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Impact of Climatic Change on Respiratory Health

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Abstract: Threatening effects of climate change are widely visible to the entire population. Though known to all, its adversity is understood only by a handful. With this study, we aimed to broaden its reach. Aiming at creating a louder voice of climate change, we wish to enlighten people about the adverse health effects it has in store for us. While reasons and results may be innumerable, yet precautions are few. Innumerable unknown repercussions have been approximated as well. Naturally occurring gases like carbon dioxide, nitrogen oxides and black carbon cause air pollution which aggravates allergenicity of plants causing earlier and longer pollen seasons. This worsens the situation for people already prone to asthma, allergens and other respiratory tract infections. Additionally, climate changes can exacerbate the issue evermore. Though the effects are perceptible, the reasons and cures are still being studied extensively.

Keywords: Climate, Pollution, Respiratory diseases, Asthma, COVID-19

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Introduction

Climate change is a constantly aggravating situation which is hidden from none. The long-term effects which lead to changes in temperature and rainfall patterns are ascertained to climate change. It is a global havoc created by man-made interventions. A change in climate has caused widespread problems and has put earth's ecosystem and life of unborn generations in trouble. The visible effects have grown dramatically over the past few years and it has

been estimated that it will grow fourfold in the next ten years if the present rates of deterioration continue. As per UN reports, an increase of 1.5°C in global temperature would help maintain survivable conditions but an estimate of 3.2°C increase has been drawn based on current climate plans.

Contrary to popular belief, climate change is not only about rising temperatures. It encapsulates fervent droughts, famine, dreadful

fires, rise in sea levels, floods, melting of polar ice, disastrous storms and reduction in biodiversity. The rising temperature in turn, causes serious damage to both flora and fauna. Man participates in the process by adding pollutants (through burning fossil fuels and releasing harmful CFCs) in the atmosphere. The gases like CFCs and those released from combustion of fossil fuels (greenhouse gases) cover the Earth and do not let the heat escape, thereby increasing global temperatures. The other emitters include garbage landfills, energy, industry, transport, buildings, agriculture and land use. The natural causes might include changes in solar cycles and weather patterns. Since the 1800s, human contribution has had a very strong upper hand in the process. Increased concentration of carbon dioxide in the air is believed to beget global warming. It is the ocean position, causing cataracts in the littoral areas. Low lying littoral areas may indeed be permanently submerged under water. It further increases the probability of food and water borne conditions and promotes the growth of pathogens and allows them to thrive in uninhabitable regions of the world. Another effect of global warming is the increase in frequent heatwaves which follows the increase in threat of heat-related ails like heat stroke and exacerbations of deterioration from habitual conditions similar as cardiovascular and respiratory conditions (Kenney *et al.*, 2015).

Along with global warming, air pollution is another cause of respiratory conditions. As the temperature increases, the hot air leads to the conformation of ground position ozone occasionally known as smog (The Economist Intelligence Unit, 2021). Smog is an efficient air contaminant that shortens life and causes difficulty in breathing especially to persons with lung complaints. Especially, children are vulnerable to dangerous air adulterants since their organ systems are yet to develop (Luber *et al.*, 2014). Climate changes escalate the amount of pollen and allergen manufactured by factories, mould proliferation and particulate matter at ground position. The main diseases of concern are

asthma, rhinosinusitis, chronic obstructive pulmonary disease (COPD) and respiratory tract infections (Fig. 1). People affected with adverse effects of climate change include individualities with pre-existing cardiopulmonary conditions. Measures like adaption and mitigation are the need of the hour. Showers during the pollen season induce severe asthma attacks in cases with Pollinosis. There will be a sharp increase in the intensity of floods along with cyclones and fungal spore product is an important asthma and rhinitis trigger. Furthermore, when exposed to natural disasters, like floods and cyclones, were reported to consolidate the burden of depression, anxiety and stress which are the threat factors for asthma (D'Amato *et al.*, 2014). Famines due to climate change leads to violent wildfires. The particles present in smoke can pierce deep into our lungs, leading to deterioration of lung and heart health. As we gobble fine particulate matter, it enters deep into our lungs, thereby obstructing lung function and damaging our alveoli. Likewise, when these poisons get passed through the bloodstream, it results in hypertension, myocardial infarctions, congestive cardiac failure, brain attack, rise in cholesterol levels, irregular heartbeats, and resistance to insulin.

A time-series study in Hong Kong, China showed that relative threat for asthma hospitalizations increased when the diurnal mean temperature rose over 27 °C in the hot season (Deng *et al.*, 2020). Another study in Brisbane, Australia, necessitates that the hot temperature was associated with increase in exigency department visits for nonage asthma and the effect appeared to be acute (Deng *et al.*, 2020). Even though numerous studies show global average temperature increasing, climate change may also lead to occasional cold axes. Cold temperature can induce bronchial hyperactive-reactivity, compression of the tracheal smooth muscle and drop of the pulmonary rotation and lung perfusion. A study on women athletes in Canada set up that exercise in cold air was associated with increased frequencies of airway

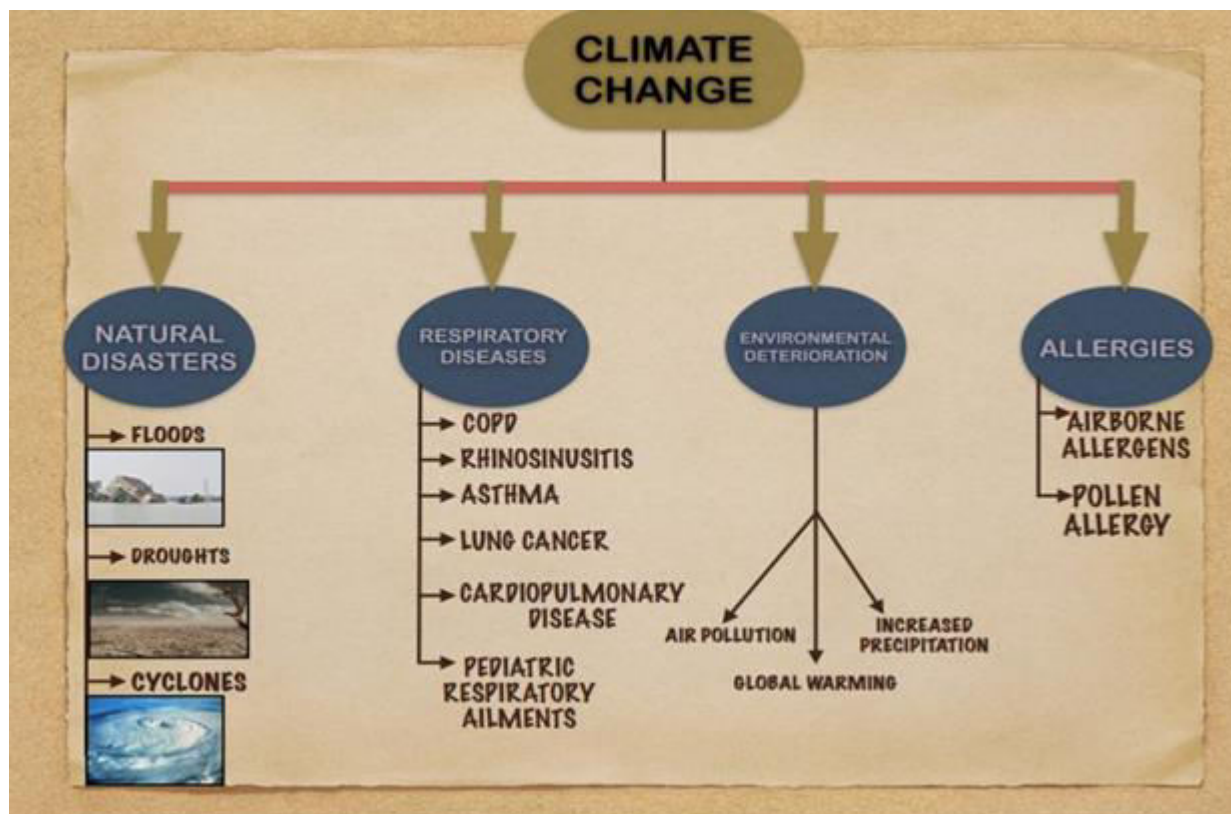


Fig. 1: Effects of climate changes.

Hyperactive - responsiveness and bronchoconstriction, which is the main characteristic of asthma (Deng *et al.*, 2020).

All of this points to the inevitable need to take immediate measures to save our Earth so that climate change and its effects can be curbed to enable future generations to lead a healthy and prosperous life.

This review focuses on the impact of climate change on respiratory diseases. The information was obtained through a comprehensive literature search using electronic databases of PubMed, Scopus, Research Gate from journal articles and the databases of the e-theses Online service and Dissertations. The combinations of keywords used were -- Climate change, Climate change stats, Effect of climate change on respiratory health, Climate change and respiratory diseases, Rhinosinusitis, Effect of climate change on rhinosinusitis, Lung cancer, Lung cancer stats, Lung cancer due to climate change, Cardiopulmonary diseases, Cardiopulmonary disease symptoms, Pediatric respiratory diseases,

Effect of climate change on respiratory health of children, Symptoms of pediatric respiratory ailments, impacts of climate change on respiratory diseases, climate change and allergies, statistical data 2017-2020 of rhinosinusitis, pediatric Respiratory Ailments, allergies, lung cancer, COPD, asthma, cardiopulmonary diseases, Respiratory Diseases due to climate change, effect of covid 19 on respiratory diseases.

Studies were included in this review if they were experimental (*in vivo* and *in vitro*) or clinical studies and if they were articles published in English.

With worsening effects of climate change, mortal beings are at peril as their respiratory health has been adversely affected. Even new born babies have been seriously affected due to the ever-worrisome climate change leading to smaller alveoli and problems in breathing as their respiratory passage is blocked (Gallacher *et al.*, 2016). Some of the most serious diseases have witnessed a huge spike in the number of cases as the climate worsened over time. The most

commonly occurring respiratory ailment has affected majority of the population.

Allergy:

The term Allergy was first used on July 24, 1906. It refers to a specifically altered reactivity of the organism. As of today, we define allergy as an immunologically-mediated and allergen-specific acuity. Allergies can be seen in nearly every organ, commonly found in the skin and the mucous membranes. The symptoms of allergies depend upon the substances involved i.e. the allergens. The various symptoms include: coughing, sneezing, itching, watery eyes, running nose, headaches, wheezing, fatigue etc. (D'Amato *et al.*, 2020). Studies have shown that warmer weather due to climate change leads to longer pollen seasons which increases allergens (an increase in the quantum of allergenic proteins contained in pollen). According to American Academy of Allergy Asthma and Immunology (AAAAI) climate change intensifies not only the pollen season but also its duration. The allergens beget allergies which spark asthma attacks. A research suggests that number of pollen-related allergic respiratory conditions like rhinitis and asthma, have expanded drastically in the past decade. In between 1995 and 2011, it was noted that due to higher temperatures in U.S, increase the pollen season by 11-27 days. Such kind of temperature produces pollen in the air, stronger airborne allergens and more allergy symptoms. Studies display that plants show higher rate of photosynthesis and reproductive functions. This results in production of more pollen in response to large concentrations of carbon dioxide (CO₂). It has been seen that 8.6 million children, or 11.5% of the children in the population, have had respiratory allergies in a 12-month period in 2010 (Hall, 2011). In the 12 months antedating the 2010 U.S. National Health Interview, there were 17.9 million grown-ups diagnosed with hay fever (allergic rhinitis), which is equal to roughly 7.8 per cent of the population of the country. In 2018, it is reported that 9.2 million children had skin allergies (Bachert *et al.*, 2014). Hay fever is known to affect 10% to 30% of

the world's population (World Health Organization, 2013). 7% of survey participators report an allergy to aspirin, ibuprofen, and other NSAIDs (Concepció *et al.*, 2022). Furthermore, it has been observed that human beings who suffer from hay fever, rhinitis, and atopic eczema may have a lower threat of COVID-19, especially in case of asthma patients. It was discovered in a large, population- grounded study of UK grown-ups. Yet, some exploration studies claim that people with allergic symptoms may not have got to know that they have COVID as symptoms cccc veritably resemble and it may have gone unnoticed.

Rhinosinusitis:

The second most common disease of concern is Rhinosinusitis. Inflammation of the paranasal sinuses and nasal cavity is known as rhinosinusitis (RS). Because inflammation of the nasal cavities nearly frequently occurs in conjunction with sinusitis, the name "rhinosinusitis" is chosen over "sinusitis". Acute rhinosinusitis (ARS) affects 6-15 per cent of people annually, while 12–15 percent of Americans have chronic rhinosinusitis (CRS). Due to doctor visits, prescription and over-the-counter medications, sinus surgeries, and missed days from work and school, rhinosinusitis is linked to a considerable decline in quality of life and expensive healthcare expenses. Patients with RS typically visit their primary care doctors. Patients with rhinosinusitis are also seen by other experts, especially those who have trouble getting better, like allergists and otolaryngologists. Chronic rhinosinusitis caused by infection or growths can stretch on for about weeks. Nasal blockage or congestion, face or dental discomfort, purulent rhinorrhea, post-nasal discharge, headaches, and cough are all signs of ARS. Fever, severe discomfort, unilateral illness, exhaustion, hyposmia, ear fullness, or pressure might also be additional symptoms of ABRS. Now with respect to climate change, the most frequent cause of sinus blockage due to bacterial rhinosinusitis is a viral upper respiratory infection, which is followed by anatomical factors and mucosal edoema from inhaled allergens. A key contributing

element is air pollution, which is most frequently cigarette smoking. Nasal polyps (such as the “aspirin triad,” which consists of aspirin sensitivity, asthma, and nasal polyps), the hormone-based turbinate edoema associated with pregnancy, medication side effects such as rhinitis medicamentosa from abuse of topical vasoconstrictors or cocaine, mucosal edoema from use of oral antihypertensive drugs, antiosteoporosis agents, or hormone. Although no clear link between allergic rhinitis (AR) and RS has been shown, they frequently coexist. The presence of AR in 25–31% of ARS patients and 84% of CRS patients suggests at least a connection between the two diseases. Although the link between AR and certain CRS forms has been investigated, the findings are inconsistent. According to certain data, people with CRS with nasal polyps (CRSwNP) have enhanced allergen sensitivity. Although it was not statistically significant, it was found that CRSwNP had a greater median number of positive skin prick tests for environmental allergens than CRS without nasal polyps (CRSsNP). Furthermore, it is not quite fully understood until now but have been said to have closely intertwined. COVID-19 has been associated with olfactory loss similar to rhinosinusitis. In case of Covid, olfactory loss may persist from about a week to an entire lifetime. The Sino-Nasal Outcome Test-22 questionnaire was used to gauge the severity of CRS symptoms and the patients' quality of life. There were no differences between CRS patients with COVID-19 and CRS patients without COVID-19 in any of the four areas of the Sino-Nasal Outcome Test-22. Therefore, COVID-19 did not worsen sinonasal symptoms in CRS patients, including olfactory function (Concepción *et al.*, 2022).

Chronic Obstructive Pulmonary Disease:

In addition, COPD (Chronic Obstructive Pulmonary Disease) is another serious problem that is a threat to human life. It is a chronic seditious lung ailment that causes blocked airflow from the lungs. Main reason for the cause of COPD is the long term exposure to particulate matter especially cigarette smoke. Emphysema and

chronic bronchitis are well known two main reasons which contribute to COPD. It is caused due to Alpha-1 antitrypsin (AAT) deficiency, a genetic disorder. It is an enzyme that protects lungs from harsh effects of inflammation. Breathing difficulty, cough, mucus (sputum) and wheezing are some common symptoms. It also includes chest tightening, unintended weight loss and lack of energy. Others include frequent morning headaches or dizziness, fever especially with cold or flu symptoms. COPD generally is caused due to long-term exposure to toxic gases or particulate matter, mostly in the form of cigarette fumes. Humans with COPD are found to be at increased risk of developing heart complication, lung cancer and a variety of other diseases. People with COPD are more likely to get infected by cold, flu and pneumonia. A study at University of Washington revealed that 1°C increase in ambient temperature was associated with a 2% increase in the likelihood of COPD exacerbations in the following two days among a group of patients. It can become more difficult to breathe for a person if he/she suffers from any other respiratory infection and it could beget more damage to lung tissue. Exposure to air pollution over a long period can affect how well the lungs work and some exploration suggests it could increase your threat of COPD. Ongoing studies suggest that air pollution and COPD are linked. In 2018, 16.4 million people, or 6.6% of grown-ups, reported a diagnosis of some or the other type of COPD (chronic bronchitis, emphysema, or COPD) (Nishiga *et al.*, 2020). Chronic obstructive pulmonary disease (COPD) is found to be third leading cause of death worldwide, causing 3.23 million deaths in 2019. By 2016, 1.6 million women and 1.8 million men had emphysema, a research study claimed. In 2015, 3.2 million people lost their lives due to COPD worldwide, an increase of 11.6 per cent compared with 1990. During that same time period, the prevalence of COPD increased by 44.2 per cent to 174.5 million beings. People with COPD are at higher risk of contracting disease upon getting exposed to SARS-CoV-2, virus that causes COVID-19. Severe infection may lead to ARDS

(Acute Respiratory Distress Syndrome) which fills lungs with fluids which causes difficulty in inhaling oxygen and lead to breathlessness. A meta-analysis pointed out that COPD patients who were infected with COVID-19, percentage of patients that had COVID-19 symptoms reported them as severe was 63%, compared to 33.4% of patients.

Asthma:

Quite similar to other ailments, when a person's airway become narrow, inflamed and produce more mucus, which makes it difficult to breathe is known as Asthma. It is the spastic contraction of the smooth muscle in the bronchioles, which partially obstructs the bronchioles and causes difficulty in breathing. It occurs in 3 to 5 per cent of all people at some time in life. As there is change in climate, more dust particles spread which causes irritation in the nasal passage and can causes airways to become inflamed. Ozone being a strong lung irritant causes asthma. Breathing polluted air can increase the severity of asthma in people who already are suffering from it. Increased mold spore concentration majorly led to thunderstorm asthma. Its various symptoms include shortness of breath chest tightness or pain, wheezing sound when exhaling, which is a common sign of asthma in children trouble in sleeping caused because of shortness of breath or due to coughing and sneezing. It also includes tachycardia, fatigue, moist skin, and anxiety. It has been found that thousands of children under the age of 5 die prematurely because of respiratory diseases caused due to air pollution (Gallacher *et al.*, 2016). Air pollution in turn leads to global warming that leads to ozone depletion. Ozone is a strong lung irritant that triggers asthma attacks. The functional residual capacity and residual volume of the lung become essentially increased during the acute asthmatic attack due to difficulty in expiring air from the lungs. Also, over a period of days, the chest cage becomes permanently enlarged, causing a "barrel chest," and both the functional residual capacity and lung residual volume get permanently increased (Hall, 2011).

Asthma is known to affect an estimated 262 million people in 2019 and caused 4,55,000 deaths. In 2019, 44.3% of children of age 18 and younger who had asthma reported having one or more asthma attacks in the past year (Moeller *et al.*, 2020). In 2019, 40.4% of grown-ups age 18 and aged who had asthma reported having one or further asthma attacks in the past year. For the first time in 20 years, deaths due to asthma rose in the year 2020 (Bachert *et al.*, 2014). About 5 million American children have asthma. The effect of COVID-19 has been lesser in the patient with asthma. It seems that a patient with asthma would be at increased risk of SARS-CoV-2 infection and more serious manifestations of COVID-19 as asthmatics normally carry high susceptibility to common viral respiratory infections partly due to a deficient and delayed innate antiviral immune response. Asthmatic patients also show an increased frequency and severity of lower respiratory tract infections compared to healthy individuals.

Lung Cancer:

The ever-increasing climate change has also contributed to a significant increase in Lung Cancer cases. The data linking lung cancer, air pollution, and climate change is growing. A recent study by experts at the University of California, San Francisco determined that rising temperatures, wildfires, and poor air quality will result in greater incidences of cancer, particularly lung cancer (Bachert *et al.*, 2014). Sedentary lifestyles and poor diets are additional risk factors for developing cancer. Improving air quality by investing in public transport or spending more time outdoors and promoting physical activity are some practices that will help reduce exposure to pollutants. Reducing carbon emissions also helps prevent agricultural challenges caused by elevated temperatures, extreme weather and sea levels, and increases access to nutritious foods. Mitigating the effects of climate change can help lessen the adverse impacts of natural disasters on public health due to environmental pollution. Coughing (sometimes with blood), chest

discomfort, wheezing, and weight loss are some of the most common symptoms. These symptoms frequently do not occur until the malignancy has progressed. The increase in global temperatures caused by the combustion of fossil fuels is expected to cause major changes in weather patterns, leading to more frequent and more devastating natural disasters. These cause carcinogen exposure to flourish. The fires that raged across California in 2020 caused an increase in air pollution, which made the Bay Area's air quality the worst in the world. Natural disasters can cause major disruptions to medical care, which can delay routine screenings, diagnoses, and treatments for cancer, resulting in higher mortality rates. For patients with ailments as serious as lung cancer, the pandemic aggravated their problems. Mandatory regular visits to the hospitals for chemotherapy among many other things, worsened their condition as it increased their susceptibility to COVID. With increasing severity of COVID, care for other patients declined significantly as the hospitals ran understaffed. The lack of proper and timely treatment accompanied with increased fear and susceptibility towards covid exacerbated the issue for lung cancer patients. This not only increased the impact but also the longevity of the disease in the patients (Luber *et al.*, 2014). For patients who contracted covid, it became extremely laborious to tell the difference between symptoms of a persisting COVID infection versus the underlying lung cancer. Individuals may receive chemotherapy or radiation treatments prior to surgery since thoracic surgeons have observed worse outcomes in patients who have surgery too soon after contracting COVID.

Cardiopulmonary Diseases:

Climate change has not only affected our lungs but has had a major effect on our cardiovascular health as well. Hence, we have observed a sharp rise in Cardiopulmonary Diseases as well. It refers to a group of illnesses that affect the heart and lungs. These organs are interconnected, and a dysfunction in one can affect the other. For

example, when the heart is unable to adequately pump blood, normal oxygen transport in the lungs is impeded, resulting in shortness of breath. An issue with the lungs, on the other hand, might make the heart work harder to deliver oxygen from the lungs into the blood. The symptoms include Bluish skin on hands and feet, chest pain, dizziness, high BP, nausea, vomiting, shortness of breath, wheezing and sudden sweating are common symptoms. Daily death rate analyses have revealed that both low and high temperatures are related with an increase in cardiovascular disease mortality. Although this basic global trend is continuous, regional climate, cultural and technological adaptation to cold and heat determine the temperature at which the least deaths occur. Non-optimal temperature was recently included to the Global Impact of Disease estimate, accounting for 1.96 million deaths worldwide, with low temperatures causing a greater burden than high temperatures. The relative relevance of extreme weather is shifting as a result of climate change. Given the pathophysiological consequences of greater heat exposure, a rise in the likelihood of acute-onset ischemic heart disease with increasing temperatures seems physiologically feasible. Thermal stress causes physiological reactions to variations in core body temperature, such as increased perspiration, increased heart and breathing rates, vasodilation, and increased or reduced coagulation. These alterations can disrupt the heart's autonomic function, raise local arterial pressures, produce systemic inflammation, and impede clotting responses. These haemostasis abnormalities may predispose vulnerable people to atherosclerotic plaque rupture and subsequent myocardial infarctions. Individuals with heart failure and a low left ventricular ejection fraction, on the other hand, are unlikely to be able to adjust for the increased circulatory demand caused by heat exposure. Pneumonia has been the major end result of COVID but it has also been a contributing factor in many significant cardiopulmonary and cardiovascular ailments like myocardial injury, arrhythmias, ACS and thromboembolism. This

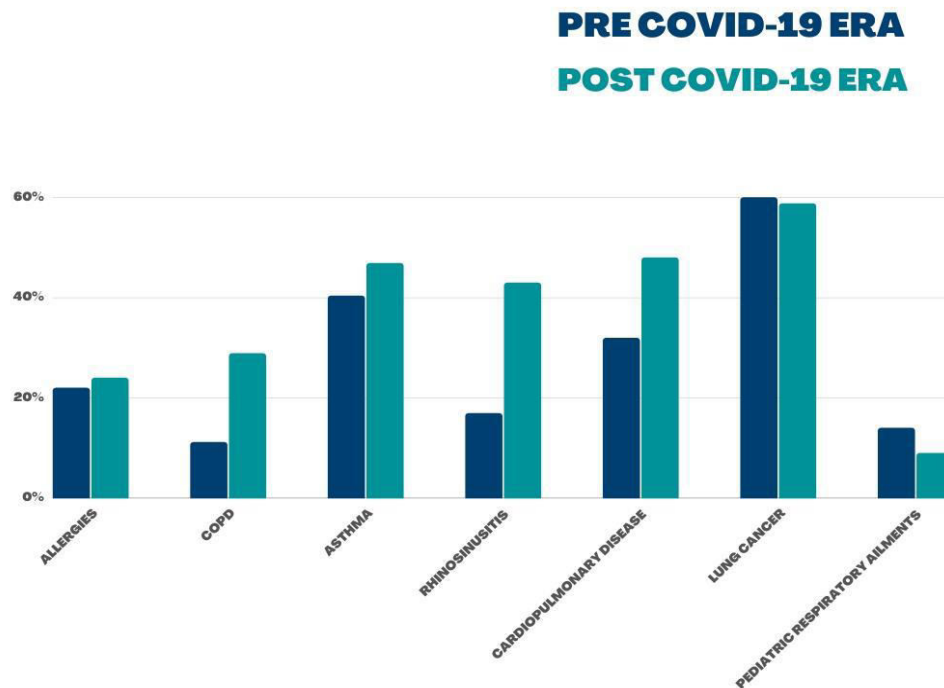


Fig. 2: Effects of COVID-19 on various respiratory diseases.

manifestation of COVID has resulted in higher mortality. Early COVID studies have revealed that patients with cardiovascular ailments reported a worse prognosis. This suggests how the course of action of the coronavirus affected the cardiopulmonary systems adversely. Coronavirus has also been known to affect myocardium which results in viral myocarditis. Other long term cardiopulmonary effects of covid are under extensive study (Nishiga *et al.*, 2020). Figure 2 depicts the respiratory diseases pre- and post-covid.

Pediatric Respiratory Ailments:

Worsening climate conditions have affected the children in the most possible grave manner, causing increase in count of patients suffering with pediatric respiratory ailments. High temperatures caused by global warming are thought to have an impact on the commencement and length of plant pollen production; in fact, a rise in autumn temperatures causes many spring-flowering species across the world to blossom sooner. It was discovered that ragweed grew

quicker, bloomed sooner, and produced much more aboveground biomass and pollen when they examined the quantitative and qualitative features of ragweed growth and pollen production. Interestingly, some studies have shown that pollen grains may absorb not just heavy metals but also nitrate and sulphur, whilst others have shown that particles can agglomerate on the surface of pollen grains. This pollen-particle interaction may influence allergen release and pollen protein absorption by airborne particles, ultimately contributing to a rise in pollen allergies and asthma in heavily polluted locations. Symptoms are generally common like sneezing, coughing, wheezing, sore throat, body and headaches. The relative influence of climate factors and air pollution on pediatric respiratory allergy disorders is a new area of study. Notably, a recent study in China aiming at quantifying the relative influence of meteorological elements and air pollutants on pediatric allergy illnesses discovered that AR and asthma prevalence were negatively related to daily mean temperature and positively related to daily air pressure, NO₂, and O₃ (Keitaro

and Naohiko, 2021). However, climate conditions found to be more important than air pollution. Indeed, the number of illnesses owing to an interquartile range change in climatic factors was larger than the number of diseases attributable to an interquartile range change in pollutants, emphasizing the higher burden of childhood AR and asthma associated with climatic variables. Strikingly, a recent South Korean study found that a "pneumonia temperature," or day-to-day temperature variation, was connected with an increased likelihood of emergency visits for pneumonia. When the pneumonia temperature was greater than 6 °C in children aged 0-5 years, each further 1 °C rise led in a 1.89 per cent (95 per cent CI: 1.34, 2.67) increase in the relative risk for an emergency visit due to pneumonia. Warm average temperatures and big DTRs provided protection, even though the latter were impacted by various constraints, such as season and socioeconomic level which weren't accounted for in the result. In a recent systematic analysis, 1065 children with SARS-CV-2 infection were included in reported paediatric cases of COVID-19 from China and Singapore published between December 2019 and March 2020. 444 of these kids were under the age of 10 when they contracted the virus. The majority of the symptoms were respiratory in nature, such as a dry cough, and systemic in nature, such as weariness and fever. Some kids showed signs of digestive problems. There was only one case presented, a severe lower respiratory tract infection requiring intensive care but no fatalities.

Conclusion

The major concern which has caused a lot of discomfort not only to mortal beings but to the environment too is climatic change. It has led to droughts, water scarcity, fires, rise in sea levels, floods, melting polar ice, catastrophic storms and declining biodiversity. The rising temperature in turn, causes serious damage to both flora and fauna. This communication majorly focuses on how climate change leads to Respiratory Diseases in human and in turn reduces the respiratory

health. During the course of the study we also found the effect of COVID-19 on respiratory diseases. As we proceeded with our research we mainly focused on the 7 respiratory diseases caused due to climate change which were allergies, asthma, COPD, cardiopulmonary disease, lung cancer, Pediatric Respiratory Ailments and rhinosinusitis. Knowledge of these associations is important to acclimatize public health programs, disaster preparedness, societal mindfulness, and education. Through this study the authors want to drive the attention of the readers towards the harmful effects of climate change and how it affects the respiratory health of the population of the country. We all as responsible citizens need to come together and eradicate the respiratory problems and work together in reducing the causes of climate change.

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