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Review

Our future: Experiencing the coronavirus disease 2019 (COVID-19) outbreak and pandemic

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ABSTRACT

Outbreaks of the novel coronavirus disease (severe acute respiratory syndrome coronavirus 2: SARS-CoV-2) (coronavirus disease 2019; COVID-19) remind us once again of the mechanisms of zoonotic outbreaks. Climate change and the expansion of agricultural lands and infrastructures due to population growth will ultimately reduce or eliminate wildlife and avian habitats and increase opportunities for wildlife and birds to come into contact with livestock and humans. Consequently, infectious pathogens are transmitted from wildlife and birds to livestock and humans, promoting zoonotic diseases. In addition, the spread of diseases has been associated with air pollution and social inequities, such as racial discrimination, gender inequality, and racial, economic, and educational disparities. The COVID-19 pandemic is a fresh reminder of the significance of excessive greenhouse gas excretion and air pollution, highlighting social inequities and distortions. This provides us with an opportunity to reflect on the appropriateness of our trajectory. Therefore, this review glances through the COVID-19 pandemic and discusses our future.

Contents

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1. Introduction

The novel coronavirus (severe acute respiratory syndrome coronavirus 2: SARS-CoV-2) has been presumed to have been transmitted from bats, the harboring hosts, to humans through livestock, wild animals, or domesticated wildlife [1,2]. Diseases that develop from infectious pathogens transmitted from animals to humans are referred to as zoonotic diseases, many of which have already caused global epidemics, such as severe acute respiratory syndrome (SARS), avian influenza (H5N1), and the Middle East respiratory syndrome (MERS). This outbreak of zoonotic diseases is partly due to the decline and disappearance of forests and wetlands as habitats for wild animals and birds resulting from global warming and climate change. This has brought wild animals and birds closer to livestock and residential areas and increased their opportunities for contact with livestock and humans. Furthermore, disparities and social inequities have been implicated in the spread of infection, with the current pandemic highlighting social distortions. Therefore, understanding the outbreak, spread of infection, and the overall structure of society, including the discussion on the prevention of future incidences, are imperative.

2. Trajectory of infectious diseases

The pandemic of infectious diseases over the last century occurred following the increased human mobility due to colonization, trade, and travel, which promoted human infections. Apart from human migration, this pandemic of infectious diseases has been related to the immature concept of public health, poor social infrastructure (e.g., water and sewage systems), and underdevelopment of vaccines and therapeutic drugs. In subsequent decades, increased global travel and trade further increased human mobility and outbreaks of infectious diseases. Aside from socio-economic structural changes, climate change had an important impact on the recent occurrence and spread of infectious diseases. Climate change has caused an increase in the number and activity range of arthropods, including disease-carrying mosquitoes and insects, resulting in several epidemics, such as dengue fever, malaria, and West Nile fever. Moreover, wildlife and bird migration have been altered, while forests and wetlands, which are wildlife and bird habitats, have been reduced or abolished. Wild animals and birds that have lost their habitat migrate closer to livestock and human populations, resulting in an increased chance of contact and contributing to the development of zoonotic diseases, such as Ebola, SARS, MERS, and avian influenza [3]. The subsequent discussions will focus on how climate change affects the occurrence and prevalence of viral infections.

3. Global warming and climate change

Global warming is defined as an increase in Earth's surface temperature, whereas climate change refers to the changes in climate associated with global warming. Aside from the naturally fluctuating temperatures, studies have suggested that human activity could also increase the average temperature by 1 °C from pre-industrial levels, with estimates showing a potential increase of 1.5 °C by 2050 [4]. Global warming has been closely linked to the melting of the Arctic and Antarctic glaciers, rising sea levels, natural disasters (e.g., hurricanes, torrential rains, floods, landslides, and forest fires), personal and socio-economic activities, and human health problems [5,6]. Global warming is primarily caused by the excretion of greenhouse gases, such as carbon dioxide and methane [7,8], that control surface temperatures with the associated climate change affecting the natural environment and human society [9].

3.1. Deforestation

Forests help prevent global warming by releasing oxygen and absorbing carbon dioxide, providing an optimal environment for plant and animal survival, and maintaining socio-economic activities. Consequently, forests benefit natural resources and humans [10–12]. Unfortunately, the progression of deforestation has decreased the forest area, with only 30% of the earth's land area currently being covered by forests. Table 1 summarizes the benefits of forests and the causes and effects of deforestation [10–14].

3.2. Wetland reduction

Wetlands are areas constantly filled with water. Inland wetlands include swamps, peat ponds, lakes, and marshes; coastal wetlands include saltwater swamps, estuaries, mangroves, lagoons, and coral reefs; and artificial wetlands include fishponds, rice paddies, reservoirs, and salt ponds. Wetlands are rich reservoirs of biodiversity occupied by 40% of the world's plants and animals. Since 1900, 64% of the world's wetlands have disappeared due to climate change, expansion of agricultural land and livestock grazing areas, land reclamation, and construction of dams and levees. As wetlands decline, they transform from carbon sinks to carbon sources, contributing to global warming and the loss of wildlife and avian habitats. This trend is particularly prominent in Asia [15,16].

3.3. Permafrost reduction

A quarter of the landmass across the Northern Hemisphere is covered by permafrost, described as the ground that has remained permanently frozen for at least 2 years. As global temperatures rise, permafrost areas come under greater risk of thawing, potentially releasing carbon stored over the years into the atmosphere. Moreover, permafrost acts as a global freezer, storing vast amounts of organic matter, including dead plants, animals, and microbial carcasses that have accumulated in the soil after being frozen thousands of years ago. As global warming causes permafrost to thaw, newly stimulated microbes decompose organic matter, releasing carbon dioxide and methane into the atmosphere, and causing a vicious cycle of global warming [17–19].

3.4. Wildfires

In recent years, climate change and global warming have been a major cause of wildfires across the Amazon rainforests, the United States (California), Australia, Indonesia, and other countries. These have a significant impact on natural ecosystems, impose health hazards to humans and animals, and create socio-economic losses. Smoke or particulate matter (PM) from forest fires promotes respiratory and cardiovascular diseases, including asthma, chronic obstructive pulmonary disease (COPD), bronchitis, and pneumonia. Middle-aged and elderly individuals, children, pregnant women, and fetuses are especially susceptible to the negative effects of wildfires [20,21]. Moreover, wildlife and birds lose their natural habitat and become susceptible to health hazards due to smoke or PM.

4. Impacts of population growth

Global estimates have projected that by 2100, the world's population would increase by nearly 4 to over 11 billion people [22]. Population growth will ultimately lead to increased demand for food and global warming due to increased carbon dioxide excretion [23]. Consequently, expansion of agriculture and livestock farming would be necessary to meet the increased demand for food associated with population growth [24]. Since 1940, agriculture is involved in more than 25% of all human infectious diseases and more than 50% of all zoonotic diseases. Moreover, studies suggest an increasing rate following the expansion and intensification of agriculture [25]. Agriculture occupies approximately half of the world's land area and utilizes over two-thirds of the world's freshwater [26]. To satisfy the food demands of a projected population of 10.1 billion people by 2100, agricultural production will need to double or even triple, requiring an allocation of more than 10.9 billion hectares [27–30]. To increase agricultural production, farmland expansion, better irrigation, breed improvement for

Table 1 – Benefits of forests, causes and effects of deforestation.

Benefits of the forest	Causes of Deforestation	Impacts of Deforestation
Carbon dioxide accumulation	climate change	Decrease in carbon dioxide absorption
Moisture cycle between atmosphere, land and forest	forest fire	climate change
Control of earth erosion and sediment disasters	forest lumbering	Loss of forest and plant growth areas
Providing habitat for multiple species	Desiccation and erosion of the earth - Decreased nutrients	Loss of wildlife and bird habitat
	Expansion of livestock grazing land	Landslide disaster and drought
	Expansion of agricultural land	

increased productivity, and social infrastructure are necessary. The necessary expansion of the livestock industry, which satisfies the demand for meat consumption, would replace natural ecosystems. In addition, the rearing environment within family farms (backyard livestock), mainly practiced in developing countries [31], needs to be examined given that this leads to higher animal densities, which increases the risk for infectious diseases. The expansion of agriculture, livestock farming, and grazing lands has been shown to increase global warming [32], affect natural ecosystems, and reduce wildlife habitat. To eradicate hunger, the United Nations Sustainable Development Goals (SDGs) recommends the growing population to find solutions through technological innovation and address the increased risk of zoonotic disease outbreaks associated with the increased demand for food and reduce the impact on natural ecosystems while maintaining a healthy environment and socio-economic balance [33]. Studies have also suggested the need to review bushmeat [34,35], dietary innovations, increased consumption of insects, and cultured meat animal protein alternatives.

5. Impact of climate change on human health

Climate change has been found to have direct (health disorders, such as heatstroke) and indirect (arthropod-, wildlife-, and avian-borne infections, food- and waterborne diseases, and allergic diseases due to pollen allergens) effects [36]. Food concerns, public health, and social infrastructure have also been associated with health problems. Several arthropod-borne infections, such as dengue fever, West Nile fever, Zika virus fever, and malaria, have been identified [36–39].

The commercial environment where wildlife, birds, and livestock are sold and the dietary habits of those who consume them have also been linked to zoonotic diseases [40–42]. The subsequent chapter discusses the relationship between forests and wetlands, which are habitats of wildlife, birds, and zoonotic diseases.

6. Non-spontaneity of zoonotic disease outbreaks

Zoonotic diseases have been increasing [43]. Studies have shown that approximately 60% of human infections and 75% of emerging infections are zoonotic [44,45]. Most zoonotic diseases that have recently emerged or resurfaced have originated from the wildlife [46], such as Ebola, avian influenza, MERS, Nipah virus, Rift Valley fever, SARS, West Nile virus, Zika virus, and recently, COVID-19. The aforementioned diseases have all been linked to human activity. The Ebola outbreak in West Africa resulted from forest loss, which consequently brought wildlife and human settlements closer together. Moreover, the avian flu outbreak was associated with intensive poultry farming, while the Nipah virus was associated with pig farming and the intensification of fruit production in Malaysia. Given the association between the commercial environment where wildlife, birds, and livestock are sold, the dietary habits of those consuming these animals, and zoonotic outbreaks [40–42], scrutinizing and clarifying the relationship between zoonotic outbreaks and social structure is imperative [47].

Climate change associated with global warming causes deforestation, permafrost thawing, forest fires, wetland loss, droughts, and floods. The acquisition of land to expand agriculture, livestock farming, and social infrastructure due to population growth has also been shown to promote deforestation and loss of wildlife and avian habitats. Such actions provide more opportunities for wild animals to come into contact with livestock and humans, increasing the likelihood of zoonotic pathogen transmission from wild animals to livestock and humans. Unless measures are taken to protect the environment and wildlife, zoonotic diseases will continue to increase.

7. Impact of environmental factors on the COVID-19 pandemic and its severity

Factors that determine the occurrence and prevalence of global viral infections are as follows: virulence, stability, and antigenic variation of the virus, vector and avian ecology, viral infectivity from vectors and birds to humans, viral infectivity from humans to humans, virus-host interactions, host infection protection and immune capacity, medical environment, effective vaccines and therapeutics, socio-economic environment, and environmental factors [48,49]. This chapter describes the impact of environmental factors, such as temperature and environmental pollution, on the incidence and prevalence of viral infections and discusses the impact of these factors on the development and pathogenesis of underlying diseases determined as risk factors for COVID-19 severity.

7.1. Temperature

Low temperatures and humidity have generally been recognized as risk factors for influenza onset and prevalence, while warmer winters report lower influenza prevalence and mortality rates [50]. However, the analysis of the association between climate and the US influenza epidemic season has shown that milder winters tend to be followed by more intense, early-onset influenza A and B epidemics [51]. A study examining the effect of environmental temperature on the host's infection protection and immune capacity revealed that influenza virus-specific CD8 T-cell function and antibody responses were significantly reduced in mice exposed to high temperatures of 36 °C. Moreover, the same study found that the administration of glucose and short-chain fatty acids restored influenza virus-specific adaptive immune responses in mice exposed to high temperatures. The aforementioned findings reveal a mechanism by which environmental temperature and nutritional status regulate virus-specific adaptive immune responses [52]. SARS-CoV-2 has been reported to promote viral transmission in cold and low-humidity environments [53]. Indeed, a study analyzing and summarizing 17 research papers on COVID-19 found that a cold and dry environment were factors promoting the transmission of SARS-CoV-2 [54].

7.2. *Ambient and indoor air environment*

Ambient and indoor air pollutants include PM and other various substances that affect the entire body [55].

7.2.1. *Impact on COVID-19 outbreaks and pandemics*

Levels of air pollutants, such as PM2.5, have been correlated with the number of cases and deaths from viral infections during SARS, MERS, or influenza pandemics [56–58], with results similar to those reported in COVID-19 [59–62]. Air pollutants have also been correlated with the prevalence of SARS-CoV-2 antibodies. Such correlations have not been limited to long-term exposure to air pollutants. Consequently, one study examining the relationship between air pollution levels and the number of patients revealed that short-term (3 weeks) exposure correlated with the number of patients [63]. The mechanisms, by which exposure to air pollutants increases viral susceptibility in living organisms include impaired cilia motility, oxidative stress generation, decreased viral phagocytosis of macrophages, modification of surfactant protein-A and -D function, decreased innate immunity, and enhanced production of inflammatory cytokines [64]. Given the involvement of air pollutants such as PM2.5 in the severity of COVID-19, measures to control both indoor and outdoor air pollution are vital. People in developing countries, refugees, and migrants living in poorly ventilated indoor spaces that accumulate air pollutants produced by the combustion of solid fuels and biomass used for cooking and heating are also presumed to be at high risk for COVID-19 [65–68]. Overcrowded housing conditions in refugee camps, indoor air pollution, inadequate drinking water and drainage, poor sanitation, and poorly maintained health care conditions all facilitate the development and spread of infectious diseases. Considering that 80% of refugees live in low- and middle-income countries, they are among the most vulnerable populations worldwide, with the COVID-19 pandemic placing them at enormous risk.

7.2.2. *Impact on the development and pathogenesis of underlying diseases determined to be risk factors for COVID-19 severity*

7.2.2.1. *Underweight babies and fetal stunting*. Air and indoor air pollution have been among the many causes of low birth weight and fetal stunting. Low-birth-weight infants are at risk of developing a variety of diseases after birth. Accumulated evidence suggests that fetal malnutrition is associated with the development of ischemic heart disease, diabetes, lipid disorders, and hypertension in adulthood [69], leading to the developmental origin of health and disease concept [70]. The environment can shape postnatal health and predisposition to lifestyle-related diseases. As a result, low-birth-weight infants develop ischemic heart disease, diabetes, and lipid metabolic disorders in adulthood due to their predisposition and postnatal environment. Birth weight has been correlated with forced expiratory volume 1.0 s ($FEV_{1.0}$) [71], while respiratory function immediately after birth has been correlated with respiratory function at age 22 [72]. Air pollution has been found to hinder lung growth in fetuses, infants, and young children, which increases the risk of developing COPD [73]. Thus, low birth weight and fetal stunting have been associated with the development of diseases, such as COPD, diabetes, and cardiac disease, which are risk factors for severe COVID-19 and mortality. Therefore, apart from disease control measures, comprehensive measures are also needed to understand the pathogenesis of these diseases.

7.2.2.2. *COPD*. While tobacco is undoubtedly a risk factor for developing COPD, other risk factors include biomass burning and air pollutants [73]. Knowledge regarding the risk factors for the severity and mortality of COVID-19 has continued to accumulate, identifying COPD as one of the risk factors [74–76]. COPD is a chronic, gradually progressive disease with often unremarkable subjective symptoms, making it difficult for patients to determine its presence. Patients with undiagnosed COPD outnumber those with diagnosed COPD. Therefore, diagnosing and appropriately treating patients with potential COPD will help mitigate the severity of COVID-19.

Altogether, addressing natural environmental factors is crucial given their relationship not only with the occurrence and prevalence of viral infections but also with the development and pathogenesis of diseases that increase COVID-19 severity.

8. Protecting our health

The average global temperature has risen by 1 °C from pre-industrial levels, with estimates projecting an increase of 1.5 °C within the next 20 years following the current rate of warming. Studies have highlighted the challenge of maintaining an average temperature below 2 and 1.5 °C [77]. Carbon dioxide emissions have been a major contributor to climate change, with studies suggesting that emissions increase again [78]. Apart from reducing fossil fuel combustion, carbon dioxide can also be reduced by conserving and increasing forests, grasslands, farmlands, and wetlands that absorb and store carbon dioxide. This also promotes livestock farming and agriculture that incorporates technological innovations, aiming to reduce methane and other greenhouse gas excretion from livestock farming and agriculture [79–81]. One study suggested that children born in recent years will suffer from a severe existential crisis due to climate change [82]. Moreover, the study reported that maintaining our current way of life would leave the next generation with an environment 4 °C warmer than pre-industrial temperatures, which may lead to food shortages, drinking water security, air pollution, increased costs of living, psychological burdens due to extreme heat, severe storms, and disease. The only way to protect our health is to protect the planet.

Thus, the COVID-19 pandemic should serve as a wake-up call for humans to reflect on our lifestyles and understand the direct link between our daily lives and the environment. Moreover, we should commit to protecting our planet and ensuring that infectious diseases, such as COVID-19, never occur again.

The following discussions will consider the immaturity and distortions of social structures and institutions highlighted by COVID-19.

9. COVID-19 and social injustice

The COVID-19 pandemic has highlighted social inequities, such as racial discrimination, gender inequality, and economic, racial, educational, and health disparities. Social inequities create disparities regarding the right to health care services and the environment, which facilitated the spread of the COVID-19 pandemic [83–85]. Thus, there is a need to understand and strive to correct social inequities, which magnified during the COVID-19 pandemic.

9.1. *Racial disparities*

Disease incidence and morbidity, access to diagnosis and treatment, and prognosis and mortality vary according to the region and race/ethnicity. Moreover, socio-economic inequalities have been observed between races, with the same being true for health care.

The results of a four-tiered classification of the number of people infected in New York City as of March 31, 2020, according to by zip codes, showed clear differences according to region, with a comparison between high- and low-income neighborhoods showing that, while not perfect, low-income neighborhoods were more likely to be infected than high-income neighborhoods. Aside from income disparities, the study further found that residences of service workers, renting and residential dwellers, and residences of people of color were correlated with COVID-19 [86].

One study examined COVID-19 and mortality according to race and ethnic composition of white Americans, African American, Hispanic, American Indian, and Asian populations in Washington, Arizona, Indiana, Kansas, Massachusetts, Minnesota, New Hampshire, Ohio, Oregon, Rhode Island, Utah, and Virginia between March and June 2020. In Minnesota, 52.9% of the white population was hospitalized, with the white population accounting for 84.1% of the state's population. On the other hand, 24.9% of the African American population were hospitalized, despite accounting for only 6.8% of the state's population. Hispanics, American Indians, and Asians also tended to have higher hospitalization rates [87]. An analysis of the Centers for Disease Control and Prevention (CDC) dataset also showed that racial and ethnic minorities, such as African Americans, were at higher risk for COVID-19 morbidity and mortality [88]. However, mortality rates between white American and African American patients who received hospital treatment showed no statistically significant difference [89]. Similarly, no differences were found between Hispanics, African Americans, non-Hispanics, and Asians [90].

Thus, health disparities in COVID-19 should be analyzed from multiple perspectives, including socio-economic factors, rather than biological race.

9.2. *Racial discrimination*

The United States is a multi-racial nation in which white Americans, African Americans, Hispanics, American Indians, Asians, and other racial and ethnic groups coexist. Although racial discrimination was abolished with the passage of the Civil Rights Act in 1964, it persists today. Two types of racism have been identified: institutional racism and structural racism [91]. The former refers to the process of racism embedded in the efficiency, policies, and practices of society and its institutions, while the latter refers to the living environment (densely populated areas, poorly maintained parks, poorly maintained social infrastructure, multi-generational households, a large number of family members, poorly maintained healthcare system, and the presence of racial segregation), work environment (inequality of employment opportunities, high proportions of essential workers, and inequality of labor wages and access to paid leaves), educational environment (inequality in primary and higher education), and inequality in the right to obtain social resource services. Racial discrimination with dense residential housing conditions due to economic disparities, high carbohydrate dietary intake, and health conditions (lack of health insurance, high rates of certain comorbidities, and chronic and detrimental stress), have been associated with disproportionately high cases of COVID-19 and deaths among patients belonging to minority groups, such as African Americans [92,93]. Thus, racial discrimination is a contributing factor to racial disparities and is a major cause of health differences.

9.3. *Gender inequality*

Academia primarily involves teaching and research. Gender inequality in positions, career development, salaries, roles, and burdens in teaching, opportunities to publish scholarly work, and access to research funding have been ubiquitous within academia. The reduction in the number of faculty positions, the introduction and expansion of tenure, and tenure application have also contributed to significant gender inequality in education. Furthermore, the prevalence of COVID-19 has increased the burden of education with the introduction of online education, where parents face new and increased challenges of taking care of and educating their children at home. These situations are not limited to academia, but to society as a whole. Furthermore, in developing countries, school closures due to the COVID-19 pandemic have resulted in the loss of educational opportunities, with women facing increased sexual victimization and domestic workloads [94–96]. Restrictions on mobility have also resulted in the loss of opportunities to work as babysitters and housekeepers in other countries [97]. Staff working in medical settings with COVID-19 are predominantly females who also work in physically and mentally demanding conditions. The COVID-19 pandemic has highlighted gender inequality not only in academia and medical settings but also in society as a whole, again revealing women's role in both the front lines of society and home [98,99]. We are devoting considerable effort to control the COVID-19 pandemic. In the near future, the correction of gender inequality and recovery should mainly focus on women to encourage women's participation in all areas, and create an environment where all people are respected, live equally, learn equally, and work on equal terms.

9.4. *Economic disparity*

Increasing economic power requires capital accumulation and technological advances. While wealthy countries benefit directly from the use of fossil fuels, poor countries have not benefited from energy consumption and are suffering greatly from global warming caused by energy consumption in wealthy countries. It is very likely that anthropogenic forcing is increasing economic disparities between countries. Gross domestic product (GDP) per capita has declined by 17%–31% in the bottom four tiers of the GDP per capita distribution at the population-weighted country level, while the ratio between the top and bottom tiers is 25% larger than that when there is no global warming. Thus, the use of fossil fuels to spur economic activity contributes to global warming, further widening the gap between rich and developing countries. Global warming disturbs natural ecosystems and reduces the economic power of developing countries due to increasing economic disparity, which affects the occurrence and spread of COVID-19.

9.5. *Educational disparities*

Educational opportunities should be equitable regardless of birth, gender, race, family background, region, and economic status. Moreover, there should be no differences in educational outcomes, such as academic achievement and background based on family, community, and other circumstances. With the closure of schools due to the COVID-19 pandemic, teachers are required to teach online, create homework assignments, evaluate students, and make changes to their teaching methods despite the lack of related experience. Students do not have a uniform learning environment, such as the Internet and required technology for online classes. Also, there is potential to widen the educational gap due to factors such as family economics. A school is a place for education and a place to interact with people and train future leaders. We want students to receive primary to tertiary education not only in their field of interest but also in public health, social inequity, bioecology, the global environment, and SDGs where everyone can help develop an overall perspective.

Considering the impact of these social inequities on the COVID-19 pandemic, it is imperative that they should be corrected.

10. Maintaining the natural environment and socio-economic activities

We live in a world where both benefit from and depend on nature in a wide variety of ways. Although maintaining the natural environment and increasing socio-economic activity appear to be conflicting aspects, the efficient use of resources, discovery, and development of solutions through increased socio-economic activity can contribute to the sustainability of a healthy and happy life while preserving nature. However, several factors, including population growth, work against maintaining the natural environment. For example, the increase in carbon dioxide emissions associated with population growth leads to global warming, while the destruction of nature reduces the productivity of the agricultural, livestock, and fish industries. It also leads to outbreaks and epidemics of infectious diseases. Consequently, this undermines the sustainability of our livelihoods. The ecological footprint and biocapacity are two indicators of the sustainability of our livelihoods [100]. The ecological footprint refers to the total area of land needed to absorb carbon dioxide from the ecosystems, such as cultivated land, pastureland, fisheries, forest land, and carbon dioxide, and required to meet all human needs. Meanwhile, biocapacity is the amount of renewable resource production and waste absorption that the ecological land can supply. Sustainability is calculated by comparing both the ecological footprint and biocapacity, with the basic requirement for sustainability, indicating that the amount demanded should be less than the amount reproduced. When demand exceeds supply, ecological overshoot (ecological deficit) will occur. The increase in our ecological footprint due to factors such as population growth and the decrease in biocapacity due to climate change threaten the sustainability of our livelihoods. Knowing our ecological footprint and biocapacity, which are indicators for calculating livelihood sustainability, is important for developing a healthy and comfortable life, maintaining medical services, and advancing medicine.

11. Challenges in medical academia

We understand that air pollution, global warming, social distortions, and inequities are linked to the outbreak of the COVID-19 pandemic. The following discussion considers solutions and codes of conduct.

With regard to scientific meetings, especially international conferences, there is a need to devise methods for holding conferences to reduce carbon dioxide excretion from fossil fuel combustion of airplane flights [101,102]. Consideration should also be given to the elimination of printed materials and bags, minimal signage and displays, meals using locally produced and consumed foods, the use of vegetables and meats grown using farming and animal husbandry methods that minimize the excretion of carbon dioxide and methane to the extent possible, the use of fair trade products, the reduction of food loss, and the ban on the use of plastic containers. In addition, priority will be given to companies whose operations contribute to the achievement of SDGs.

In terms of conference management, opportunities should also be given to new and female physicians to speak freely and run the conference, similar to physicians with extensive experience. In addition to education in their areas of expertise, they will have the opportunity to learn about social inequities based on racism, gender inequality, educational disparities, and economic disparities, and to study sociology.

The 17 ″SDGs″ set out in the 2030 Agenda for Sustainable Development, adopted at the UN Summit in September 2015, officially came into force on January 1, 2016. Over the next 15

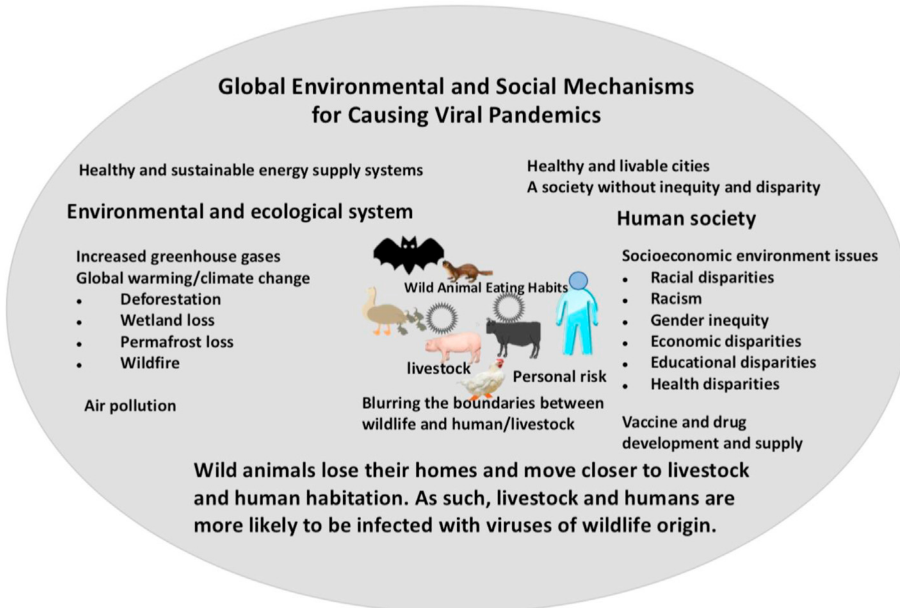

Fig. 1 – Global environmental and social mechanisms causing viral pandemics.

years, these new goals, which apply universally to all, will advance efforts to end poverty in all its forms, redress social inequities, and address climate change while ensuring that "no one is left behind" [103]. The SDGs call on all countries—poor, rich, and middle–income—to protect the planet while pursuing abundance. It also recognizes that to end poverty, strategies are also needed to address climate change and environmental protection while stimulating economic growth and meeting a wide range of social needs, including education, health, social protection, and employment opportunities. The content of the 17 goals set out in the SDGs was identified and achieved in COVID-19. It is the best way to combat this disease. Having experienced the outbreak of COVID-19, a new zoonotic disease, we must not only contribute directly to Goal 3 of the SDGs, "Health and Welfare for All," to prevent the recurrence of such an infectious disease but also eliminate social distortions and inequities and achieve all the goals of the SDGs, so that "Who Understand that it is important that the goal of "No one left behind, health and well-being for all" is achieved.

The COVID-19 pandemic has made us aware of the threat of infectious diseases. Medical academia should establish an interdisciplinary discipline that includes veterinary medicine, animal husbandry, agriculture, sociology, economics, and environmental studies, in addition to medicine, to comprehensively study and educate the public about the outbreak of COVID-19, the pandemic, its control, and the impact of the COVID-19 pandemic on society. Early career medical students and researchers should play a central role in the establishment of this new interdisciplinary discipline. They should be involved in the decision-making process and organizational management from the present because they are the leadership team that will build the future. They do not have enough time to devote to clinical, research, and education. The administrative burden should be reduced so that they can devote sufficient time to it. Their experience in overcoming obstacles is a personal resource and prepares them for the future. However, the future should not be closed off by obstacles. We must believe in them and trust them in our future (103).

12. Conclusion

COVID-19 arose from the disruption of the natural environment. The free global movement of humans has led to a global epidemic. The COVID-19 pandemic reveals distortions and inequities in social structures and contributes to the spread of the epidemic (Fig. 1). We must examine inequities in our society.

By moving freely and interacting with people, we gain knowledge and experience and acquire resources to deal with any situation. Clinicians learn and practice the pathology, diagnosis, and treatment of diseases. In the clinical setting, clinicians will learn and grow through contact with patients. The pathogenesis of a disease is related to a variety of disciplines, including sociology, socio-economics, natural ecology, and medicine. We are conscious of the "global environment" every time we breathe and learn that our daily lives are related to the global environment. A young doctor whom I admire has said, "Our future must be in our grasp, and the future we must seize" should be a future where we are equal in all respects, where no one threatens us, where we can live healthy and happy lives. For this future to happen, all obstacles must be removed. We must look at and learn from the trends and structures of society as a whole, in addition to the fields of medicine and healthcare, and not take the wrong path.

Declaration of competing interest

The authors have no conflicts of interest to disclose.

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