MMSL Military Medical Science Letters Since 1925

Mil. Med. Sci. Lett. (Voj. Zdrav. Listy) 2021, 90(2), 93-99
ISSN 0372-7025 (Print)
ISSN 2571-113X (Online)
DOI: 10.31482/mmsl.2021.010

REVIEW ARTICLE

CLIMATE CHANGE AND HUMAN HEALTH

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Received 6th March 2021.
Accepted 31st March 2021.
Published 4th June 2021.

Summary

This paper's aim is to provide clear basic explanation of the relationship between human health and climate change. It focuses on global warming, connecting it with the greenhouse effect and describing various effects the global warming has already had on human health. After the disclosure of other threats connected to climate change, the paper studies the history of it according to the Anthropocene concept theory. It also uses the perspective of weather extremes to explain climate change in the past and its connection to human health. Furthermore, this article focuses on the air pollution and its impact on the health of human population. Lastly, it touches on the topic of health inequalities and provides collected data and numbers for the future of climate change and human health.

Key words: climate change; human health; global warming; air pollution; health inequalities

Introduction

Climate change is a serious threat to our planet, the wellbeing of animals, plants, and people (1). The purpose of this paper is to focus on climate change and its effects on human health. It firstly discusses the effects of global warming explaining the phenomena, its creators and the impacts and consequences it has. Secondly, it pursues the lessons learned from the past to shed a light on the evolution of climate change's impact on human health, elaborating on the Anthropocene concept as well as following history from the perspective of weather extremes. Thirdly, it focuses on a specific issue, explanation of the air pollution and its effects on the population. And finally, it touches an issue of connection of climate change to health inequalities. Although more research needs to be done to cover all the problematics, this paper could serve as an important guideline and for some, maybe an eye-opening article of how climate change and human health are interconnected.

Global warming and its effects on human health

In the last century, it has been recorded that the atmospheric temperature on the planet Earth increased by 1.5°C (2). This phenomenon, also known as global warming, is mainly caused by the so called "Greenhouse Effect". The Greenhouse Effect on its own is not harmful at all, on the contrary, it is essential for maintaining an optimum

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temperature of the planet hereby making it suitable to live in. However, the gasses like carbon di-oxide and methane are not produced only by nature. They are also a by-product of several chemical reactions caused by humans. The gasses could be compared to a glass in greenhouses. They allow the short-wave radiations i.e. visible light and UV rays coming from the sun to enter, but they trap the long wave radiations i.e. infrared radiations, which are responsible of warming up the atmosphere, as well. Hence the name - greenhouse gasses. An excessive amount of the greenhouse gasses then traps more long wave radiations, resulting in an unnatural rise in the global temperature (3).

According to many scientists and academics, the global warming is going to be responsible for drastic changes in the human health (4). Among others, we should be most aware of possible respiratory ailments, heat stroke and water-borne, and water-bred diseases. For example, the respiratory tract illnesses could be caused by the ground level ozone, which is formed by the photochemical reaction between nitrogen oxides and VOC, which are the chemicals released from industries and cars (5). Children, outdoor workers, and people with impaired airway function are likely to experience the effects of the ground level ozone, leading to possible decrease in the lung function and increase of the airways resistance that causes lung inflammation (6). Another example of the influence of climate on humans' health is the RPM (respirable particulate matter) or in other words, microscopic particles of solid or liquid matter suspended in the air. It is yet another agent causing respiratory illnesses. When in the range of 0.5-3.0μ in diameter, these particles can lead to inflammation of lungs, fibrosis, and reduction in the lung function after being inhaled. They are also known to lead to blood thickening (3).

A connection of global warming to heat strokes is self-explanatory. Nevertheless, it is not to be taken lightly. Individuals experiencing heat strokes can get symptoms like headaches, giddiness, excessive thirst, hyperpyrexia, loss of consciousness, blood pressure fall and cyanosis. The following scanty urination can disturb fluid-electrolyte balance in the body, resulting in cardiac arrhythmias, convulsion or even death if medical care is not provided timely. In some cases, there might be severe life-long consequences such as neurological disorders for example loss of memory, epileptic episodes, or insanity (7).

Furthermore, other quintessential threats to human health connected to climate change are water-borne and water-bred diseases. Diarrhea, dysentery, cholera, hepatitis, and many others usually lead to malnutrition consequently predisposing the infected individual to further infections, thus creating a vicious cycle. Also, the stagnant waters after floods and storms are going to be a source of breeding habitat of infection disease vectors. For example, the *Culex sp*. of mosquitos carrying malaria prefer stagnant water to breed and the rising temperature is ideal for them. Finally, all the diseases carried by insects are going to strive in the new environment (8).

Climate and health in the past

The connection of climate change to human health in the past is a very interesting topic to follow. Especially intriguing is the 'Anthropocene' concept created by *Stoermer and Crutzen* (9). According to this concept, in the 19th century humanity moved into a new era, or more precisely to a new geological epoch. After more than 10 000 years in the postglacial Holocene period, when the environment was suitable for humans to strive in (10), we now got to the Anthropocene. A time, when the geological scale and human activity changed and is still changing the conditions on planet Earth to be less accommodating. Professor Sharon Friel further elaborates on the Anthropocene concept. The Industrial Revolution of the late eighteenth and early nineteenth century started the Anthropocene period (11) as well as the increase of greenhouse gasses with the biggest acceleration around 1950s. Scientists and academics come to agreement that global warming is a consequence of human activities since the Industrial revolution. The growth of manufacturing, innovations in transport and agriculture are all dependent on fossil fuels, increasing the amount of CO_2 and other greenhouse gasses in the air since the revolution. CO_2 is a dominant greenhouse gas and is very difficult to get rid of. It persists for decades in the air as well as in the water, where it causes acidification (12). In conclusion, the Anthropocene period which we are living in now, is closely intertwined with the effects of climate change on human health. As we have discussed before in this paper, the increase of greenhouse gasses in the atmosphere are what all most future health problems begin with.

But before humanity moved to Anthropocene, it lived very long time in the Holocene period. During this period, the average global temperature was 15°C (10). The differences between decade-average temperatures were in 1-2°C range. Most weather extremes were caused by major volcanic eruptions and super El Niños, combined

with the multidecade events like long droughts, extreme colds in the North in 1600s and regional climatic episodes such as the European region's Roman Warm or the Little Ice Age in Eurasia mostly contributed to food shortages, starvations, epidemic outbreaks, displacement of population, social upheavals and political changes (13). Examples of such outcomes are the cooling in 530s that started the spread of bubonic plague and was responsible for the Plague of Justinian, however it was the warming in Central Asia, which happened around 1300, that triggered the bubonic plague pandemic. Societies in Holocene usually reacted to climatic changes too late and had little knowledge about environment to begin with. Furthermore, contagion was not understood for most of the Holocene period, therefore people believed that displeased deities, transient conjunction of planets and malodorous emanation known as miasmas are the cause of infectious diseases. Other than bubonic plagues in the sixth, fourteenth, and nineteenth centuries in Eurasia (14), there have been typhus epidemics during famines, and malaria's fluctuations in the north of Europe during the Medieval Warm and Little ice ages, however, there is very little data about disease in the pre-colonial sub-Saharan Africa and the pre-Columbian Americas. The most important information we have from this period is that many infectious diseases, particularly those spread by vector organisms, such as mosquitoes are highly affected by climate change, particularly changes in temperature both up and down, for example the Yellow Fever of 1793. That the temperature extremes have an impact on human health has been proven by for example 1347 Black Death after the heat in the summer 1344, bubonic plagues after hotter temperatures in Central Asia around 1300 and 1665 London (15).

If we leave behind the Anthropocene concept and look at the climate change from the perspectives of the weather extremes, we can find other interesting connections to the human health. For example, in 1815 erupted Mt. Tambora in the Indonesian island of Sumbawa. It is regarded as the biggest eruption in over thousand years and referred to as a start of Tambora decade. The eruption affected the climate not only in Asia, but in Europe, northern America, and maritime Canada as well. The following year entered the history as the "year without summer" and in the three years after the incident, global cooling and erratic weather was recorded (15). What is most interesting for this paper, however, is the effects of the Tambora decade on human health.

Firstly, the eruption caused agricultural problems resulting in severe famines, leading to social upheavals. Diseases such as typhus or relapsing fever had perfect conditions to spread. Secondly, in China, fertility halved showing that severe undernutrition caused by the famines reduces libido due to the effects on sex hormone levels. Interestingly, however, in Sub-Sahara, the cooling brought a decline of the deadly infectious disease sleeping sickness. It is also speculated if the cooling and worldwide food shortages had not influenced the occurrence of cholera pandemics between 1817 and 1825 (16).

Another example of this approach to the connection between climate and health is the Potato Famine of 1846-1849. During the 1830s and 1840s the conditions in northern Europe were already not ideal, nevertheless they got even worse in 1835 with the volcanic eruption of Cosigüina in Nicaragua (17). The ash from the eruption travelled from Central America around the world and caused temperatures to drop by 0.75°C for the next five years. In Ireland, the peasant population was majorly undernourished and unfortunately in 1845, a mainly warm and humid year, a fungus, *Phytophthora infestans*, appeared. It spread very quickly and caused rotting and wilting of many crops. The starving people also got to experience typhus and cholera leading to mass emigrations of the surviving Irish folk (16).

Air pollution and human health

One of the main causes of climate change is air pollution. According to The World's Health Organization (WHO), air pollution yearly kills around seven million people worldwide and therefore poses a real threat to human health and climate (see Fig. 1 for specifications) (18). A combination of chemicals, particulate matter and/or biological materials that is found in the air in a form of solid particles, liquid droplets, or gases, is called pollutants and is responsible for affecting weather, human health, plants and animals. The pollutants are produced for example by heat generating systems, industries, transportation processes, use of insecticides and fungicides and nuclear programs (19). Air pollution has different forms that cause for example changes in atmosphere like depletion of stratospheric ozone, acid rains and of course global warming. Most common air pollution form is a smog, however for the main cause of global warming is responsible a greenhouse gas, Carbone dioxide (20). This greenhouse gas is emitted by all living things, however, the amount that is regarded as a pollutant is produced by means of transport and other activities that involve burning of fossil fuels like gasoline and natural gas (21).

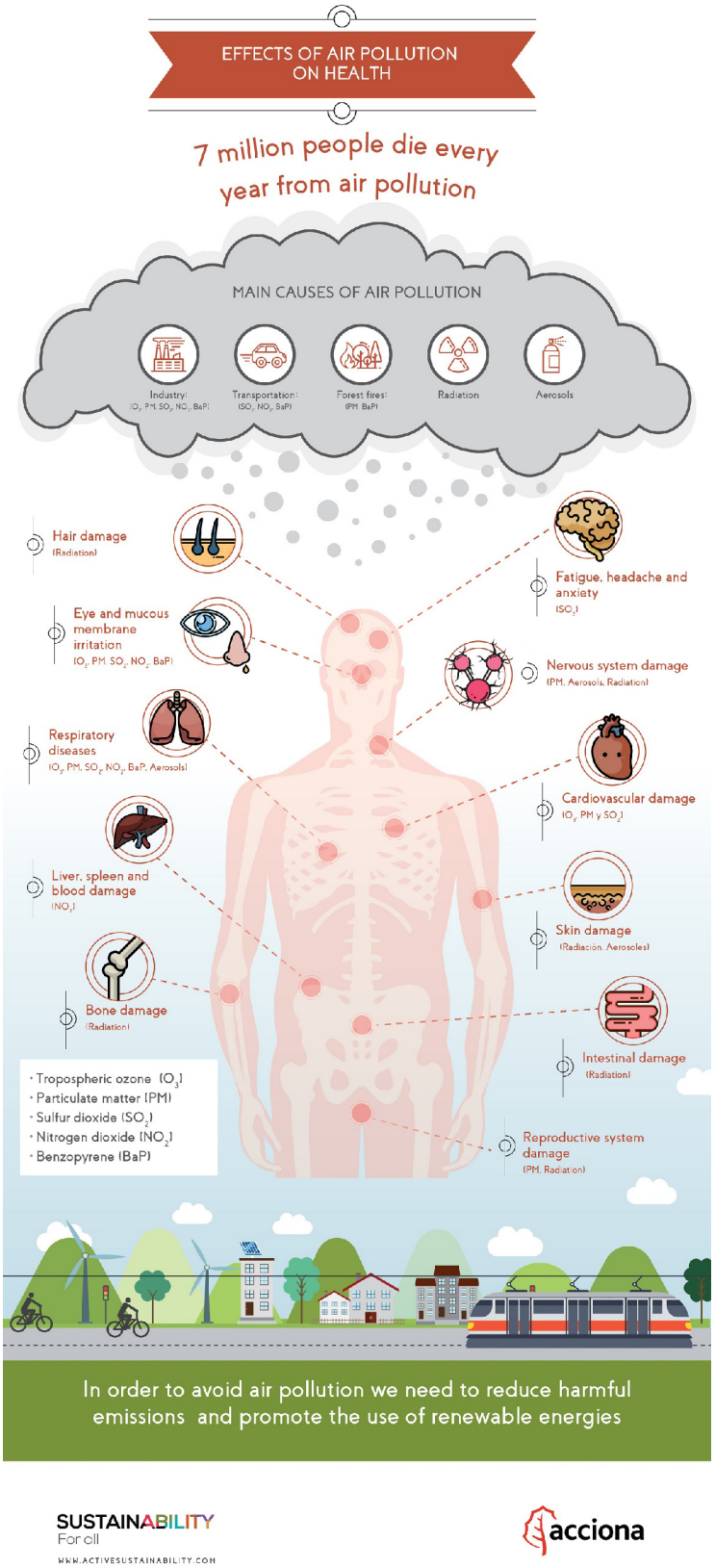

Figure 1. Effects of Air Pollution on Health
(https://www.activesustainability.com/environment/effects-air-pollution-human-health)

What is curious about air pollution is that it has big consequences on human health in all low-, middle-, and high-income countries. WHO does research in all of the countries and in 2016, it estimated that 58% of outdoor air pollution-related premature deaths were caused by ischaemic heart disease and strokes, 18% by chronic obstructive pulmonary disease and acute lower respiratory infections and 6% of deaths were due to lung cancer. Their studies have shown that air pollution contributes to an increased threat of lung and urinary tract/bladder cancer, the particulate matter, which we have discussed previously in the paper is known to cause acute lower respiratory infections, cardiovascular disease and chronic obstructive pulmonary disease, whereas excessive ozone in the air is responsible for breathing problems, triggering asthma, reducing lung function and causing lung diseases. Furthermore, long term exposure to Nitrogen dioxide (NO_2) increases symptoms of bronchitis in asthmatic children and Sulphur dioxide (SO_2) affects respiratory system and the functions of the lungs and causes eye irritation (22).

All the findings above can be concluded as such – air pollution is closely connected to climate change and it is proven that it has severe impacts on human health. Even if WHO does what it can to solve this issue, other states should follow its guidelines and research to know how to reduce the impact of climate change on our health as well.

Climate change and health inequities

That health inequities exist in the modern word is probably a common knowledge. What many people probably do not know, however, is how the climate change impacts the existing health inequities. For better clarification, turn to Fig. 2. Climate change has negative impacts on hydrological systems, causes ocean acidification, sea level rises, species extinction, and increasing food and water insecurity. All of this creates difficulties for the human survival and greater risks for our health (23). An interesting study from WHO revealed a shocking estimated number of deaths caused by climate change in the year 2030. They project that an additional 241,000 deaths will occur, dividing the causes to 38,000 deaths by heat exposure in elderly people, 48,000 due to diarrhea, 60,000 by malaria, and 95,000 due to childhood undernutrition. WHO also estimates that between 2030 and 2050 annually an additional 250,000 deaths will happen, mostly in developing countries. These studies predict that human health will be most affected by climate change until 2030 in sub-Saharan Africa, the causes of deaths being undernutrition, malaria, diarrheal disease, dengue fever, and heat and until 2050 South Asia is going to be most affected region (12).

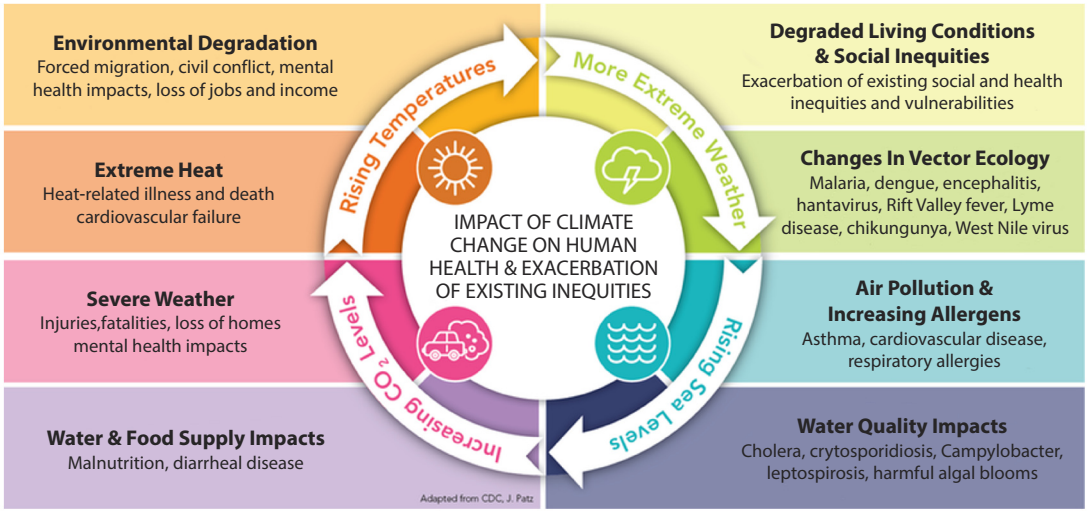

Figure 2. Impact of Climate Change on Human Health & Exacerbation of Existing Inequities (http://www.adorngeo.com/2-consequences-of-climate-change.html)

Most severe outcomes of climate change are going to be experienced by poor people living and working in urban and coastal areas, elderly people, children, traditional societies, and subsistence farmers, simply put the people with the least capacity and resources to adapt to the changes. Extreme weather events, rising sea level and heat

stress are of course going to affect this group of people more, however besides that, the poor people are going to experience great issues with global warming creating ideal habitat for many infectious disease vectors such as ticks, rodents or mosquitos and having very negative influence on agricultural resources (24).

Conclusion

In the paper, we have examined what is climate change, its forms, factors and how precisely it affects human health. From all the research, it is easy to conclude that climate change had severe impacts on human health not only in the past but is going to affect mankind in the future as well. From the past we have learned how the climate changed and how it can influence people's lives. These important information from experience together with knowledge obtained in recent years show the sensitivity of human health. The prospects WHO has presented do not look very well for the mankind. It is essential that policy makers stop seeing climate change not only as an issue affecting polar bears, Amazonian forests, and coral reef. We live in a world where minds can connect in a millisecond, thoughts can be shared instantly, and information can be spread to every corner of the planet where electricity is available. We need to use the advantages we have access to, to create global consensus to help decelerate climate change and in this manner, to save not only human population from serious threats to health, but more importantly, our planet.

Funding

A long-term organization development plan DZRO ZHN are gratefully acknowledged.

Conflict of Interest

The authors state that there are no conflicts of interest regarding the publication of this article.

Adherence to Ethical Standards

This article does not contain any studies involving animals performed by any of the authors. This article does not contain any studies involving human participants performed by any of the authors.

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