasing [19]. The human body, which gets used to the summer heat as time passes, cannot achieve this physiological adaptation in sudden temperature increases. Malignant melanoma is one of the skin cancers increasing worldwide due to ultraviolet radiation (UVR) [20, 21]. UVR causes corneal, lens and retinal damage in the eye. Photokeratitis is seen in long-term transplantation, cataract and other eye damage is seen in life-long cumulative transplantation. A 10% reduction in the total amount of stratospheric ozone causes approximately 1.7 million additional cases of cataracts worldwide each year [21]. It is known that eye diseases, especially cataracts, are very common in Africa, where hot climatic conditions prevail.

By the middle of the 21st century, crop productivity in Central Asia is expected to decrease by around 30%. This can cause problems such as insufficient feeding and malnutrition [22]. Due to changing climatic conditions, water resources that do not face

the need or increase in pollution, and soils that lose their productivity, people will change their places and migrate in time [16]. The transmission of endemic diseases to the migrating countries due to intense migration is also an important risk. Climate change affects fresh water, adequate food and safe shelter conditions, which are among the social and environmental determinants of health. Although retrospective evaluations are difficult, according to WHO; between 2030 and 2050, 250,000 more deaths are expected each year as a result of malnutrition, malaria, diarrhea and heat stress caused by climate change [7]. Changes in temperature and humidity, excessive precipitation, changes in winter temperatures, urbanization, decrease in vegetation or cause structural changes, may cause vectors to be seen in different areas from where they are found and to increase their numbers [16]. Also, climate change increases the risk of interspecies viral transmission, such as the formation of the COVİD-19 virus, which is the main topic of this article [23].

AVICENNA'S PHYSIOLOGICAL PERSPECTIVES ON THE EFFECTS OF CLIMATE CHANGE ON HEALTH

We are facing the COVID-19 pandemic in the 21st century, similar to the pandemic periods that threatened humanity in the past when we could not cope with microorganisms. At the same time, we are in a period where the effects of global warming are seen. It is required to conduct a good analysis of this situation and take strategic steps for the future both scientifically and politically. Although human suffering due to global warming spreads slower than a pandemic, it is the threat that is most likely to harm humanity in the future [24]. A direct relationship between global warming and the COVID-19 pandemic has not yet been demonstrated. But an organism is never likely to remain unaffected by changes in its environment. This indicates that a possible interaction, direct or indirect, between global warming and the COVID-19 pandemic is possible. It has been suggested that the Earth's climate system and microbial activity in the soil are linked, and the physiology of microbial organisms is affected by changes in this environmental factor [25].

Until 2019, especially in developed societies, scientists and political authorities focused on metabolic disorders such as obesity, diabetes and cardiovascular diseases, which have increased like epidemics [26]. It seems that humanity now has to produce scientific data and solutions in terms of combating both microbial pandemics and metabolic epidemics [27, 28]. It is not possible to isolate this situation from the lifestyle changes that emerged with industrialization and the global warming that develops as a result. Every organism has to keep the effects of the environment on its physiological functions within a certain limit or range. Maintaining homeostasis, which is a fundamental principle in terms of the continuity of physiological functions, would be more difficult, especially in extreme conditions such as global warming. As in the Ice Age period, abnormal climatic conditions as a result of global warming would affect physiological functions and even the distribution and survival of some species, including humans [29].

In order to make the pandemic and post-pandemic period more favorable for humanity, it is essential to develop multi-directional scientific strategies based on past experiences to slow down global climate change and prevent its effects. In terms of past experiences and knowledge, the findings of researchers and philosophers who have important contributions to medicine have a substantial influence. One of them is Ibn-i Sina (980,

Usbekistan-1037, Iran). This important physician and philosopher, known as Avicenna in the world, left his famous works named ‘‘the Canon of Medicine (also called as El-Kanun Fi’t Tıbb)’’ as a legacy to humanity [30]. These books, written about 1000 years ago, continue to shed light on the period we live in, with their determinations on the effects of air quality and climate changes on human health. In The Canon of Medicine, it is stated that the body has a healthy condition (physiological condition), a diseased condition (pathological condition) and a pathophysiological condition that is in between. Atmospheric air is among the 6 basic etiological factors that can cause changes in the health of the body. Others are related to food and drinks, physical activity, psychological activity (psychological states), sleep-wakefulness, and digestion/excretion. Avicenna draws attention to the negative effects of changes in atmospheric air and temperature-related characteristics of the seasons on health. It is stated that, if the characteristics of a season are not the same as its temperature, it may turn into a potential risk to health, and a season that becomes largely abnormal may have negative effects on the physiological functions of both healthy and disadvantaged people (possibly those with chronic diseases, elderly, children and those with genetic predisposition). Moreover, the connection between the abnormality of various consecutive seasons and the risk of pandemics are also among the issues mentioned in these books [30]. From 1000 years ago to the present, in brief, Avicenna recommends paying attention to the quality of the breathing air and the temperature of the climate for a healthy life.

In the 21st century, when the deterioration in the quality of atmospheric air and global warming started to threaten our health, the fact that we are facing a global pandemic makes Avicenna's words even more meaningful. As a matter of fact, it is interesting that humanity continues to fall under the slow but heavy and overwhelming effects of adversities related to global warming, although the determinations of 1000 years ago are still valid. During the COVID-19 pandemic, humanity is about to gain the ability to act globally against a common enemy. These behaviors and sensitivities should also be applicable to global climate change, which is the common enemy of future generations, because global changes or environmental factors that threaten the health of today's society are not excluded from the possible impact of global warming.

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