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The Impact of Climate Change on Public Health

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Abstract: Climate change and its impact on human health have been at the heart of research and governments agenda for quite some time. Although local warming could partly have a positive impact, most of the impacts are considered to be negative. Not only exist the risk of increased air and ozone pollution, the greater spread of pollen and therefore the more frequent occurrence of allergies and respiratory diseases, but also an increase in deaths due to heat waves, floods, drought, fires, decreased availability and cleanliness of drinking water, reduced food security and reduced availability of health services. High temperatures will also change the distribution and increase the overall burden for certain diseases that are transmitted through vectors, food and water. Protecting human health is the cornerstone of climate change strategies, which can no longer be regarded as an environmental or developmental issue, because it compromises the protection and improvement of human health and well-being. It is now necessary to have a greater appreciation of the dimension of climate change affecting human health, both for the development of effective policies and for the mobilization of public participation. The aim of this work is to critically study and present the impacts of climate change on public health and the presentation of trends and policies developed to mitigate these impacts. The available literature, including scientific research, lessons learned, and decisions at international level, is critically reviewed. Public health data associated with the impacts of climate change is being processed, and evaluated.

Key words: climate change, impact on human health, Infectious diseases, vectors, pollen, food safety, water and food related diseases, atmospheric pollution, asthma, exposure to mold, extreme weather events, mitigation, adaptation

1. Introduction

Human actions have almost certainly started to change the world's climate, mainly through the accumulation of concentrations of greenhouse gases in the lower atmosphere [1]. This reflects the escalation of the size and intensity of modern human entrepreneurship. During the 20th century, the size of the human population quadrupled and the average per person economic activity tripled. The overall demand for materials, energy and waste disposal now seems to be greater than the planet can tolerate — in fact, recent broad estimates suggest that we have been living beyond Earth's biological capacity for the last three decades. Globally, our ecological exceeding is now 30% above estimated sustainable natural limits — and the gap is widening [2]. Climate change is currently on a clear continuous upward trend (with its normal fluctuating year by year), and the average temperature on the surface of the Earth is now well above the threshold of natural temporal variation over the last thousand years. Modern urban populations usually live far from the natural fundamental principles of health and life. Consequently, the common, but mistaken view is that “health” is something personal, depending on individual and local factors: pills, vaccinations, the promising genes and access to healthcare. In fact, and most importantly, populations health depends above all on food supplies, fresh moving water, stability in infectious disease characteristics, natural adjustment to extreme weather conditions (from forests, wetlands, reefs, and so on), overall social stability and conflict avoidance for limited natural resources. The nature of the ecological impact on human health must be understood. Without this knowledge, in turn, it is not

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possible to understand the changes that climate change will bring to people and communities of living organisms — not just the risks to their economies, jobs, possessions and vacation opportunities [3].

1.1 Climate Change and Its Effects on the Foundations of Health

The global climate is changing faster than any other moment in human history, and many of the consequences will be felt in the health sector, with developing countries facing the most serious risks.

Extreme temperatures and air pollution are health risks. Heat waves are directly related to deaths from cardiovascular and respiratory diseases, especially among the elderly. High temperatures also increase ozone levels and other gaseous pollutants, which exacerbates cardiovascular and respiratory diseases, pollen and other asthma-inducing allergens.

Floods, droughts and water pollution increase the risk of diseases. Rainfalls are highly volatile, increasing the frequency and intensity of both floods and droughts. At the same time, higher temperatures accelerate the evaporation rates of surface water and help melt glaciers, which provide clean and potable water to many people. Lack of drinking water deteriorates hygiene, thereby increasing the incidence of diarrhea diseases. In extreme situations, water scarcity leads to drought and famine. Too much water on the other hand, in the form of floods, causes contamination of drinking water supplies and also creates the conditions for the spread of vector-borne diseases, such as malaria.

The effects of climate change on agriculture threaten to increase malnutrition. Increasing temperatures and changes in rainfall patterns are projected to reduce arable land in many developing countries, reducing food stocks [5]. For populations that depend on agriculture for their living or do not have enough income to buy food, this situation seems to lead directly into wider malnutrition. In turn, malnutrition increase the severity of many infectious diseases, especially among children.

An increasingly extreme and unpredictable climate can destroy homes, communities and lives. The expected increase in the frequency and severity of floods and thunderstorms will lead to the destruction of homes, medical facilities and other critical services, particularly affecting people in slums or living in borderline conditions. The gradual rise in sea level, coupled with strong storm surges, tends to lead to more frequent and severe coastal flooding. Ensuing destruction of homes and communities will eventually force unprotected populations to seek safe areas, often increasing environmental and social pressures on their new destinations.

Climate change brings new challenges to the control of communicable diseases. Many of the major deadly diseases transmitted by water and contaminated food, as well as by insect vectors, are particularly sensitive to climatic conditions and extreme weather events. Climate change threatens to slow, halt or reverse progress in the fight against such infections.

Not all the effects of climate change will be harmful, but health damage will outweigh the potential benefits. A warmer climate is expected to benefit some populations, including lower winter mortality and morbidity and greater local food production, especially at high northern latitudes. However, studies by the WHO [6] and the IPCC [7] indicate that the adverse effects of climate change on health will outweigh the potential benefits.

1.2 Impact of Climatic Conditions on Human Health and Well-Being

Climate change operates at many levels and with a different relative impact on its health impacts. In general, it plays a multiplying role, usually enhancing or extending the existing health risks or problems of the population.

Observations of the effects of climate change on human health are now very important, especially in relation to heat and cold exposure [8]. The effects of

heat on health had already been a concern since the 19th century — in particular among European colonial officials, military personnel and other workers [9] — and mechanistic physiological research has clarified the negative effects of excessive heat [10]. Thermal physiology, environmental ergonomics, bio meteorology and other disciplines continue to accumulate evidence of the impact of heat and cold on human health and labor productivity. Excessive daily exposure to heat causes stroke, which can lead to death [6], heat depletion reduces labor productivity [12, 13] and heat stress interferes with daily household activities [14]. Other extreme weather events, such as thunderstorms, floods, and droughts, create immediate risks of injuries and subsequent manifestations of infectious diseases, lack of food and mental stress [15]. Any decrease in the capacity to perform daily activities in relation to heat, cold or weather should be considered as an "impact on health", given the World Health Organization's definition of health ("Health is a state of complete physical, mental and social well-being, not just the absence of illness or disability). In addition, if actions taken to prevent the adverse effects of extreme weather conditions unintentionally harm health or well-being, this should also be considered as a 'health impact' related to climate.

The indirect effects of changes in climatic conditions are many and varied. Changes in access to clean drinking water, especially in conditions of overcrowding and poverty, can cause diarrhea and other water-related diseases, including cholera [16]. Other important examples are malnutrition and depleted childhood development due to the decline in local agriculture [17], fluctuations in the levels and range of various diseases transmitted through vectors and other infectious diseases [18-20] and the tensions caused by forced migration from affected homes and workplaces 21]. Of course, a variety of other factors are affecting these health problems and can have a far greater impact than climate change. Examples of systemic impacts include food crises (sometimes causing famine), water access conflicts/wars, and serious adverse economic impacts due to reduced human and environmental productivity [22-25].

Climate change can have a positive impact on cold temperate regions [26]. However, a detailed analysis [27] concluded that there is no general reduction in winter mortality in the US and Europe (differences are observed within these regions). Improving agricultural productivity is another possible beneficial effect on these temperate regions [28], although this may contribute to increasing inequality between high and low income countries.

2. Associations with Non-Communicable Diseases, Social Determinants and Equality in Health

Great attention has been paid to the risks associated with climate change and communicable disease [29]. However, there will also be various effects on non-communicable diseases [30].

Surveys [31, 32] have shown increases in the rates of incidence and incidence rates for non-communicable diseases in healthcare structures in Australia and the United States, during heat waves. Along with the exacerbation of cardiovascular diseases, the largest heat-related increase in hospital admissions in these reports was for kidney diseases. This could signal the physiological link between high heat exposure, sweat function, dehydration and kidney function [33].

A related issue is the apparent increase in kidney stone incidence in relation to a warmer climate [34]. Another link with NCDs is the higher risk for heat-related illnesses among overweight people [35]. The clinical condition of patients with chronic diseases (e.g., hypertension, heart disease, diabetes, etc.) will often worsen if the patient is exposed to excessively high levels of heat [36]. This has been studied and known for several decades, and is easily overlooked in current research. An example for the negative impact of heat on patients with cardiovascular diseases comes from Texas in the 1950s [37]. One particular hospital

had some units with air conditioning and some without. The clinical progression of acute heart disease was much worse in patients in wards without air conditioning. Now, air conditioning may be a standard infrastructure for all hospitals in high-income countries with very hot days a year, but in low-income countries, this is probably not true and excessive exposure to heat at home or in the health care providers may have a negative impact on the clinical condition and progress of treatment [38].

The direct effects of heat are of course "non-transmissible" (thermal leakage depends on individual environmental exposure). The biggest impacts of climate change on health and well-being in large parts of the highly densely populated world with high temperatures are likely due to heat stress and heat exhaustion, which are often overlooked by the health sector as victims rarely approach health services for help. High heat exposure also increases the risk of injury [39], which is not classified as NCD, but the underlying mechanism is fundamentally related to thermal effects on non-communicable health variables.

2.1 Does Climate Change Already Affected Human Health?

An increasing number of studies provide data on the impact of observed climate change on vector-borne diseases and other infectious diseases. There is evidence that vector species respond to recent climate change in Europe [40].

There have been shifts in the latitude of ticks transmitting encephalitis in Northern Europe [41, 42] although there are other plausible alternative explanations such as changes in confounding factors, such as land use or socioeconomic, demographic, and other environmental factors.

There has been some evidence of changes in the frequency of extreme weather conditions in recent decades [43]. Many health outcomes are susceptible to individual extreme events (e.g., heavy rainfall and high temperatures). Analyzes of the 2003 heatwave in Europe concluded that it was a truly extreme event and the summer of 2003 was probably the hottest in Europe since 1500 [44]. Climatologists now consider it "highly probable" that human influence on the global climate has at least doubled the risk of a heatwave as in 2003. Recent evidence has also emerged about the possible causal role of climate change (and in particular the increase of Sea level warming), in the intensity of tropical cyclones[45, 46], although a single event such as Hurricane Katrina cannot be attributed to climate change.

Where health monitoring data has been available for several decades to date, it may be possible to determine whether observed changes in diseases may be related to climate change. The interpretation is complicated by possible competing explanations for changes in the major determinants of health over time, as well as changes in the way diagnoses can be recorded. Experimental observations of the recent health impacts of climate change with the subsequent formulation, testing and subsequent modification of the assumptions would require long-term (possibly several decades) careful monitoring. While this process may be in line with the principles of empirical science, it would not provide the timely information needed to inform current political leadership that is taking decisions about reducing greenhouse gas emissions, to offset potential health consequences in the future. nor would it allow for timely adaptation policies to be implemented at some level of climate change, which is unavoidable due to previous greenhouse gas emissions. Therefore, a better estimate of the future impacts of climate change on health will necessarily result from an assessment of the risk based on the current understanding of the effects of climate change on health from observations made in the present and recent past, recognizing the impact of a wide range of modulators.

Observations on short-term fluctuations in climate or weather indicate that even slight increases in temperature and changes in rainfall can lead to

measurable effects on malaria, diarrhea episodes, flood-related injuries and malnutrition. Knowledge of these relationships allows an approximate estimate of health impacts from climate change in the past and in the future.

2.2 Climate Change and Proliferation of Sensitive to Temperature Changes Parasites, Microorganisms and Vector-Borne Diseases

Climate change is increasing the risk to health in many parts of the world and can affect it as it has been said directly and indirectly. Particularly serious is the further spread of temperature-sensitive changes in pests, micro-organisms and vector-borne diseases — such as malaria, dengue fever and schistosomiasis [47]. Such indirect effects mainly concern the higher proportion of poor people in developing countries. These will then provide a detailed account of these effects of climate change on health.

3. Infectious Diseases

What impact will the projected effects of climate change have on the spread of diseases? The most well-known diseases that will be discussed below and linked to climate change include cholera, malaria, dengue fever and schistosomiasis. These occur mainly in tropical regions of the world, but are — such as cholera and schistosomiasis — often present in non-tropical regions. In Europe, climate change has been linked primarily to Lyme disease, which is transmitted by tick [48].

3.1 Direct Effects of Climate Change on the Transmission of Viral Diseases to Humans

Higher temperatures on the Earth's surface will cause global average precipitation to increase, although in some areas of average latitude it will become drier. Rainfall can favor the transmission of vector-borne pathogens by creating tanks in the ground and other insect breeding areas. In addition, drought can cause stagnant running water, it can also induce people to store water in tanks, and containers, which also serve as mosquito breeding sites [49].

One could speculate that mass clearing of forests exposed to rising temperatures could allow contacts between immunized people with dangerous viral infectious cycles and their corresponding tanks in forests [50].

The global consequence of this could be the spread of viruses, which is confined to the tropics, beyond those in the future. It is generally accepted by experts in the life cycles of vectors that mosquito-borne diseases, especially arboviruses in the field of virology, which can cause very serious bleeding fever, could be caused by global warming [51].

Thus, the spread of "exotic" viruses could be observed in Europe and North America. Emerging arboyiruses (arthropod-related viruses) such as dengue virus, Chikungunya virus, West Nile virus, Tick — Borne encephalitis virus, Rift Valley Fever virus, Japanese encephalitis, could be mentioned, Crimean Congo hemorrhagic fever virus as well as forest viruses could pose a threat to humans, such as yellow fever virus [52].

3.1.1 Arboviruses: Dengue Fever

A relatively new problem is dengue fever, an influenza-like viral infection, which first appeared in the 1950s in the Philippines and Thailand. It is transmitted through the Egyptian and Asian mosquito tiger, which affects almost exclusively primates and humans, and is nowadays the most widespread mosquito species in the world. It occurs, like the Anopheles mosquito, mainly in tropical and subtropical regions [53], and in recent years this species has expanded, especially in Asia and Africa, but also in Central and South America (northeast Brazil) and in the part of North America. In India, for example, in 2012 there were 35,000 reported infections, or twice as many as in the previous year. In Europe, the virus occurs much more locally and almost exclusively in Southern Europe. Especially in Croatia and Greece, as well as in France and lastly Portugal has been

mentioned on several occasions in the past, and in some areas, the tiger mosquito is already on a permanent basis.

Transmission takes place primarily in cities and their surrounding environment and is spreading due to population growth, globalization and through trade in goods and tourism, while being reinforced by ineffective mosquito control and lack of sanitation [54]. Worldwide, over 2.5 billion people live in 125 countries, which are areas of risk for dengue fever, with 50-100 million cases each year, of which approximately 2.5% of patients die. The danger comes from the multiplication of the tiger mosquito. This was mainly due to the trade in tires, which the mosquitoes used to lay their eggs, and led to them spreading. Second, this mosquito is characterized by high adaptability, and survives even at low temperatures and can winterize (e.g., Italy). Mosquitoes sting, unlike mosquitoes of other types, even during the day and appears especially in urban areas, which makes the outbreak of the disease frequent [55]. In relation to climate change, the virus appears to be sensitive to increasing temperature and rainfall, and multiplied, in contrast with the malaria parasite, notably at optimal temperatures over 30°C. Especially the increase in minimum temperatures seems to have an impact on the appearance of mosquitoes. Additional risks of the disease mainly arise from the fact that carriers occur in both wet and dry climates and benefit from continued and increasing urbanization [56]. Preventive measures therefore have to do with the effective control of mosquitoes and the prevention of their spawning. The fight against mosquitoes, and therefore the disease, should focus mainly on the social aspects. Thus, homes and areas where crowds are synchronized should be released from mosquitoes and then controlled.

3.1.2 Arboviruses: The Yellow Fever Virus

This flavivirus is mainly transmitted by *Aedes aegypti* mosquitoes in forests and urban areas. It has been largely observed in the regions of Equatorial Africa and America. The estimated burden on public health is about 200,000 cases a year, with 30,000 fatalities. Severe cases include fainting, changes in kidney, liver, and heart function with diffuse bleeding points [57].

Prevention consists of controlling mosquitoes. In addition, the use of a very effective vaccine, mandatory for foreign travelers in endemic countries, will be crucial if the incidence of the disease is increased. Increasing global warming could alter forests and favor contact between immunized people and certain transmission cycles in the forest. Indeed, extremely dangerous viruses, removed from the forest, could then cause epidemics in humans. This risk could include the yellow fever virus [58].

3.1.3 Arbovirus: West Nile Virus

The West Nile virus (WNV — West Nile Virus), another flavivirus, is transmitted in birds and transferred to the mosquito *Culex*. Humans and horses are random hosts for viruses. WNV fever mainly occurs at the end of summer, capable of causing deadly human meningitis or encephalitis in elderly patients. It is endemic to Africa, south-west Asia, eastern and Southern Europe and the Mediterranean basin. It was also frequently detected in North, Central and South America and the Caribbean. Paz and Albersheim [59] analyzed the correlation between weather (especially air temperature) and plenty of mosquitoes *Culex pipiens*, and frequency of fever WNV in humans between 2001 and 2005 in Israel. Israel is an important hub for the huge flocks of migratory birds, the WNV reservoir. In 2000, a large outbreak of 429 cases (35 deaths) occurred in Israel with a very hot previous summer and long heat waves, compared to cases previously reported in Romania (1996) and New York City (1999). There has been a recent trend of rising temperatures during the warm season in Israel. These positive temperature abnormalities appear to have increased the amount of mosquitoes and disease in humans. Most of the WNV fever occurred in the metropolis of Tel Aviv, where the risk is very high due to the combination of high temperatures, high air

humidity, and high population density. In the context of future uncertainty about climate change, WNV should be considered a major health problem.

3.1.4 Arboviruses: Tick-Borne Encephalitis Virus (TBE)

The Tick — Borne Encephalitis Virus (TBE), is transmitted by ticks *Ixodes* in an area stretching from Western Europe to the eastern coast of Japan. TBE virus causes acute meningoencephalitis, more or less severe. Climate change is partly responsible for the increased incidence of the disease in Europe. TBE appeared to be circulating at higher altitudes in the Czech Republic. In Sweden, a northward extension of *I Ricinus* has been observed, with milder winters and earlier spring appearing to be more frequently associated with the disease [60].

3.1.5 Other Viruses

The outbreak in 1993 of the hantavarius (Sin Nombre virus) pulmonary syndrome in the United States is noteworthy. There was a dramatic increase in rainfall related to the El Niño phenomenon in 1992 and 1993. This led to an abundance of rodent food sources (vegetation and insects) and a 20-fold increase in rodent population, favoring the transmission of viruses from rodents in humans [61].

Difficulties in organizing the viral diagnosis of the above diseases, in patient care and in avoiding secondary infections could be very serious, in the absence of strong health networks. Moreover, the weak health structures in Africa could make prevention difficult in the case of changes in forest areas and the subsequent dissemination of infectious agents. The treatment of such infections is difficult or ineffective. Prevention is vital, and involves the destruction of mosquitoes, the control of contacts between sick and healthy people, between non-immunized people and the circles of infectious diseases in the forest.

3.2 Indirect Effects of Climate Change on the Spread of Viruses

A significant impact could be traced to the climatic conditions that disrupt the organization of the social and economic characteristics of the populations. Thus, displacement and overcrowding could facilitate contacts between humans, humans and animals, as well as between humans and contaminated water, favoring infections related to intestinal or respiratory viruses [62]. These pathogens, under these ideal dispersal conditions, could cause such large epidemics, possibly worldwide, for diseases such as influenza.

3.2.1 Cholera

Cholera is an infectious disease which is transmitted by bacteria that are found mainly in stagnant waters and estuaries, and in water containers and fountains, which accounts for 3 to 5 million cases and over 100,000 deaths annually. It occurs mainly in countries where the provision of clean water and adequate hygiene is not guaranteed. Especially slums and refugee camps, but also crisis areas are considered areas of infection. An example of this is Haiti, where cholera after the catastrophic earthquake of 2010 was entered through the UN relief team from Nepal. The increased risks of climate change are caused by the fact that the increase in temperatures leads to extensive use of water tanks, while the fields are technically irrigated, resulting in the creation of additional outbreaks of the bacteria, which multiply rapidly at elevated temperatures. Since the disease mostly occurs in combination with cyanobacteria (blue-green algae) and their growth is accelerated by higher temperatures and increased rainfall, there is a clear link between climate change and the spread of cholera [63].

Similar conditions exist for the spread of schistosomiasis, a parasitic disease caused by worms transmitted to humans through snails in the water and in addition affecting most organs, and is also responsible for the underdevelopment of children. In Africa, this disease occurs almost everywhere, and is also on the rise in Asia (mainly in China) and partly in Central America. Because of climate change, artificial water storage and irrigation, and shortening at temperatures above 15°C, the life of the pest is

prolonged. The disease is also spread by refugees but also by tourists. Prevention can only be achieved through increased hygiene measures, water filtration and improved health education. Unlike the communicable diseases caused by bacteria, malaria, dengue fever and Lyme disease are spread by vectors, such as mosquitoes and ticks. These intermediaries are generally sensitive to climate change, although there are differences here [64].

3.2.2 Malaria

Malaria is transmitted by the mosquito *Anopheles* occurring in approximately 100 countries, mainly in Africa, but can also be found in India and parts of Southeast Asia. This disease caused by a parasite that is responsible for 200 to 500,000,000 cases of the disease each year and approximately 1 million deaths. Most deaths are recorded in countries such as Nigeria and the Democratic Republic of the Congo. Over the last century, malaria areas have declined by a quarter of the continent's land area due to demographic changes and urbanization, but the number of people exposed to malaria is higher [65].

Most cases of malaria in Europe and the Middle East occur with its introduction from other countries, although in Europe, as in Egypt, these are mainly isolated cases. In the 1990s there was a brief resurgence of the disease in Turkey. As part of a large irrigation project there, 80,000 cases were recorded annually. In Central Asia (Turkmenistan, Kyrgyzstan, Tajikistan, Uzbekistan, Kazakhstan) as well as in Azerbaijan, Armenia and Georgia malaria was still widespread around the turn of the millennium. Due to the consistent and good control of mosquitoes and good health systems this area has for many years been largely free of malaria [66]. This also applies to migration flows and changes in agriculture.

An indirect effect of climate change, which is contributing to the spread of malaria, is the increase in poverty due to multiple natural disasters in developing countries, which results in deteriorating hygiene and countermeasures. In general, the presence of mosquitoes has been particularly enhanced in tropical Africa by the reduction of financial resources and the neglect of combating them, often in conjunction with civil wars [67]. For example, in recent years fewer mosquitoes, insect repellent and financial resources were available.

The importance of climate change for the spread of malaria is particularly evident in the emergence of potential breeding sites for intermediaries, which depend mainly on rainfall conditions. These could be increased and / or relocated to other regions in the context of overheating, for example, even in Europe. In addition, high humidity promotes mosquito activity and survival capacity, thus extending the transmission time of the disease. Regarding temperature, according to various scientists, another picture is presented. According to that, high mean temperatures have a rather negative impact on mosquito pest proliferation, whereas at lower mean temperatures below 20°C and daily temperature changes, in contrast, favor a stronger increase [68]. This is related to the fact that at higher temperatures, the pest development time is extended to mosquitoes and at the same time their reduced life span is increased so that these pests can no longer be transmitted to humans or animals. In addition, droughts will increase in the formerly malaria-affected areas, and thus their breeding sites, the mosquitoes and the species that eat mosquitoes themselves, will be reduced, which will cause a shift in the areas, but not by need raising them.

And the effects of climate change on geographic dispersal are controversial, although it has been partially possible to prove malaria in higher areas. In general, the risk of malaria returning to Central Europe has been underestimated. Despite the generally accepted climate-favorable conditions, namely, increased rainfall and floods with rising temperatures, the conditions for the spread of mosquitoes through integrated structural reforms in agriculture and the lack of wetlands appear only locally, so that the disease is expected to occur only sporadically [69].

3.2.3 Lyme Disease

A major European, but also North American, disease is Lyme — Borreliose disease, which is transmitted by ticks and for which there is no vaccine, as opposed to tick-borne meningoencephalitis. The overall incidence of ticks is generally considered stable, but its geographical spread is constantly increasing. Climate change is likely to increase the survival rate of ticks, given the milder winters and the longer growing season, and the tendency to spread them to higher altitudes has already been detected. Increasing the temperature is not the only factor for this. Even land use changes, the number of suitable host animals and altered human behavior partially affect the occurrence and spread of ticks [70]. In the future, tick habitats will probably move north due to frequent droughts in Southern Europe. Whether this will lead to a more widespread dissemination is unclear at this time.

If one observes the diseases just mentioned, it is clear that it is above all the social and economic factors, as well as the geographical conditions, that have a decisive influence on the spread of the disease vectors. In addition to globalization, these factors include continued urbanization and political crises, as well as resistance formation and incomplete health care. Due to the growing global trade, travel and migration flows, dengue fever or West Nile fever could in the future pose an increased risk for Europe. Climate change and its effects will have a significant impact on the spread of diseases in the future, according to the majority of scientists.

4. Climate Change and Air Pollution: Asthma and Chronic Obstructive Pulmonary Disease COPD

Elevated atmospheric temperatures and associated meteorological effects can aggravate ground-level pollution, notably with the emergence of high ozone values [71], leading to reduced lung function, increased use of health care and pre-treatment. People with COPD, CVD, diabetes and chronic ozone exposure are at particular risk. The higher burden of these conditions is disproportionately distributed among low-income people, who often reside in more polluted areas [72]. Climate change can also lead to higher atmospheric concentrations of fine particulate matter (PM 2.5) [73]. The projected increase in temperature threatens our ability to meet air quality standards for health in the future.

5. Forest Fires: All Respiratory Diseases & CVDs

Forest fires cause episodes of severe air pollution. Higher temperatures and increased drought contribute to a greater risk of forest fires, as recent analyzes for example from the Canadian Forest Service show that the average annual fires could double by the end of the century due to climate change [74]. This increase in fire risk is due to higher temperatures in spring and summer, reduced rainfall and snowfall, early snow melting, and prolonged fires in areas at higher altitudes. Higher temperatures will also put forests at risk for new and more widespread threats that further increase the risk of fire. For example, the mountain pine beetle has destroyed the local pine in British Columbia and may threaten other areas of Canada [75].

Forest smoke is a complex mixture of particles and gases that are known to have acute and chronic health effects [76]. Much of the epidemiological research focuses on elevated PM 2.5 during tobacco episodes that have been associated with acute respiratory effects, including symptoms of pain, irritation, cough and phlegm [77], with increases in medication consumption, an increase in outpatient visits [78] visits to intensive care units, hospital admissions and an increase of mortality. Further, evidence suggests that babies in the womb during tobacco outbreaks are at higher risk for low birth weight [79], and with adverse effects on their health throughout their lives. There have been no studies investigating the long-term effects of fires and exposure to tobacco in children and adults. However, it is known from the literature

concerning the air pollution in cities that increasing of concentrations annual average PM 2.5 associated with increased rates of chronic respiratory diseases and CVD s in the population [80].

As emissions from transport and industrial sources are more effectively controlled, it is expected that fire smoke will play an increasingly important role in the lifelong exposure to PM 2.5 and therefore in the development of chronic diseases [81]. A recent global study estimated that an average of 339,000 deaths could be attributed to the acute and chronic effects of fire smoke each year [82]. These health threats could increase in the future as climate change exacerbates the risks of forest fires around the world [83].

6. Changes in Pollen Release: Asthma and Allergic Rhinitis

The production and distribution of plant allergen pollen is affected by climate change, with multiple increases in trees, grass and weeds occurring as a result of higher carbon dioxide concentrations [84] and prolonged crop growth. In central-western North America between 1995 and 2009, ambrosia production increased up to 27 days of pollination during the year [85]. Increases in pollen concentrations in the environment are associated with higher rates of allergic awareness, increased use of health care, and large increases in sales for allergy medication [86]. Drought conditions are also predicted to increase, and may exacerbate these effects as more pollen, dust and particles are transported by air in dry conditions.

7. Heat Waves: COPD, CVD

During periods of heatwave, additional deaths can range from tens of thousands, such as 2003 in Europe and 2010 to heatwave in Russia, among other notable events. Extreme increases in heat causes short premature morbidity and mortality from a variety of causes, including those directly related to heat (heat stroke, syncope, heat edema, etc.) and a number of cardiovascular, respiratory, renal and other diseases [87].

Increased temperature variability can also increase mortality among elderly patients, even in typically moderate climates [88].

8. Storms, Floods and Mold Exposure

Climate change is expected to increase the intensity of thunderstorms. Thunderstorm activity has been associated with asthma outbreaks in North America, Europe and Australia [89], due to the rupture and widespread dispersal of pollen from the turbulent atmosphere, with more severe thunderstorms also leading to rainfall. Further downpours will also lead to more floods [90] which threaten health infrastructure, even in rich countries. Patients who need mechanical respiratory support and intensive care are particularly vulnerable due to the challenges posed by evacuation and power outages. Poor facilities are likely to be even more vulnerable to extreme weather threats. Flooding and persistent moisture in the home can favor the growth of germs, especially mold. The high indoor/outdoor mold ratio was observed in the months following the Rita and Katrina hurricanes, indicating the potential for high indoor exposure [91].

Mold levels may increase with climate change due to increased humidity in building materials and indoor humidity, elevated temperatures and high carbon dioxide concentrations that encourage its growth [92]. In immunosuppression individuals, respiratory illness associated with mold exposure is due to fungal elements that may be allergenic or respiratory irritants, leading to outbreaks of allergic rhinitis and asthma. In immunosuppression individuals or those with concomitant pulmonary disease, thunderous fungal infections, such as aspirgillosis, may follow [93].

9. Climate Change — Water and Food Borne Diseases

Food borne and water-borne diseases are likely to pose a greater public health problem as climate change

accelerates due to high temperatures, increased rainfall and flood frequency, while water quality is expected to deteriorate, followed by drought.

An increased incidence of hot days and increased humidity may increase the incidence of food borne infectious diseases. Data from the UK show a strong correlation between food poisoning and high temperatures over the past 2 to 5 weeks [94]. In addition, warm temperatures have contributed to about 30% of salmonellosis cases across much of continental Europe, especially when they exceed the minimum threshold of 6°C above average 95]. Other food poisoning agents, such as campylobacter, are also seasonal, but are not as strongly associated with temperature fluctuations. Food alterations are temperature dependent, due to various types of pests, particularly flies, rodents and cockroaches, which have increased contact with food at higher temperatures [96].

10. Climate Change and Mental Health

Mental health disorders such as post-traumatic stress disorder (PTSD) can significantly affect the well-being of the population following natural disasters and/or displacement due to climate change, depending on the unexpected impact, intensity of experience, degree personal and community disruption, and long-term exposure to the visual signs of disaster [97]. PTSD symptoms were found in 75% of children and adolescent refugees [98]. The impact on human health of disasters in the United States is projected to be less serious than in the poorest countries where public health infrastructure is less developed.

11. Mitigation and Adaptation to Climate Change

Climate change mitigation is a critical task for the world. However, while governments continue to struggle with this unprecedented, complex political and ethical task, the most immediate challenge for the health sector is to identify the major regional health threats posed by climate change and to ensure the development of adaptation strategies and risk reduction. A favorable aspect of efforts to mitigate climate change is that local health benefits will emerge rapidly in populations undertaking such efforts [99]. The health benefits will derive from mitigation measures addressing transportation and transport patterns, housing design standards, energy production, and agricultural systems (including livestock production).

In many poorer populations, improvements in environmental technologies will help to replace the polluting fuels used in cooking with low carbon fuels, while improving information on reproductive health will lead to better nutrition and less health problems with both types of improvements reducing stress on the climate system [100]. All of these actions will immediately reduce known risk factors for disease and premature death (e.g., air pollution, sedentary life, and dietary excesses). Innovative urban planning can have a wide range of positive effects on energy use, greenhouse gas emissions, urban thermal island impacts, patterns of physical activity, social relationships, and community cohesion [101].

12. Challenges for the Health Sector

The health sector plays an important role in reducing climate change and adapting strategies to limit the inevitable health risks [102]. These strategies will include “greening” healthcare structures and participating in national health impact assessment and cross-sectoral planning of sustainable energy systems, transport and urban planning. National delegations to international policy-making meetings on global trends and threats (e.g., annual conferences convened under the United Nations Framework Convention on Climate Change) should include well-informed representatives from the health sector 103].

13. Conclusions

Overwhelming evidence suggests that human activities are affecting the climate of the planet.

Climate change is a significant and emerging threat to public health, and is one of the greatest environmental, social and economic threats facing the planet. According to the World Health Organization, the health risks associated with climate change can be significant and different depending on the geographical area and are often irreversible. Climate change and disease-related risk factors are among the major contributors to the global health burden, including malnutrition — estimated to kill 3.7 million people a year), diarrhea (1, 9 million) and malaria (0.9 million people per year). Such situations as well as other health impacts, as described in detail in the present work, will be continuously affected as climate change accelerates, due to their adverse effects on food production, water supplies and human resistance to hosts and pathogens. As we have seen, global warming is predicted to cause serious health threats, mainly through storms, floods, drought and heat waves, fires, with consequences for water supplies, food supplies and sanitation, while high temperatures will change the distribution and increase the overall burden on certain diseases caused by vectors, food and water.

Protecting human health is the cornerstone of climate change strategies, which can no longer be regarded as merely an environmental or developmental issue, as it endangers the protection and improvement of human health and well-being. Greater appreciation of the climate change dimension of human health is needed, both to develop effective policies and to mobilize public participation.

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