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The Potential Impact of Climate Change on Neural Health and The Development of Neurodegenerative Disorders.

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Abstract

Background: The study explores the impact of climate change on neural health and the development of neurodegenerative disorders, focusing on the rising global temperatures, pollution, and increased incidence of infectious diseases as key contributors to neurological decline. The research highlights the vulnerability of populations, particularly in climate-affected regions like the Maldives. It examines the correlation between environmental stressors and the prevalence of conditions such as Alzheimer's and Parkinson's disease.

Methods and Materials: Utilizing a comprehensive review of current scientific literature from sources like PubMed and Hindawi, the study integrates findings from articles, case studies, and clinical trials published within the last five years. Keywords including "neurodegenerative diseases," "climate change," "neuroplasticity," and "omega-3- fatty acids" guided the literature search, aiming to uncover novel insights into the pathogenesis and potential mitigative strategies against neurodegeneration.

Results: The investigation underscores the complex interplay between climate change and neural health, revealing significant findings on the exacerbation of neurodegenerative and neurodevelopmental disorders, cognitive impairments, and mental health issues due to environmental factors. Specifically, reductions in omega-3 fatty acids attributed to climate change emerge as a critical concern, given their crucial role in neurogenesis and neuroplasticity.

Conclusion: This study establishes a clear link between climate change and the acceleration of neurodegenerative disorders, emphasizing the need for targeted research and intervention strategies. Addressing these challenges requires a multifaceted approach, integrating environmental, nutritional, and therapeutic measures to mitigate the adverse effects of climate change on neural health.

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1. Introduction

The effects of climate change are undoubtedly one of the world's most paramount and urgent problems, given the increased global temperature, rising sea levels, and increased frequency of weather-related catastrophic occurrences. The eight most recent years have been the warmest on record, according to the WMO Global Climate Report, while the pace of sea level rise has doubled since 1993 and increased by almost 10 mm since January 2020, setting a record high this year. (Polderman et. al., 2009)

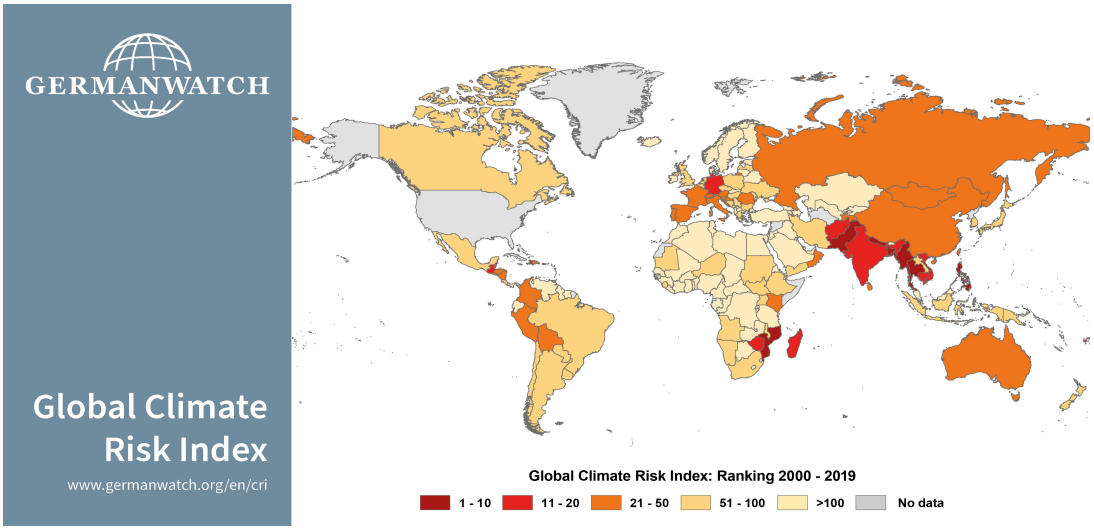
There is evidence linking environmental factors and various diseases and conditions in different fields of medicine. Thus, the effect of climate change on health conditions is irrefutable. Different studies focusing on the health effects of climate change have also been published; however, the effect of climate change on brain/neural health is rarely focused on. This paper aims to observe the relationship between climate and increased prevalence of neurodegenerative disorders. It seeks to understand not only the pathogenetic mechanisms of the effect of climate change on neurodegeneration but also neuroplasticity and neuro-regeneration.

1.1 Relevance

According to a UN report, 1 in 11 people worldwide were 65 or older in 2019, and by 2050, that number will almost quadruple to 1 in 6. The prevalence of neurodegenerative diseases, such as Alzheimer's disease (AD) and Parkinson's disease (PD), is rapidly rising as the world's population ages. Notably, projections show that from 13.5 million cases in 2000 to 21.2 million in 2025 and 36.7 million in 2050, dementia cases will increase in the industrialized world. (Grande et. al., 2020)

Global Climate Risk Index 2021, the latest updated version, shows that the countries most affected by climate change are Mozambique, Zimbabwe, and the Bahamas in 2019, followed by Japan, Malawi, and the Islamic Republic of Afghanistan. Table 1 shows the ten most affected countries (Bottom 10) in 2019, with their average weighted ranking (CRI score) and the specific results relating to the four indicators analyzed.

Figure 1: World Map of the Global Climate Risk Index 2000 – 2019



The Maldives, a sovereign state comprising a collection of 1,190 islands distributed across 20 atolls spanning a distance of approximately 900 km in the Indian Ocean, is widely recognized as one of the nations most susceptible to the impacts of climate change. This heightened vulnerability is primarily attributed to the country's geographical characteristics, characterized by a low-lying topography. The nation faces a significant threat from rising sea levels, as projections indicate that a substantial portion of

the country may become unsuitable for human habitation within the 21st century. Indeed, in the year 1988, authorities in the Maldives believed that a significant portion, specifically 80% of the nation's territory, had the potential to become unsuitable for human habitation due to global warming.

The Maldives has made significant efforts to address the challenges posed by climate change and has developed a comprehensive National Adaptation Programme of Action. The nation has also devised a strategy to eradicate or counterbalance its entire greenhouse gas emissions inventory. Nevertheless, there has been a shift in attention from the climate threat to the issue of mass tourism, with a greater emphasis on prioritizing development.

The Maldives is currently confronted with environmental challenges, including inadequate solid waste management practices. This issue poses a discernible risk to the reefs, which serve as the primary barrier against storms and the potential rise in sea levels. The Maldives Environment Management Project, a $13.5 million initiative, is being undertaken by the World Bank in collaboration with the Government of the Maldives to tackle the aforementioned challenges.

Notwithstanding the obstacles, the Maldives demonstrates unwavering dedication to tackling climate change on national and global fronts. The nation's significant reliance on a limited number of pivotal environmental assets necessitates the prudent management of these resources. Due to a combination of political, geographic, and social factors, Maldives is recognized as highly vulnerable to climate change impacts, ranked 106th out of 182 countries in the 2020 ND-GAIN Index. The ND-GAIN Index ranks 182 countries using a score that calculates a country's vulnerability to climate change and other global challenges and its readiness to improve resilience. Vulnerability measures a country's exposure, sensitivity, and ability to adapt to the negative impact of climate change. ND-GAIN measures the overall vulnerability by considering vulnerability in six life-supporting sectors – food, water, health, ecosystem service, human habitat, and infrastructure. The Vulnerability score for Maldives ranks 143rd out of 180 countries, and the readiness score ranks 83rd among 182 countries, showing its ability to leverage investments and convert them to adaptation actions. ND-GAIN measures overall readiness by considering three components: economic, governance, and social. (Wikipedia contributors, 2023) (No Higher Ground, 2021) ("Climate Change in the Maldives," 2012) (Gilchrist, 2021)

1.2 Purpose and objectives

This study aims to assess the relationship between neurodegenerative diseases and climate change. I have highlighted the impact of climate change in the countries most affected by it, including my country, the Republic of Maldives specifically, and the implications on neural health in this research work. The research questions I concentrated on during this work were the main health implications of climate change and their associated pathogenetic mechanisms. I also focused on the ways and causes of the reduction of omega-3 fatty acids due to climate change and if such a reduction could cause an increase in neurodegenerative diseases (Krauchi et. al., 2004). I further examined the use of omega-3 fatty acids in neurogenesis and neuroplasticity and how their use could reduce neurodegeneration. Another objective of my research work was to observe if there is an increase in infectious diseases due to increased temperature and their effect on neural health. Furthermore, an additional objective was to understand the effect of climate change on neural health during earlier ages of life, even during fetal development, and the possibility of pathogenic treatment methods such as omega-3 fatty acids supplements targeting therapy towards neurotransmitters or hormones.

1.3 Objects

The most relevant literature is compiled, including articles, case studies, and clinical trials. This research reviewed the results to formulate new approaches to treating and prophylaxis neurodegenerative disorders.

1.4 Materials and research methodology

As this is a current scientific literature review, I will seek out the most recent research work in the areas of interest in scientific journals such as PubMed and Hindawi using the keywords "neurodegenerative diseases", "climate change", "neuroplasticity", "neuro-regeneration", "omega-3- fatty acids", from the last 5 years (2017-2023).

Research methods: The articles obtained through the literature search will be reviewed for eligibility based on relevance to the topic, evidence of data, year of research work, quality of the research work, the language of the publication (English), type of publication (scientific literature), and full text published article. The exclusion criteria for research papers were if it is grey literature published in journals that are non-scientific, written in another language than English, and focusing on other areas of climate change effects on health, along with articles that are not within the time frame. The information from the articles is summarized according to these factors and then to be analyzed for inclusion in this research work.

1.5 Practical significance

With the global issue of climate change, many other public health concerns have arisen, including various diseases and conditions. The effect of climate change on neural health or the brain is of interest and importance due to the increasing global morbidity and mortality of neurodegenerative diseases. Hence, this research work's understanding of this relationship is going to be very important in the diagnosis, treatment, and prevention of this arising public health issue.

2. Main health effects due to climate change

2.1 Heat exposure

Heat-Related Neurological illnesses: Extreme heat and heat waves can cause conditions like heatstroke and heat exhaustion, which are heat-related neurological illnesses. These illnesses can bring on confusion, delirium, seizures, and even coma. If heatstroke is not treated right away, it can cause serious and long-lasting brain damage. (Polderman et. al., 2009)

Cognitive Impairments: Exposure to high temperatures can affect cognition, especially in sensitive groups, including the elderly and those with pre-existing cognitive disorders. According to studies, prolonged exposure to heat is linked to memory loss, impaired cognitive function, and a higher chance of developing neurodegenerative disorders, including Alzheimer's and Parkinson's. (Grande et. al., 2020)

Increased temperatures and heat waves can interfere with sleep cycles, resulting in sleep disorders and insomnia. High ambient temperatures can disrupt thermoregulation and make it difficult to get a good night's sleep, harming brain health and cognitive performance. (Karauchi et. al., 2004)

The heat-related effects of climate change can have a major influence on mental health. Anxiety, sadness, and suicide rates are known to rise during heatwaves and extended periods of high temperatures. Extreme heat can worsen pre-existing mental health issues and contribute to the emergence of new psychiatric diseases by causing psychological stress and social upheaval. (Obradovich et. al., 2017)

Exacerbation of Pre-Existing Neurological Diseases: Pre-Existing neurological diseases may get worse as a result of climate change. Heat waves and high temperatures can worsen the symptoms of epilepsy, multiple sclerosis, and other autoimmune conditions that impact the neurological system, as well as increase the frequency and intensity of migraines. (IPCC 2014)

2.2 Pollution

Neurodevelopmental Disorders: Exposure to pollutants, particularly during crucial stages of neurodevelopment, may be a factor in the emergence of these conditions. Neurodevelopmental disorders,

including autism spectrum disorder (ASD) and attention-deficit/hyperactivity disorder (ADHD), have been connected to air pollutants such as fine particulate matter (PM2.5) and polycyclic aromatic hydrocarbons (PAHs). (Volk et. al., 2013)

Pollutants, particularly air pollutants, have been linked to cognitive deficits in children and adults. Long-term exposure to pollutants, such as ozone (O3) and nitrogen dioxide (NO2), has been connected to memory loss, executive dysfunction, and decreased cognitive performance. (Clifford et. al., 2016)

Neurodegenerative disorders: Pollution brought on by climate change might hasten the onset and progression of neurodegenerative disorders like Alzheimer's and Parkinson's. Air pollution exposure has been linked to increased neuroinflammation, oxidative stress, and the buildup of pathogenic proteins in the brain. Air pollution includes particulate matter and hazardous gases. (Block et. al., 2009)

Pollution brought on by climate change can have a serious negative influence on mental health. Increased rates of depression, anxiety, and other mental health illnesses have been related to poor air quality, tainted water supplies, and exposure to heavy metals. Problems with mental health are further exacerbated by the psychosocial pressures connected to pollution and climate change. (Gibson et. al., 2018)

Children are especially susceptible to the negative impacts of pollutants brought on by climate change on neurological health. Neurodevelopmental abnormalities, including cognitive deficiencies, behavioral issues, and lowered IQ, can result from prenatal exposure to pollutants such as heavy metals (such as lead and mercury) and certain chemicals. (Grandjean et. al., 2014)

2.3 Extreme weather events (Hurricanes, tsunamis, natural disasters, etc.)

Post-Traumatic Stress Disorder (PTSD): Traumatic experiences can be brought on by extreme weather occurrences, which can result in PTSD in those who are impacted. Invading memories, flashbacks, nightmares, and hyperarousal symptoms are possible for survivors. Such incidents' long-term psychological repercussions may have a significant negative influence on mental health. (Lowe et. al., 2018)

Depression and anxiety disorders are more likely to develop when people are exposed to harsh weather occurrences. Feelings of despair, helplessness, and anxiety can be exacerbated by the loss of one's home, possessions, and loved ones, as well as by the disruption of social networks and support systems. These mental health issues are further exacerbated by the ongoing stress brought on by recovery and rebuilding initiatives. (Norris et. al., 2018)

Traumatic Brain Injuries (TBIs): Extreme weather conditions can cause physical harm, including TBIs. These accidents may result in falls, debris impacts, or falling structures. Cognitive impairments, memory issues, as well as changes in mood and behavior can all be results of TBIs. The long-term effects of TBIs may greatly impact an individual's quality of life. (Finkelstein et. al., 2006)

Long-Term Cognitive deficits: Prolonged exposure to harsh weather conditions and their aftereffects may cause cognitive deficits. Chronic stress, regular disruptions, and a lack of access to resources can negatively impact cognitive skills, including focus, attention, and judgment. This might have a lasting effect on a person's everyday functioning and general well-being. (Arnsten et. al., 2009)

Disruption of Neurodevelopment in Children: Children's growing brains are particularly in danger from extreme weather occurrences. During these occurrences, displacement, stress, and loss can impair neurodevelopmental processes, resulting in cognitive and behavioral problems. Extreme weather events can cause children's learning impairments, emotional dysregulation, and poor social skills. (Berman et. al., 2008)

2.4 Infectious diseases

Neurological Complications: Several infectious diseases linked to climate change, including Lyme disease and Zika virus infection, can cause neurological complications. Infants who contract the Zika virus during pregnancy are more likely to experience congenital Zika syndrome, which causes neurological damage and developmental delays. Tick-borne Lyme disease can result in neurologic symptoms like facial palsy, peripheral neuropathy, and cognitive decline. (WHO 2017) (Wormser et. al., 2000)

Cognitive Impairments: Climate change-related infectious diseases can exacerbate cognitive impairments. Examples include cerebral malaria, a severe form of malaria, and neurocysticercosis, a parasitic infection brought on by the tapeworm Taenia solium. Cognitive deficits, memory loss, and diminished executive function can result from these diseases. (Garcia et. al., 2014) (Idro et. al., 2010)

Impacts on mental health: The increased prevalence and shifting distribution of infectious diseases brought on by climate change may have profound effects on mental health. Infected people and communities may experience fear, anxiety, and psychological distress as a result of infectious disease outbreaks like Ebola and COVID-19. Mental health disorders may develop or worsen as a result of the psychosocial stress brought on by infectious diseases. (Rubin et. al., 2020)

Immune-Mediated Disorders: Infectious diseases brought on by climate change can set off immune-mediated disorders that affect the nervous system. One viral infection that has been linked to climate and environmental factors is multiple sclerosis (MS), for instance. Changes in infectious disease patterns may impact the risk and development of immune-mediated neurological disorders. (Lunemann et. al., 2020)

Long-Term Neurological Sequelae: Climate change-related infectious diseases may have long-term neurological aftereffects. For instance, survivors of Japanese encephalitis, which is spread by mosquitoes, may experience neurological disabilities as a result of brain inflammation. These long-term consequences may significantly impact an individual's quality of life and neurological function. (Solomon et. al., 2003)

2.5 Pathogenic mechanisms of neurodegeneration due to climate change in different diseases

Temperature-related mechanisms can have an impact on neurodegeneration due to the increase in global temperatures associated with climate change. The occurrence of protein misfolding and aggregation, oxidative stress, and inflammation may be heightened by heat stress and thermal fluctuations, thereby playing a role in the development of neurodegenerative disorders such as Alzheimer's and Parkinson's diseases. (Huang et. al., 2021) (Mahlknecht et. al., 2020)

The presence of air pollution, a notable outcome of climate change, encompasses various harmful components such as particulate matter, heavy metals, and other toxic substances. These pollutants have the ability to infiltrate the brain through inhalation and trigger a state of neuroinflammation. Neuroinflammation, which is characterized by the activation of microglia and astrocytes, plays a role in neurodegenerative processes and has been linked to diseases such as Alzheimer's, amyotrophic lateral sclerosis (ALS), and Parkinson's. (Block et. al., 2009) (Kiomourtzoglou et. al., 2016)

The dynamics of infectious diseases are influenced by climate change, leading to alterations in the geographic range and frequency of these diseases. Consequently, such changes can have implications for the progression of neurodegenerative processes. Certain viral and bacterial infections that are associated with climate change have been found to have a connection with neurodegenerative diseases. This connection is established through the direct invasion of neural tissues, the occurrence of neuroinflammation, and the activation of immune responses in the host. (Wang et. al., 2020) (Misra et. al., 2009)

The impact of climate change-related factors, such as temperature fluctuations and air pollution, on biological systems can lead to oxidative stress and the impairment of mitochondrial function. Neuronal

damage and dysfunction in neurodegenerative diseases are caused by the disruption of cellular homeostasis as a result of heightened levels of oxidative stress. Climate change-related stressors have the potential to worsen mitochondrial dysfunction, which is recognized as a significant characteristic of neurodegeneration. (Orr et. al., 2018) (Domazet et. al., 2017)

The interaction between genetic susceptibility and climate change-related environmental factors has the potential to influence the risk and progression of neurodegenerative diseases. The susceptibility to climate change-related neurotoxic exposures, oxidative stress, and inflammation, which contribute to the development of diseases like Huntington's disease and multiple sclerosis, is influenced by gene-environment interactions. (Bruscoli et. al., 2004) (Goverdhan et. al., 2016)

3. Neural differences with age

The cognitive abilities of individuals can be impacted by various factors related to climate change across different stages of life. A correlation exists between elevated temperatures and heat waves with cognitive deterioration, particularly among the elderly population. Furthermore, the correlation between exposure to air pollution, which is further intensified by the effects of climate change, and the decline in cognitive abilities, as well as the heightened susceptibility to neurodegenerative disorders, has been established. (Kjelllstrom et. al., 2018) (Power et. al., 2016) (Lee et. al., 2011)

The brain's structure can be influenced by climate change, resulting in age-related neural variations. Research findings have indicated that extended periods of exposure to air pollution have been linked to notable modifications in the brain's structure, such as a reduction in the volume of gray matter and changes in the integrity of white matter. These modifications have the potential to contribute to cognitive impairment and neurological disorders. (Calderon-Garciduenas et. al., 2004) (Chen et. al., 2017)

Neuroplasticity, the brain's capacity to adapt and reorganize in response to environmental demands, may be influenced by factors associated with climate change. The occurrence of heat stress and extreme weather events has the potential to induce cellular stress and inflammation, which may lead to a potential impairment of neuroplasticity mechanisms. The impairment of neuroplasticity can impact various cognitive processes, such as learning, memory, and cognitive flexibility. (Simons et. al.,2016) (Sani et. al., 2017)

The mental well-being of individuals can be significantly impacted by stressors associated with climate change, such as natural disasters and extreme weather events. The psychological consequences of climate change, such as anxiety, depression, and post-traumatic stress disorder (PTSD), have the potential to influence neural functioning and contribute to cognitive decline and neurodegeneration in the long run. (Berry et. al., 2010) (Lowe et. al., 2018)

Socioeconomic factors play a significant role in the differential impact of climate change on various populations, particularly those who face economic disadvantages and limited healthcare accessibility. Socioeconomic inequalities concerning climate change can influence neural disparities as individuals who encounter environmental adversities may encounter heightened stress levels, insufficient healthcare access, and limited cognitive engagement prospects. These factors have the potential to affect neural health outcomes. (Fritze et. al., 2008) (Clayton et. al., 2017)

3.1 Effect of climate change in neural health during fetal development

The phenomenon of climate change has been observed to result in heightened occurrence and intensity of temperature extremes, thereby exerting potential effects on the development of the fetal neural system. The potential impact of extreme temperatures, whether excessively hot or cold, on

neurodevelopmental processes during crucial stages of gestation can result in cognitive and behavioral impairments in the offspring. (Haines et. al., 2006) (Basu et. al., 2002) (Xu et. al., 2012) (Block et. al., 2009)

The escalation of air pollution, encompassing particulate matter and diverse toxins, plays a role in detrimental neural health consequences in developing fetuses. The risk of neurodevelopmental disorders and cognitive impairments is heightened by exposure to air pollutants, whether they are encountered indoors or outdoors. (Volk et. al., 2013) (Chen et. al., 2015) (Bale et. al., 2010)

Maternal stress can be triggered by climate change-related factors, including natural disasters and resource scarcity, leading to subsequent impacts on fetal neural development. Maternal stress hormones, specifically cortisol, possess the ability to traverse the placental barrier and interfere with the typical development and arrangement of the fetal brain, thereby heightening the susceptibility to neurological disorders. (Bale et. al., 2010) (Wadhwa et. al., 2009) (Monk et. al., 2012)

Climate change can directly influence the distribution and prevalence of infectious diseases, potentially impacting fetuses' neural health. Maternal infections occurring during pregnancy, such as Zika virus and toxoplasmosis, have the potential to result in congenital neurological abnormalities and neurodevelopmental disorders in newborns. (Vasconcelos et. al., 2016) (Jones et. al., 2012) (Van de Hof et. al., 2019)

The availability and quality of food are impacted by climate change, resulting in alterations in maternal nutrition and the possibility of nutrient deficiencies during pregnancy. Insufficient maternal nutrition, specifically with regard to vital nutrients such as omega-3 fatty acids, iron, and folate, has the potential to undermine the neural development of the fetus and heighten the likelihood of neurodevelopmental disorders. (Stratakis et. al., 2017) (Starling et. al., 2015) (De-Regil et. al., 2010)

3.2 Effect of climate change in neural health during adult life

Cognitive Decline: Various climate change-related factors, including elevated temperatures and occurrences of heat waves, can potentially contribute to cognitive decline among adult individuals. Extended periods of being subjected to elevated temperatures can have detrimental effects on cognitive functions, encompassing memory, attention, and decision-making capabilities. (Basner et. al., 2014)

The occurrence of mental health disorders can be influenced by climate change, resulting in a heightened susceptibility to conditions such as anxiety and depression in adulthood. The occurrence of severe weather phenomena, population displacement resulting from environmental calamities, and increased psychological strain linked to climate change collectively contribute to the emergence of mental health disorders. (Hsiang et. al., 2014)

Neuroinflammation can be induced by environmental alterations resulting from climate change, such as air pollution and exposure to toxic substances. Prolonged exposure to pollutants and particulate matter has the potential to induce the initiation of inflammatory pathways within the brain, thereby contributing to the occurrence of neural damage and dysfunction. (Calderon-Garciduenas et. al., 2003)

The risk and progression of neurodegenerative diseases in adults may be exacerbated by climate change-related factors, including heightened pollution levels and increased heat stress. The pathogenesis of diseases such as Alzheimer's and Parkinson's can be influenced by oxidative stress, inflammation, and vascular dysfunction that arise as a consequence of climate change. (Allen et. al., 2021)

3.3 Effect of climate change in neural health in elderly patients

The heightened susceptibility to neurodegenerative diseases: The elderly population faces an increased susceptibility to neurodegenerative diseases due to various climate change-related factors, including temperature extremes and air pollution. Research has indicated that there exists a positive

correlation between elevated temperatures and extended periods of heatwaves and the prevalence of Alzheimer's disease and other neurodegenerative disorders (Barkhordarian et. al., 2020). The association between exposure to air pollutants, specifically fine particulate matter and ozone, and increased susceptibility to neurodegenerative diseases has also been established (Meo et. al., 2020).

Cognitive Decline: The impact of climate change, specifically elevated temperatures and heat waves, can adversely affect cognitive function among the elderly. Heat stress has the potential to result in cognitive impairment, which encompasses a range of negative effects such as diminished attention, memory deficits, and impaired executive function (McMichael et. al., 2006). The extended duration of exposure to elevated temperatures has the potential to worsen the decline in cognitive abilities associated with aging and heighten the susceptibility to developing dementia (Oudin et. al., 2022).

The elderly may experience notable psychological effects due to climate change-related occurrences, including natural disasters and extreme weather events. These events are correlated with a heightened prevalence of anxiety, depression, post-traumatic stress disorder (PTSD), and other mental health disorders (Berry et. al., 2010). The psychological impacts of climate-related events disproportionately affect the elderly population, primarily due to their heightened susceptibility to social isolation, limited access to resources, and pre-existing health conditions.

The susceptibility of elderly individuals to heat-related illnesses is attributed to physiological changes associated with aging and underlying health conditions. Elevated temperatures and heat waves linked to climate change amplify the vulnerability of the elderly population to heat exhaustion, heatstroke, and other heat-related ailments (Rocque et. al., 2018).

4. Omega-3 FA

4.1 Ways and causes of reduction of OFA due to climate change

The phenomenon of increasing sea temperatures: climate change is a significant factor in escalating sea temperatures, directly influencing marine ecosystems. Elevated temperatures can alter marine organisms' spatial arrangement and population sizes, encompassing species rich in omega-3 fatty acids. According to Del Carratore (2021), the thermal conditions of water bodies have the potential to induce changes in the metabolic rates and reproductive behaviors of fish, thereby potentially influencing the composition of omega fatty acids in their bodies.

Ocean acidification refers to the ongoing decrease in the pH levels of Earth's oceans, primarily caused by the absorption elevated carbon dioxide levels in the atmosphere result in ocean acidification, which harms marine organisms. The presence of acidic waters can impede the growth and maturation of phytoplankton and other primary producers, thereby diminishing the accessibility of precursor compounds for omega-3 fatty acids. The perturbation in the marine food web can consequently affect omega fatty acids in fish and other types of seafood (Forouzanfar & Kousha, 2021).

The topic of discussion pertains to modified food webs: the impact of climate change on marine ecosystems can lead to changes in the dynamics of food webs. Alterations can influence the diets of omega-3-rich fish and higher trophic-level marine organisms in the abundance and distribution of prey species. According to Ransohoff (2016), the diminished presence of prey can result in a decline in the levels of omega fatty acids in predatory species.

The topic of concern in this discussion is pollution and contaminants: the phenomenon of climate change has the potential to interact with pollution and contaminants, thereby exerting additional influence on the

levels of omega fatty acids. Marine organisms can potentially accumulate pollutants, such as heavy metals and persistent organic pollutants (POPs). The presence of elevated concentrations of pollutants has the potential to adversely affect the nutritional composition and safety of seafood, thereby restricting the advantageous effects associated with the consumption of omega-fatty acids (Ashraf et al., 2016).

4.2 Relationship between reduction of OFA and ND

Alzheimer's disease has been the subject of extensive research regarding the potential protective effects of omega-3 fatty acids, specifically docosahexaenoic acid (DHA). The presence of diminished quantities of omega-3 fatty acids in the brain has been linked to a decline in cognitive function and an elevated susceptibility to Alzheimer's disease (Freund Levi et al., 2014).

Parkinson's disease has been the subject of research exploring the potential neuroprotective effects of omega-3 fatty acids. According to De Franceschi et al. (2017), there is evidence to suggest that omega-3 fatty acids have the potential to mitigate neuroinflammation, oxidative stress, and neuronal damage that are commonly observed in the pathology of Parkinson's disease.

Multiple sclerosis (MS) is a condition that has exhibited potential benefits from using omega-3 fatty acids in regulating the immune response and mitigating inflammation. According to Shinto et al. (2017), certain studies indicate that the administration of omega-3 supplements might yield advantageous outcomes in terms of disease activity and symptom control among individuals diagnosed with multiple sclerosis (MS).

The potential antidepressant effects of omega-3 fatty acids, specifically eicosapentaenoic acid (EPA), have been the subject of research. An elevated risk of depression has been linked to decreased levels of omega-3 fatty acids. According to a study conducted by Grosso et al. (2014), the addition of omega-3 fatty acids to one's diet may potentially enhance both the symptoms of depression and the effectiveness of treatment.

Anxiety disorders have also been the subject of research regarding the potential anxiolytic effects of omega-3 fatty acids. According to existing research, the supplementation of omega-3 has been found to potentially alleviate symptoms associated with anxiety disorders and enhance overall mental well-being. A correlation has been observed between decreased levels of omega-3 fatty acids and an elevated likelihood of developing anxiety disorders (Su et al., 2015).

4.3 The use of OFA in neuroregeneration and neuroplasticity

The phenomenon of neurogenesis, which involves generating novel neurons, occurs in distinct brain regions, such as the hippocampus. Numerous investigations have examined the impact of omega-3 fatty acids on the facilitation of adult hippocampal neurogenesis. Previous studies have demonstrated that these particular fatty acids possess the ability to augment cellular proliferation, viability, and neuronal differentiation in animal models (Smith et al., 2013; Wu et al., 2015). Furthermore, the administration of omega-3 supplements has been shown to yield favorable outcomes in cognitive function and emotional state, potentially due to the promotion of neurogenesis (Luchtman & Song, 2013).

The topic of discussion pertains to the relationship between omega fatty acids and synaptic plasticity. In this context, synaptic plasticity denotes synapses' capacity to undergo modifications and adjustments in reaction to neural activity. Omega-3 fatty acids have been suggested to play a role in augmenting synaptic plasticity through various mechanisms. Fatty acids significantly impact cellular membranes' composition and fluidity and the modulation of signaling pathways associated with synaptic plasticity. Additionally, they play a role in promoting the synthesis of neuroprotective factors (Gomez-Pinilla, 2008). Previous research on animals has provided evidence that omega-3 supplements can effectively enhance synaptic plasticity, thereby leading to improvements in cognitive functions such as learning and memory (Dyall, 2015).

The relationship between omega fatty acids and cognitive function is an area of interest within the field of cognitive science. Cognitive function refers to a range of cognitive processes, such as attention, memory, and executive function. Research has demonstrated that omega-3 fatty acids are paramount in facilitating optimal cognitive function maintenance. Previous research has indicated that there are links between increased levels of omega-3 fatty acids and enhanced cognitive functioning in individuals of various age groups, such as children, adults, and older adults (Bauer et al., 2014; Gomez-Pinilla, 2008). In addition, the administration of omega-3 supplements has demonstrated promising effects in ameliorating cognitive deterioration in neurodegenerative conditions, including Alzheimer's disease (Dyall, 2015).

Therapeutic Implications: The therapeutic implications of omega fatty acids, with their neuroregenerative and neuroplasticity-enhancing properties, are of great importance in treating diverse neurological disorders. Previous research has indicated that the addition of omega-3 supplements may have potential advantages in the treatment of various disorders, including depression, schizophrenia, and traumatic brain injury (Gomez-Pinilla, 2008; Wu et al., 2015). The aforementioned findings underscore the potential of omega fatty acids as a supplementary therapeutic strategy for promoting brain health and the augmentation of neural recuperation.

5. Pathogenic treatment and prophylactic methods

The therapeutic approach in pathogenic treatment centers on interventions implemented subsequent to the occurrence of neural health impairments to mitigate symptoms and facilitate the process of recuperation. The subsequent methodologies have demonstrated efficacy in mitigating the neural health consequences associated with climate change.

Cognitive Behavioral Therapy (CBT) is a psychotherapeutic approach that aims to address and modify maladaptive thoughts, emotions, and behaviors. Cognitive Behavioral Therapy (CBT) is a prevalent therapeutic modality employed in the treatment of various psychological disorders, including Post-Traumatic Stress Disorder (PTSD), depression, and anxiety. The process entails assisting individuals in recognizing and altering detrimental cognitions and behaviors, consequently mitigating symptoms and enhancing overall psychological and emotional health. According to Niles and O'Donovan (2019), cognitive-behavioral therapy (CBT) has been shown to be effective in the treatment of mental health conditions that are a result of climate change.

Rehabilitation for Traumatic Brain Injury: rehabilitation programs play a crucial role in addressing the needs of individuals who have experienced traumatic brain injuries (TBIs) as a consequence of climate change-related incidents. These programs incorporate physical, occupational, and speech therapy interventions to enhance cognitive functioning, motor skills, and overall quality of life. According to Tate et al. (2014), the implementation of personalized rehabilitation strategies has demonstrated favorable results in the recovery of individuals with traumatic brain injuries. Pharmacological interventions refer to the use of medications or drugs as a means of treating various medical conditions or diseases

Pharmacological interventions are of paramount importance in situations where medication is required to address neural health effects. Pharmaceutical interventions, including antidepressants, anxiolytics, and antipsychotics, may be recommended by healthcare professionals to mitigate symptoms and enhance neural well-being. Thorough assessment and diligent surveillance are imperative in order to achieve optimal medication management (Hawryluck et al., 2002).

Prophylactic methods refer to preventive measures or strategies employed to reduce the risk of a particular disease or condition prophylactic measures are implemented to mitigate or minimize the

incidence of neural health consequences associated with climate change. Implementing preventive measures can serve as an effective strategy for safeguarding the neural well-being of individuals.

The topic of discussion pertains to early warning systems. Early warning systems are crucial in delivering prompt notifications and guidance during severe weather phenomena like hurricanes and floods. According to Paz-Soldán et al. (2016), these systems facilitate the evacuation of individuals and the implementation of necessary precautions, thereby mitigating the likelihood of traumatic experiences and subsequent neural health consequences.

The concept of community resilience building refers to the process of enhancing the capacity of a community to effectively respond to and recover from various challenges and disruptions

Individuals' ability to cope with climate change-related stressors is enhanced by establishing community resilience, which is facilitated by education, training, and social support networks. According to Aldrich (2012), mitigating neural health impacts resulting from climate change events can be facilitated by enhancing social cohesion and promoting community resilience.

The Impact of Green Spaces and Nature Exposure on Human Well-being: the promotion of access to green spaces and the facilitation of nature exposure have positively influenced mental well-being. The provision of parks, gardens, and natural environments that are easily reachable by individuals has been found to positively impact stress reduction, mood enhancement, and overall neural well-being. The integration of these initiatives into urban planning and policy development has been discussed by Bratman et al. (2012).

5.1 Omega 3 Fatty Acids

The Impact of Omega-3 Fatty Acids on Neural Health Omega 3 fatty acids, specifically eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are indispensable dietary components that influence cognitive well-being. According to Swanson, Block, and Mousa (2012), phospholipids play a crucial role in cell membranes and possess properties that can mitigate inflammation and oxidative stress. These properties contribute to safeguarding the brain against potential harm and inflammatory responses.

Numerous studies have demonstrated that the consumption of a diet abundant in Omega 3 fatty acids can effectively mitigate the likelihood of developing neurodegenerative disorders. An investigation conducted by Morris et al. (2003) revealed that individuals who incorporated fish, which is abundant in Omega 3 fatty acids, into their diet on a weekly basis experienced a significant reduction of 60% in the likelihood of developing Alzheimer's disease.

The Role of Omega-3 Fatty Acids in the Treatment of Pathogenic Conditions Omega 3 fatty acids have demonstrated potential as a therapeutic intervention for neurodegenerative disorders. The modulation of the inflammatory response in the brain has the ability to decrease the synthesis of pro-inflammatory cytokines while simultaneously enhancing the synthesis of anti-inflammatory cytokines (Calder, 2013). This intervention has the potential to mitigate the advancement of neurodegenerative disorders, which frequently exhibit persistent inflammatory processes.

Furthermore, it has been observed that Omega 3 fatty acids possess the ability to augment brain plasticity and facilitate the proliferation of nascent neurons, a phenomenon commonly referred to as neurogenesis. According to Gomez-Pinilla (2008), engaging in this activity has the potential to enhance cognitive function and postpone the initiation of neurodegenerative disorders.

The Use of Omega-3 Fatty Acids as Prophylactic Measures Omega 3 fatty acids possess therapeutic properties and can potentially function as a prophylactic measure against the neural health consequences associated with climate change. One potential benefit of their usage is the ability to mitigate oxidative stress, a significant factor in developing neurodegenerative conditions. Oxidative stress arises from a

disparity between the generation of free radicals and the organism's capacity to mitigate their deleterious consequences. According to Simopoulos (2002), the introduction of omega-3 fatty acids has the potential to counteract the detrimental effects of free radicals, thereby safeguarding the brain against harm.

In addition, Omega 3 fatty acids have the potential to augment the brain's capacity to withstand the adverse effects of environmental stressors, including elevated temperatures and air pollution, which are further intensified by the phenomenon of climate change. According to Gomez-Pinilla (2008), they can modulate the stress response within the brain, decreasing the synthesis of stress hormones and increasing the production of neuroprotective factors.

5.2 Target therapy: neurotransmitters and hormones

The Impact of Climate Change on Neural Health Climate change, distinguished by the phenomenon of global warming, the escalation of sea levels, and the heightened occurrence of extreme weather events, has been associated with various health consequences. The impacts of climate change encompass both direct and indirect consequences. Direct impacts refer to injuries and fatalities resulting from extreme weather events. Indirect impacts, on the other hand, encompass alterations in the distribution of disease vectors, food insecurity, and mental health effects (Watts, Amann, Arnell, Ayeb-Karlsson, & Belesova, 2018).

The impacts of climate change on neurological health can manifest in both direct and indirect ways. The primary consequences encompass traumatic brain injuries resulting from severe weather phenomena, whereas the secondary consequences encompass disorders related to stress, mood, and cognition, which are associated with heat stress and other exposures related to climate change (Clayton et al., 2017).

The topic of interest is target therapy, specifically focusing on utilizing neurotransmitters and hormonal methods. Targeted therapy is a therapeutic approach that focuses on the specific biological pathways implicated in disease mechanisms. In the context of the neural health implications arising from climate change, a potential therapeutic approach could entail the precise targeting of neurotransmitters and hormonal pathways that are impacted by stressors associated with climate-related factors.

Neurotransmitters, including serotonin, dopamine, and norepinephrine, are pivotal in regulating mood, stress response, and cognitive function. According to Bennett (2015), alterations in the concentrations or operations of these neurotransmitters have the potential to give rise to mood disorders, anxiety disorders, and cognitive deficits. These disorders are also associated with hormonal pathways, specifically those involving stress hormones like cortisol (McEwen, 2017).

Targeted therapies encompass pharmacological agents that regulate neurotransmitter or hormone levels, cognitive-behavioral interventions that aid individuals in stress management and mood enhancement, and lifestyle modifications that foster optimal brain well-being (Bennett, 2015; McEwen, 2017).

6. Results

Climate change is a pressing global issue, with rising temperatures, rising sea levels, and weather-related catastrophic occurrences. The increasing prevalence of neurodegenerative diseases, such as Alzheimer's and Parkinson's, is a growing concern, with projections showing an increase in dementia cases in industrialized countries. The Maldives, a highly vulnerable country, is ranked 106th out of 180 countries in the 2020 ND-GAIN Index. The study aims to assess the relationship between climate change and the increased prevalence of neurodegenerative disorders, focusing on the main health implications and their associated pathogenetic mechanisms. The research questions include the ways and causes of the

reduction of omega fatty acids due to climate change, the use of omega-3-fatty acids in neurogenesis and neuroplasticity, the increase in infectious diseases due to increased temperature, and the effect of climate change on neural health during earlier ages of life, even during fetal development.

The research aims to formulate new approaches to the treatment and prophylaxis of neurodegenerative disorders. The research will review relevant literature, including articles, case studies, and clinical trials, to formulate new approaches to treating and prophylaxis neurodegenerative disorders. Understanding the relationship between climate change and neurodegenerative diseases is crucial for diagnosing, treating, and preventing these public health issues. Climate change has significant health effects, including heat exposure, neurodevelopmental disorders, pollution, and extreme weather events. Heatstroke and heat exhaustion are heat-related neurological illnesses that can cause brain damage, cognitive impairments, and increased risk of developing neurodegenerative disorders like Alzheimer's and Parkinson's. Exposure to high temperatures can also interfere with sleep cycles, leading to sleep disorders and insomnia.

Pre-existing neurological diseases may worsen due to heat waves and high temperatures, worsening symptoms of epilepsy, multiple sclerosis, and other autoimmune conditions. Pollution, particularly during crucial stages of neurodevelopment, can lead to neurodevelopmental disorders like autism spectrum disorder (ASD) and attention-deficit/hyperactivity disorder (ADHD). Long-term exposure to pollutants like ozone and nitrogen dioxide (NO2) has been linked to memory loss, executive dysfunction, and decreased cognitive performance.

Neurodegenerative disorders, such as Alzheimer's and Parkinson's, can be hastening due to increased neuroinflammation, oxidative stress, and the buildup of pathogenic proteins in the brain. Pollution and climate change can have a serious negative influence on mental health, with increased rates of depression, anxiety, and other mental health illnesses.

Extreme weather events, such as hurricanes, tsunamis, and natural disasters, can cause post-traumatic stress disorder (PTSD), traumatized experiences, and long-term cognitive deficits. These events can disrupt neurodevelopment in children, causing learning impairments, emotional dysregulation, and poor social skills.

Infectious diseases linked to climate change, such as Lyme disease and Zika virus infection, can also cause neurological complications. Infants who contract the Zika virus during pregnancy are more likely to experience congenital Zika syndrome, which causes neurological damage and developmental delays. Climate change-related infectious diseases can exacerbate cognitive impairments, such as cerebral malaria and neurocysticercosis, leading to cognitive deficits, memory loss, and diminished executive function. These diseases also have profound effects on mental health, with infected people experiencing fear, anxiety, and psychological distress. Infectious diseases can also trigger immune-mediated disorders, such as multiple sclerosis (MS), which may be impacted by changes in infectious disease patterns.

Long-term neurological sequelae can result from climate change-related infectious diseases, such as Japanese encephalitis, which can lead to neurological disabilities. Pathogenic mechanisms of neurodegeneration due to climate change include temperature-related mechanisms, such as protein misfolding and aggregation, oxidative stress, and inflammation, which can lead to neurodegenerative disorders like Alzheimer's and Parkinson's. Air pollution, a significant outcome of climate change, can infiltrate the brain and trigger neuroinflammation, which is linked to neurodegenerative processes.

The dynamics of infectious diseases are influenced by climate change, leading to alterations in the geographic range and frequency of these diseases. These changes can have implications for the progression of neurodegenerative processes. Genetic susceptibility and climate change-related environmental factors have the potential to influence the risk and progression of neurodegenerative diseases.

Neuroplasticity, the brain's capacity to adapt and reorganize in response to environmental demands, may be influenced by climate change factors, such as heat stress and extreme weather events. The mental well-being of individuals can be significantly impacted by stressors associated with climate change, such as natural disasters and extreme weather events. Psychological consequences of climate change, such as anxiety, depression, and post-traumatic stress disorder, can influence neural functioning and contribute to cognitive decline and neurodegeneration in the long run.

Socioeconomic factors play a significant role in the differential impact of climate change on various populations, particularly those facing economic disadvantages and limited healthcare accessibility. The presence of socioeconomic inequalities in relation to climate change has the potential to influence neural health outcomes.

In conclusion, climate change-related infectious diseases can significantly impact cognitive, mental, and neural health. The impact of climate change on these factors is significant, and it is crucial to address these issues to ensure the well-being of individuals and the environment. Climate change impacts food availability and quality, leading to maternal nutrition alterations and potential nutrient deficiencies during pregnancy. Insufficient maternal nutrition, particularly in omega-3 fatty acids, iron, and folate, can undermine the neural development of the fetus and heighten the likelihood of neurodevelopmental disorders.

Climate change-related factors, such as elevated temperatures and heat waves, can contribute to cognitive decline among adult individuals. Extended periods of exposure to elevated temperatures can have detrimental effects on cognitive functions, including memory, attention, and decision-making capabilities. Mental health disorders, neuroinflammation, and neurodegenerative diseases in adults may be exacerbated by climate change-related factors, including heightened pollution levels and increased heat stress.

The elderly population faces increased susceptibility to neurodegenerative diseases due to climate change-related factors, including temperature extremes and air pollution. Research has shown a positive correlation between elevated temperatures and extended periods of heatwaves and the prevalence of Alzheimer's disease and other neurodegenerative disorders. The elderly population may also experience psychological effects due to climate-related events, such as natural disasters and extreme weather events.

The reduction of omega-3 fatty acids due to climate change can be attributed to various factors, including increasing sea temperatures, ocean acidification, modified food webs, pollution, and contaminants. Alzheimer's disease has been linked to reduced quantities of omega-3 fatty acids in the brain, Parkinson's disease has been studied for its neuroprotective effects, and multiple sclerosis (MS) has shown potential benefits from omega-3 fatty acids in regulating immune response and mitigating inflammation. Research has shown that omega-3 fatty acids, specifically eicosapentaenoic acid (EPA), have potential antidepressant effects and anxiolytic effects on depression and anxiety disorders. Adding omega-3 fatty acids to one's diet may improve symptoms of depression and treatment effectiveness. Additionally, omega-3 fatty acids have been found to enhance cognitive function and emotional well-being, potentially due to the promotion of neurogenesis.

The relationship between omega-3 fatty acids and synaptic plasticity is also significant, as they impact cellular membrane composition and modulate signaling pathways associated with synaptic plasticity. Studies have shown that omega-3 supplements can effectively enhance synaptic plasticity, leading to improvements in cognitive functions such as learning and memory.

The therapeutic implications of omega fatty acids are significant in treating various neurological disorders, including depression, schizophrenia, and traumatic brain injury. The addition of omega-3

supplements may have potential advantages in treating various disorders, including depression, schizophrenia, and traumatic brain injury.

Pathogenic treatment and prophylactic methods involve interventions implemented after neural health impairments to mitigate symptoms and facilitate recovery. Cognitive-behavioral therapy (CBT) is a popular psychotherapeutic approach used to address and modify maladaptive thoughts, emotions, and behaviors, aiming to mitigate symptoms and improve overall psychological and emotional health. Rehabilitation for Traumatic Brain Injury (TBI) is crucial in addressing the needs of individuals who have experienced traumatic brain injuries (TBIs) due to climate change-related incidents. These programs include physical, occupational, and speech therapy interventions aimed at enhancing cognitive functioning, motor skills, and overall quality of life.

Pharmacological interventions, such as antidepressants, anxiolytics, and antipsychotics, are essential for addressing neural health effects. Preventive measures, such as early warning systems, community resilience building, and green spaces, have been shown to positively influence mental well-being. Omega-3 fatty acids, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are essential dietary components that exert a pivotal influence on cognitive well-being. A diet rich in omega-3 fatty acids can mitigate the likelihood of developing neurodegenerative disorders and augment brain plasticity, facilitating neurogenesis.

Omega-3 fatty acids have demonstrated potential as therapeutic interventions for neurodegenerative disorders, as they can modulate the inflammatory response in the brain and counteract the detrimental effects of free radicals. They also have the potential to augment the brain's capacity to withstand environmental stressors, such as elevated temperatures and air pollution, which are further intensified by climate change.

Targeted therapy, specifically targeting neurotransmitters and hormonal pathways, is a therapeutic approach that focuses on the specific biological pathways implicated in disease mechanisms. Neurotransmitters, such as serotonin, dopamine, and norepinephrine, are pivotal in the regulation of mood, stress response, and cognitive function. Alterations in these neurotransmitters can lead to mood disorders, anxiety disorders, and cognitive deficits, which are associated with stress hormones like cortisol.

Targeted therapies encompass the use of pharmacological agents that regulate neurotransmitter or hormone levels, cognitive-behavioral interventions that aid individuals in stress management and mood enhancement, and lifestyle modifications. By addressing these issues, we can work towards a more sustainable and resilient future for individuals affected by climate change.

7. Conclusion

The correlation between the escalating occurrence of neurodegenerative disorders like Alzheimer's and Parkinson's and the worldwide concern of climate change, which manifests through elevated temperatures, rising sea levels, and intensified occurrences of extreme weather events, has been established. This study aims to investigate the correlation between climate change and the decline of omega-3 fatty acids, with a specific emphasis on their involvement in neurogenesis and neuroplasticity. Additionally, this research will examine the association between elevated temperatures resulting from climate change and the increased prevalence of infectious diseases. Furthermore, the impact of climate change on neural health will be explored in the context of prophylactic measures against neurodegenerative disorders. The present study aims to conduct a comprehensive review of pertinent academic literature to formulate novel strategies

for managing and mitigating these disorders. The study additionally emphasizes the adverse impacts of heat-related neurological disorders, sleep disturbances, environmental pollution, and stress on neural well-being. The association between the decline in omega-3 fatty acids as a consequence of climate change and the occurrence of Alzheimer's disease, Parkinson's disease, and multiple sclerosis has been established. Omega-3 fatty acids have demonstrated promising potential as therapeutic interventions for these disorders, as they have been found to impact cellular membrane composition and regulate signaling pathways associated with synaptic plasticity. The research emphasizes the significance of comprehending the correlation between climate change and neurodegenerative diseases, as it is crucial for accurate diagnosis, treatment, and prevention.

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Figures

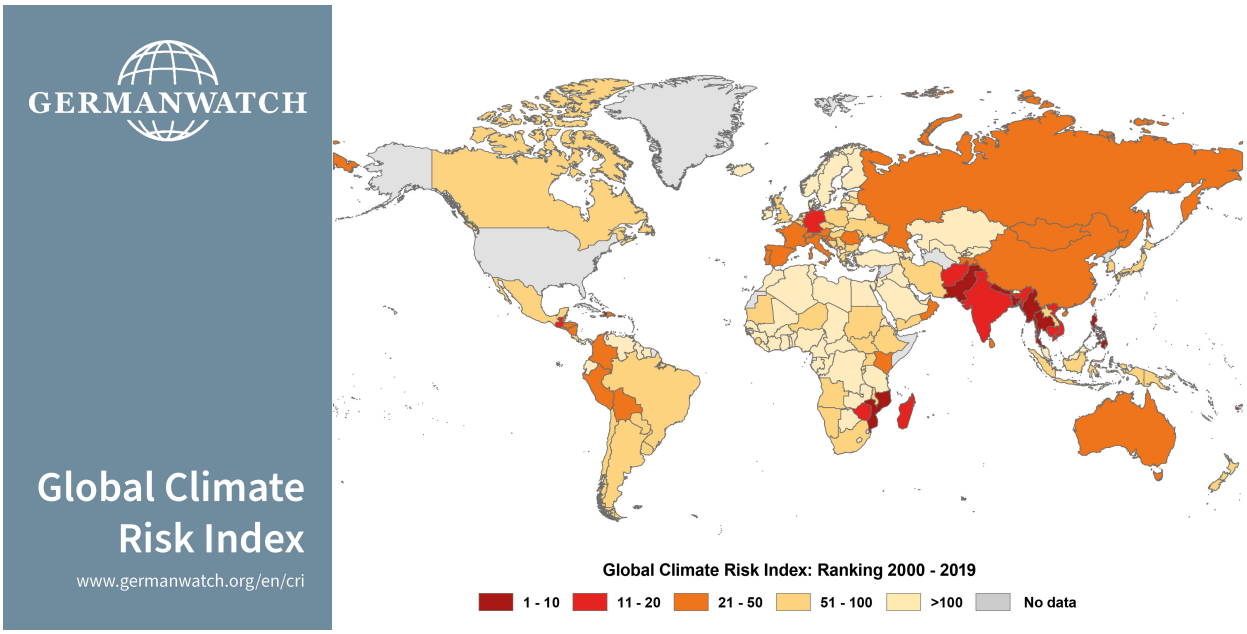

Figure 1. [Global Climate Risk Index 2021: country rankings (2000-2019) depicting the level of vulnerability of South Asia and other regions to the adverse effects of climate change. Source: Eckstein, Künzel & Schäfer (2021), p. 15; Germanwatch and Munich Re NatCatSERVICE.]