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CLIMATE CHANGE AND AIR POLLUTION: THE TWIN THREATS TO CHILDREN'S HEALTH AND WELL-BEING

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ELIJAH SRIROSHAN SRITHARAN
University of Maribor, Faculty of Law, Maribor, Slovenia
elijah.sritharan@gmail.com

CORRESPONDING AUTHOR
elijah.sritharan@gmail.com

Abstract Environmental factors, such as air pollution and climate change, significantly contribute to the global burden of disease and are critical to understanding health disparities between countries, with low- and middle-income nations facing the highest environmental health burdens across various diseases and injuries. While health is universally acknowledged as both a fundamental human need and a basic human right, yet the harmful effects of unhealthy environments disproportionately impact children. Research indicates that pre- and post-natal exposures to environmental toxicants can disrupt brain and lung development, impairing their function. These health impacts are distributed unequally, with marginalised populations experiencing greater harm. The IPCC identifies fossil fuel combustion as the primary driver of climate change. Epidemiological studies further highlight the existing and future consequences of climate change, including its effects on infectious diseases, cardiovascular and pulmonary diseases, and mental well-being.

Keywords
environmental toxicants, convention on the rights of the child, united nations framework convention on climate change, human rights-based approach, sustainable development goals

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1 Introduction

Climate change and air pollution are both regarded as invisible killers, with devastating human health impacts. Until recently, the global community has focused its attention on climate change and the greenhouse gases (GHGs) contributing to it. The ongoing emissions from burning fossil fuels are behind the planet's warming trend and thus it is accurate to say that the burning of fossil fuels is causally responsible for most of the climate change (Shue, 2021, p. 37). Unlike natural disasters, climate change is not a random occurrence but a direct consequence of human actions. Scientific consensus now unequivocally confirms that human-induced emissions of carbon dioxide (CO_2) and other GHGs have significantly altered the atmosphere, leading to a rise in global temperatures. At the core of the climate change problem lies the issue of equity. Not all individuals or nations have contributed equally to environmental degradation, nor do all segments of society engage in unsustainable practices. Crucially, those least responsible for the problem often face the most severe consequences. Very few scientists would now question whether human-made carbon pollution released by burning fossil fuels has heated the planet 1.3 degrees Celsius (°C) since preindustrial times (Parsons, 2023, p. 201-202).

Despite this alarming reality, many nations continue to rely on fossil fuel-based economies, shaping policies that exacerbate the crisis. Moreover, a relatively small number of corporations bear a disproportionate share of responsibility. Just one hundred currently operating carbon producers have accounted for 71 percent of global industrial GHG emissions since 1988. This highlights the urgent need for systemic changes and corporate accountability to address the root causes of both climate change and air pollution (Grasso, 2022, p. 31). In 2015, leaders from 196 nations came together to address climate change by signing the Paris Agreement[1], a global treaty aimed at limiting global warming to well below 2°C, while pursuing efforts to limit warming to 1.5°C. This target is considered critical to avoiding the most severe consequences of climate change impacts (Gazmararian & Tingley 2023, p. 3). However, 2024 has been confirmed as the hottest year on record globally, and according to the EU's Copernicus Climate Change Service, global warming has

[1] Paris Agreement (adopted 12 December 2015, entered into force 4 November 2016), UN Doc FCCC/CP/2015/L.9/Rev.1.

exceeded 1.5° over an entire year for the first time in 2024.[2] The Intergovernmental Panel on Climate Change (IPCC)[3] projected that the 1.5°C threshold above pre-industrial temperature – an essential benchmark for protecting developing nations and small island nations – would be crossed permanently by the middle of the next decade (IPCC, 2022).

The burning of fossil fuels has triggered two interconnected crises: climate change and air pollution. What was once considered a set of localised problems has now escalated into a serious global problem for human health (Attfield, 2024, p. 42). The World Health Organisation (WHO)[4] identifies air pollution as the leading environmental risk to human health and one of the most preventable causes of death and disease worldwide (Okowa, 2021, p. p. 477). Since GHG emissions are often accompanied by other toxic air pollutants that harm public health and the local environment, efforts to combat air pollution and mitigate climate change are closely linked. Indeed, the United Nations Framework Convention on Climate Change (UNFCCC)[5] is fundamentally an attempt to regulate fossil fuel-related carbon pollution emissions (Harrington, 2021, p. 39). Increasing public awareness of air pollution's health impacts has also made air quality regulation a growing priority, particularly in Europe, where it has become a widely embraced cause (Fisher, Lange & Scotford, 2019, p. 561). The EU Emissions Trading Scheme, the world's first and largest international cap-and-trade program, exemplifies efforts to reduce GHG emissions (Perera, 2022, p. 119).

While discussions about fossil fuel combustion often focus on CO_2 and its role in climate change, the health impacts of co-emitted pollutants are frequently overlooked. In recent years, however, air pollution has been recognised as a public

[2] According to the EU's Copernicus Climate Change Service, the period from February 2023 to January 2024 reached 1.52°C of warming. This first year-long breach does not break that landmark Paris Agreement but at current rate of emissions, the Paris goal of limiting warming to 1.5°C as a long-term average - rather than a single year- could be crossed within the next decade.

[3] The IPCC (the world's leading authority on climate science) was established by the United Nations Environment Programme (UNEP), the World Meteorological Organisation (WMO), and the World Health Organisation in1988 to synthesize research on climate change. IPCC reports intended to provide policymakers with regular scientific assessments on climate change, its implications, and potential future risks, as well as to put forward adaptation and mitigation options.

[4] Constitution of the World Health Organisation, adopted on 22 July 1946 (entered into force on 7 April 1948), in 14 UNTS 185. The WHO was established by an international conference convened in New York in 1946 at the request of the UN Economic and Social Council.

[5] United Nations Framework Convention on Climate Change (UNFCCC) (adopted 9 May 1992, entered into force 21 March 1994) 1771 UNTS 107.

health emergency in its own right. Understanding the substantial health burden of air pollution has become a crucial driver for advancing climate change action. The impact of air pollution is comparable to that of climate change in terms of human casualties. Emissions from vehicles and domestic and industrial fires are significant contributors to both crises. These dual threats are interconnected, with overlapping causes, which weakens the argument of climate change denial, particularly the rejection of the causal link between human activity and climate change. The millions of deaths and illnesses caused by air pollution are clearly linked to a subset of factors that all scientists agree contribute to climate change. Therefore, the crises of climate change and air pollution can be seen as part of a single emergency, that will worsen rapidly without strong and coordinated action (Attfield, 2024, p. 46-47).

Furthermore, addressing air pollution and climate change together is both logical and necessary, as both crises are primarily driven by the burning of fossil fuels. Their combined effects amplify harm, particularly to children's health. Integrating these dual threats allows for the development of comprehensive and equitable policies that safeguard vulnerable populations today and in the future. Since 2009, the efforts to reduce GHG emissions have been framed in terms of their health co-benefits, particularly through the reduction of air pollution (Perera, 2022, p. 46-47). Whether framed as an air pollution or a climate mitigation policy, both target emissions from fossil fuel combustion, and their success is often measured by the avoided health impacts directly linked to reduced air pollution (Perera, 2022, p. 138). The fact remains that climate warming is an air pollution problem with a classic profile. To substances that occur naturally in our environment and are beneficial to life on the planet in their natural concentrations. Human activity has added an excessive amount of the same substances, resulting in disruptive concentrations (Billiet, 2024, p. 100).

A study published in the *British Medical Journal* links air pollution from fossil fuel use in industry, power generation, and transportation to 5.1 million additional deaths annually worldwide. This accounts for 61 percent of the estimated 8.3 million global deaths caused by ambient (outdoor) air pollution from all sources in 2019 (Lelieveld, et al., 2023).[6] Similarly, the 2024 *State of Global Air Report*, released by the Health

[6] In 2022, an update report on the 2017 publication of the *Lancet* Commission on Pollution and Health found that pollution was responsible for approximately 9 million premature deaths per year, corresponding to 1 in 6 deaths

Effects Institute, highlights the devastating impact of air pollution on children, reporting that nearly 2,000 children under five die each day due to air pollution (Harvey, 2024). Further research has uncovered alarming evidence that air pollution's health effects begin before conception. Studies indicate that pollution can disrupt the development of eggs, lowering their quality and affecting reproductive health – an impact previously unreported (Devlin, 2024). Successive reports of the IPCC emphasize that transitioning from fossil fuels to clean, renewable energy sources over the coming decades could significantly reduce deaths from air pollution. Additionally, such a transition would help limit the global mean temperature increases to below 2°C, aligning with the goals of the Paris Agreement. Environmental factors, including inadequate access to clean water, poor sanitation, exposure to disease-carrying insects and air pollution, contribute to nearly one-quarter of the total global disease burden. Among children under fourteen, as much as one-third of the disease burden is believed to be attributable to modifiable environmental conditions such as lack of adequate water for drinking and sanitation, exposure to disease-carrying insects and air pollution (Wiley, 2022, p. 160).

Health has long been considered as both a fundamental human need and a basic human right. In 1948, the Universal Declaration of Human Rights (hereinafter: UDHR)[7] explicitly recognised health as a human right and a necessity. Specifically, Art. 25 of the UDHR highlights the rights of children, stating that everyone, including children, has "the right to a standard of living adequate for the health and well-being of ourselves and our families, including food, housing and healthcare and necessary social services" while also granting children the right to special care, assistance, and social protection. In 1959, the UN adopted the Declaration of the Rights of the Child, which laid the foundation for the 1989 United Nations Convention on the Rights of the Child (hereinafter: CRC).[8] Furthermore, when the WHO was established in 1948, its constitution declared that the highest attainable standard of health is a fundamental human right "without distinction of race, religion, political belief, economic or social condition" (Sachs, 2015, p. 275). In 2022, the United Nations General Assembly (hereinafter: UNGA), overwhelmingly passed

worldwide. The 2022 Lancet study found that air pollution causes 6.5 million deaths each year globally, and this figure is increasing.

[7] Universal Declaration of Human Rights (UDHR) (adopted 10 December 1948) United Nations General Assembly Resolution 271 A (III).

[8] Convention on the Rights of the Child (adopted 20 November 1989, entered into force 2 September 1990) 1577 UNTS 3.

a resolution recognising an international human right to a clean, healthy, and sustainable environment, with a vote of 161-0. A healthy and functioning environment is essential for the wellbeing of individuals, families, and communities (Sritharan, 2023, p. 149).

We are facing a public health crisis: the profound impact of fossil fuel pollution on human health, with a particularly severe impact on all children and their future. Air pollution and climate change affect people in every country in the world, leading to millions of deaths yearly. However, low- and middle-income countries, along with disadvantaged populations, bear the greatest burden. While all children are at risk, those in poor, developing nations, as well as socially disadvantaged children in wealthier countries, are the most vulnerable (Perera, 2022, p. 10, 80). The developing fetus and children under five are especially susceptible to the harmful effects of air pollution from fossil fuel combustion. Their heightened vulnerability is due to their rapid growth, developing brain, and immature respiratory, detoxification, immune, and thermoregulatory systems, making them more biologically and neurologically at risk than adults (Vohra, et al., 2021).

Protecting the right to health and well-being is a key objective of the United Nation's Sustainable Development Goals (hereinafter: SDGs)[9] for 2030 (Gerards, 2023, p. 504). Good health is fundamental to sustainable development, as it underpins overall well-being and is crucial for achieving many other aspirations. It enables children not only survive the disease but to thrive, learn, and successfully progress through school and into adulthood, ultimately contributing to the work force. SDG 3 aims to ensure healthy lives for all. By 2030, countries aim to reduce under-5 mortality rates to below 25 per 1,000 live births and maternal mortality to below 70 per 100,000 live births. Meanwhile, SDG 13 calls for urgent action to combat climate change and its impacts (Sachs, 2015, p. 275, 486-489). Improving air quality plays a significant role in achieving several of the UN's SDGs, as air pollution is recognised as a critical sustainability issue. It is directly addressed in two SDG targets: SDG 3.9 (which aims for a substantial reduction in health impacts from hazardous substances) and SDG 11.6 (focused on reducing the adverse impacts of cities on people) (Lelieveld, et al., 2023).

[9] Resolution adopted by the UN General Assembly on September 2015, *Transforming Our World: The 2030 Agenda for Sustainable Development* (UNGA/RES/70/1). The SDGs are non-binding and do not specifically address human rights, but they can play a role in interpreting fundamental rights norms.

The idea of climate justice highlights the difference in vulnerability faced by the highest and lowest emitters. This inequality in generation and impacts of carbon emissions is vitally important to understanding how and why climate change manifests (Parsons, 2023, p. 4). The world's most vulnerable people are not well protected from climate-caused disasters by climate policy. They have benefited the least from the advances of industrial society enjoyed by the world's wealthy. They are also those who have suffered the most from fossil fuel extraction, which continues to displace them as it poisons and destroys their land. The vulnerability of those populations is not simply a coincidence. Just as carbon emissions are not acts of God, neither is exposure to the results of those emissions. Both are rooted in the current unsustainable, fossil fuel-dependent global economy that relentlessly extracts and consumes the Earth's resources in increasing amounts (Sritharan, 2023, pp. 147-188).

In the next section, this article begins by examining the unique vulnerability of the developing child, and the multiple and combined effects of air pollution and climate change on the health of children. It looks at the many health and developmental impacts now being inflicted on children, harm beginning even before they are born, by the toxic air pollutants and climate-altering gases released by the production and combustion of fossil fuel. Sections 3 and 4 assess the impacts of air pollution and climate change on children's health. They focus on the extraordinary versatility of fossil fuel-generated air pollutants and climate-related disasters in harming the health of children. Section 5 discusses the many factors contributing to the differential vulnerability of children. Awareness of the harm caused by fossil fuel-generated toxic air pollutants and climate change to children's health has been growing. Finally, Section 6 outlines the soft law instruments and multilateral conventions addressing transboundary air pollution and climate change, while also examining the impact of human rights frameworks and the legal concept of sustainable development.

2 The Vulnerability of the Developing Child to Environmental Insults

One of the greatest miracles of biological engineering in humans is the prenatal development of the brain. Extensive research reveals the diverse ways in which environmental exposures and toxins linked to air pollution and climate change can harm children's brains and bodies during critical stages of development, resulting in disease and impairment. Laboratory and epidemiological studies have suggested how

environmental toxicants and stress can derail development. The carefully arranged processes associated with early development are highly vulnerable to adverse environmental conditions and physical toxicants, nutritional deprivation, physical and psychological trauma and stress (Dresser & Balsari 2021, p. 497-520).

A large body of recent epidemiological studies have shown that pre- and post-natal exposures to harmful stimuli impair the developing brain and lungs and affect their functioning. The advent of new types of magnetic resonance imaging (hereinafter: MRI) has allowed neuroscientists to study the steps in human brain development. Christopher Smyser, a paediatric neurologist at Washington University in St. Louis, Missouri, used MRI scans of preterm infant's and children's brains to examine prenatal brain development. His research revealed that babies born as early as 26 weeks have immature versions of many functional brain networks found in adults (Konkel, 2018; Perera, 2022, p. 25).

Joan Stiles and Terry Jernigan at the University of California San Diego describe brain development as the product of a complex series of interactions between inherited, genetically intrinsic factors and environmental input. These interactions between genes and environment occur throughout brain development. During the fetal period, genetic factors play a dominant role; but across the fetal period and all the way to adulthood, factors in the external world increasingly influence the course of brain development (Stiles & Jernigan, 2010). Robert Wright, a paediatrician at Icahn School of Medicine at Mount Sinai in New York, highlights those toxic exposures, such as lead, can disrupt synaptic development pruning, hindering the proper development of brain signalling networks (Konkel, 2018).

At the end of nine months, the brain is a functioning organ; however, it is still a work in progress. Neurodevelopment continues all the way through adolescence. By age two, a toddler's cerebral cortex has over 100 trillion synapses. The remarkable speed of growth and elegant complexity of organ development during the fetal and postnatal periods place the young at significant risk of harm from pollutants, and things can go wrong. Neurodevelopmental disorders resulting from disruptions in early brain development include conditions such as autism spectrum disorders (hereinafter: ASD) and attention deficit hyperactivity disorder (hereinafter: ADHD) (Perera, 2022, p. 27 & 28; Mizuno, et al., 2019).

The brain is the only organ known to have its own security system. The barrier that protects the developing brain is known as the blood-brain barrier. While physiological defences like the placental and blood-brain barrier once protected the fetus, new toxicants from fossil fuel burning, such as polycyclic aromatic hydrocarbons (hereinafter: PAHs), fine particulate matter ($PM_{2.5}$), ground-level ozone, and mercury, can now bypass these barriers through diffusion or active transport. The blood-brain barrier evolved to operate as the brain's sentinel. However, research has shown that this protection is far from complete, with many new harmful chemicals quite easily breaching the barrier. These toxic invaders show great versatility in derailing normal neurodevelopmental programs (Perera, 2022, p. 33). The greater the lipid solubility of a toxic chemical, the greater the placental transfer. Research from the United States and other countries has increasingly shown that the placenta is permeable to environmental chemicals and toxicants, with evidence of their presence in cord blood, fetal tissue, and the placenta (Grandjean, 2013).

The young are particularly vulnerable to air pollution and the effects of climate change due to the underdevelopment of their biological defence systems, including enzyme systems responsible for metabolising toxic pollutants. Immune defences are also limited in the young. The fetal immune system itself develops along two lines: the first line of defence is "innate immunity", and the second line of defence is "acquired immunity". At birth, the innate immune system is weak, making newborns more vulnerable to infections. The acquired immune system is also immature in both fetuses and newborns. However, immune protection strengthens over time, leading to fewer infections in young adults. Besides their toxicity to the developing brain and their interference with the function of natural hormones, toxicants like PAHs, lead, and mercury are harmful to the immune system, so the infant will have even less ability to mount a defence against viruses and other infectious agents (Simon, Hollandar & McMichael, 2015).

Environmental toxicants and stress can interfere with the immune system to produce inflammation. Chronic stress during early development is linked to immune system malfunction, resulting in an excess production of inflammatory proteins, with potentially serious lifelong consequences in terms of chronic disease. Exposure to air pollution can trigger an inflammatory response, and when combined with

other exposures, it increases the risk of developing asthma. Mercury also stimulates the immune system to release inflammatory proteins (Olvera Alvarez, et al., 2018).

Children tend to be more physically active than adults. The higher breathing rate of young children results in a greater intake of any pollutants present in the air. Therefore, environmental toxicants present in the air, such as air pollutants, molds and pollen, are directly delivered to children at higher doses than adults. Their disproportionate exposures, plus the increased concentrations of these toxicants due to climate change, are clearly factors in the high incidence of childhood asthma and hospitalisations due to asthma (Perera, 2022, pp. 36-37).

Toxic exposures, such as air pollution, mercury, and stress, can also overwhelm the body's detoxification and repair systems, leading to damage to DNA, proteins, and other cell components. This is known as "oxidative damage," which happens when reactive oxygen forms are generated due to exposure to harmful stimuli. This can potentially cause gene mutations or altered gene expression through DNA methylation changes. Exposure to air pollution, malnutrition, and stress during early life can cause epigenetic changes that may be inherited, leading to lasting health impacts across future generations. Environmental pollutants, and stress-related hormones like cortisol generated by maternal stress (due to adverse social and environmental factors), can cause prenatal DNA damage that may lead to an alteration in the DNA sequence of a gene (a gene mutation). Consequently, the resultant proteins may be non-functional or abnormal, with potentially dire consequences for health and brain development (Perera, 2022, p. 33, 37).

When DNA damage from chemicals is detected, the DNA repair enzymes are called in. DNA repair enzymes generally work well in adults, but their efficiency is limited in fetuses and children (Perera, 2022, p. 33, 37). Toxic exposures can also disrupt protein production by switching certain genes on or off at the wrong moment in early development but without altering the DNA sequence of a gene. The result is the same as that of a gene mutation, and it may have grave consequences for the developing fetus and child. DNA methylation is the most extensively studied part of epigenetic damage. Numerous studies, including those involving newborns, have found that environmental exposures such as air pollutants (PAHs, particulate matter, ozone, and mercury) and stress can alter normal epigenetic programming, potentially impacting the child's health (Perera & Herbstman, 2011).

Extreme heat puts toddlers and young children at risk of hyperthermia. An early stage of hyperthermia can be "heat stress" or "heat exhaustion," and if the condition turns into "heatstroke", it needs to be treated as an emergency. If untreated, heatstroke can be fatal. Infants and children are less capable than adults of regulating body temperature during prolonged heat, and their greater time spent outdoors, and vigorous activity levels increase their exposure extreme heat. Also, children cannot recognise the early signs of distress and rely on adults for hydration. More heat-related deaths among infants are reported during heatwaves. For these reasons, children under the age of four face a significantly higher risk of illness and death caused by heat (Dresser & Balsari, 2021, pp. 511-512).

Climate-related droughts and crop failure particularly affect the young by depriving them of the macro- and micro-nutrients. Water is also considered an essential nutrient. Climate disasters that affect nutrition can therefore have devastating effects on infants and children. Newborn infants have low stores of fat and protein and can only cope with starvation for short periods of time. Throughout infancy and childhood, nutritional requirements are higher per kilogram of body weight than at other developmental stages. Because of their particularly rapid growth, infants have the greatest nutritional demand. Nutritional deficiencies during pregnancy, infancy, and early childhood can significantly affect the developing brain. From conception to 3 years of age, the rapidly growing brain requires more nutrients than at other stages of development. During this period, essential nutrients for brain development include protein, certain fats, iron, zinc, copper, iodine, selenium, choline, and vitamins A and B. Although malnutrition is linked to stunting of the body, stunting of the brain is the more serious outcome, affecting health and function over the child's life (Spencer, Chandra & Arthur, 2021, pp. 424-432).

The logic behind focusing on environmental exposures is that, unlike genes, once they are identified as harmful these exposures can be averted. Many studies have shown that the special susceptibility of the fetus, infant, and child arises from a host of biological and behavioural factors all occurring at the same time. These factors include rapid growth, complex developmental programming, immaturity of detoxification and immune defence systems, limited ability to regulate body temperature during periods of severe heat, greater nutritional needs, and dependence on adult caretakers. The combination of susceptibility factors such as toxic exposures, air pollution, heat, malnutrition, viral infection, and stress – often linked

to fossil fuel burning and climate change – greatly increases the risks to the developing fetus and child, amplifying the potential harm.

3 The Impacts of Air Pollution on Children's Health

3.1 Mortality, Preterm Birth, Low Birth Weight

According to the WHO, air pollution is linked to around seven million premature deaths annually. These deaths are attributed to diseases such as ischemic heart disease, stroke, chronic obstructive pulmonary disease, lung cancer, and acute respiratory infections like pneumonia which disproportionately impact children in low- and middle-income countries (WHO/Newsroom, 2023). In 2019, air pollution was associated with nearly 500,000 newborn deaths within their first month of life.[10] Furthermore, in 2020, according to the WHO, household air pollution alone was linked to an estimated 3.2 million deaths, including over 237,000 deaths among children under the age of five.[11]

With the global rise in outdoor air pollution levels, mortality rates among children under the age of five are projected to exceed current figures. The many health and developmental impacts now being inflicted on children are often initiated in utero. Newborns, who are already susceptible to infection because of their immature immune systems, are vulnerable to a second hit from air pollution. By weakening the lung's immune response to respiratory infection and then causing further inflammation, air pollution causes a more severe course of illness. The grim prediction is that, at the present rate of emissions, by 2050, outdoor air pollution will become the leading cause of child death (Perera, 2022, p. 49-50).

[10] In 2012, air pollution was linked with 1 out of every 8 deaths, globally: Around 600,000 of those were children under 5 years old, see: UNICEF. (2016, October). *Clear the air for children*. Retrieved December 20, 2023, from Clear_the_Air_for_Children_Executive_summary_ENG.pdf (unicef.org). in 2019, Air pollution now accounts for 1 in 9 deaths globally. It is estimated to have contributed to 6.67 million deaths worldwide. According to the State of the Global Air report, it is estimated that in 2019, 476,000 infants died in their first month of life from health effects associated with air pollution exposure, see: The State of Global Air. (2023, November). *Global Health Impacts of Air Pollution*. Retrieved December 20, 2023, from https://www.stateofglobalair.org/health/global#Millions-deaths; In 2021, 572,000 infants died in their first month of life from health effects associated with air pollution exposure, see: The State of Global Air. *Impacts on Newborns*. Retrieved from: https://www.stateofglobalair.org/hap/newborns#fragile-stage (20 December 2023).

[11] According to the WHO's News, the combined effects of ambient air pollution and household air pollution are associated with 6.7 million premature deaths annually, see: WHO News. (15 December 2023). *Household air pollution*. Retrieved December 20, 2023, from Household air pollution (who.int).

Each year, an estimated 15 million babies are born preterm worldwide, a figure that continues to grow. Preterm birth, defined as delivery before 37 completed weeks of gestation, is the leading cause of death among children under five, with over one million preterm infants dying shortly after birth. Additionally, many preterm babies experience lifelong disabilities, often resulting in significant financial and social impacts (UNICEF, 2021). Air pollution has also been linked to another critical birth outcome: low birth weight. Globally, around 20 million low-birth-weight babies are born annually. According to the WHO, low birth weight is defined as less than 2,500 grams, regardless of gestational age (Devaguru, et al., 2023).

Considerable research has documented that both exposure to air pollution and heat have a hand in preterm birth and low birth weight. Globally, 2 million premature births in 2019 were attributed to ambient exposure to mostly $PM_{2.5}$ but not all in developing countries.[12] A comprehensive review of 48 studies comprising 32 million births in the United States concluded that there was overwhelming evidence that exposure to $PM_{2.5}$ is associated with increased risk of both preterm birth and low birth weight (Bekkar, Pacheco, Basu, & DeNicola, 2020). Disorders due to preterm birth and low birth weight are not only the leading causes of infant mortality but also contribute to lifelong consequences of being born too soon and too small. Preterm babies are at higher risk for increased respiratory infections, other infectious diseases, asthma in childhood, and long-term intellectual disabilities, IQ loss, ADHD, autism, anxiety, and depression – often extending into adulthood (Jonhson & Marlow, 2011).

3.2 Neurodevelopmental Disorders

Neurodevelopmental disorders are seen in a large and growing number of children globally. Multiple studies have linked fossil fuel-generated air pollution to neurodevelopmental disorders in children and adolescents. The developing brain of fetuses, infants, and young children is particularly vulnerable, and research over the past two decades has strongly established that exposure to combustion-related air

[12] In 2019, neonatal disorders caused 2.42 million deaths, with nearly one-fifth linked to $PM_{2.5}$ air pollution, see: Environment.ec.europa.eu. (2023, August 10). *Air pollution to blame for one-fifth of the global burden of newborn health disorders.* Retrieved from: https://environment.ec.europa.eu/news/air-pollution-blame-one-fifth-global-burden-newborn-health-disorders-2023-08-10 (20 December 2023).

pollutants during early life, even before birth, negatively impacts cognitive and behavioural development (Perera, 2022, p. 52).

3.2.1 Cognitive Abilities

The term "cognition" encompasses many aspects of intellectual functioning and processes, such as perception, memory, judgment, and reasoning. Several cohort studies conducted across the US, Europe, and Asia have investigated the links between early-life exposure to $PM_{2.5}$ or traffic-related air pollutants and cognitive development in infancy and childhood. The researchers have accounted for factors like income, age, race, ethnicity, and education. Research on $PM_{2.5}$ exposure has produced mixed findings, with some studies linking it to lower IQ. Conversely, studies on traffic-related pollution have more consistently shown links to diminished mental development in young children, including impaired memory and lower IQ scores (Chiu, et al., 2016). Frederica Perera and her team at Columbia University have extensively studied the impact of PAHs on cognitive development in populations living in New York City (hereinafter: NYC), Krakow, Poland, and Chongqing, China, for many years. Their research has also found consistent associations between prenatal PAH exposures and cognitive problems across these different populations (Perera, 2022, pp. 52-53).

3.2.2 Attention Deficit Hyperactivity Disorder (ADHD)

Exposure to combustion-related air pollutants has been linked with attention difficulties and ADHD in children. The previously mentioned NYC study found that prenatal exposure to PAHs was linked to symptoms of inattention and ADHD in children aged 6 to 9. The findings also highlighted those socioeconomic challenges amply the impact of pollution. Children with high prenatal PAH exposure exhibited more pronounced symptoms of ADHD compared to those with lower exposure, with the most differences observed among children whose mothers faced material hardship during pregnancy and their early childhood (Perera, et al., 2012).

3.2.3 Autism Spectrum Disorders (ASD)

Studies in the US and other countries have reported associations between prenatal exposure to $PM_{2.5}$ or traffic-related air pollutants and autistic traits, indicating that these exposures are likely to be causally related to the condition. Studies conducted in Israel, Denmark, and the US, also found postnatal exposure to air pollution has been implicated as a contributor. In the NYC study mentioned above, testing of the children at age 11 found a link between prenatal PAH exposure and deficits in social communication (an autistic trait), as well as reductions in children's capacity to regulate their emotions (Perera, 2022, pp. 52-54).

3.2.4 Mental Health Disorders

Mental health disorders are afflicting a record number of children and adolescents, at a 15 percent prevalence globally.[13] Researchers have recently begun to focus on the role of air pollution in the mental health of children and adolescents. A cohort study in London found that children exposed to higher levels of outdoor air pollution had an increased likelihood of major depressive disorder by age 8 (Fisher, et al., 2018). Similarly, a US cohort in Cincinnati, Ohio, found that exposure to traffic-related air pollutants correlated with higher rates of self-reported depression and anxiety symptoms by age 12 (Yolton, et al., 2019). In the NYC study, greater prenatal PAH exposure was linked to more anxiety and depression symptoms in children (Phillips, et al., 2011). A related study in Poland observed that prenatal PAH exposure, combined with maternal psychological distress, significantly raised the risk of anxiety and depression symptoms in children (Wang, et al., 2013).

3.2.5 Brain Changes

Researchers using MRI brain imaging to study the impact of prenatal or postnatal exposure to air pollutants on brain development, have shown that exposure to PAHs or $PM_{2.5}$ prenatally and in childhood can change the architecture of the brain. In some cases, the observed changes were linked to worse neurodevelopmental

[13] An estimated 15 percent of 10-19-year-olds worldwide experience mental health conditions, with depression, anxiety, and behavioral disorders as leading causes of illness and disability. Adolescents with mental health conditions face heightened risks of social exclusion, stigma, discrimination, educational challenges, poor health and human rights violations, see: WHO News, (2021, November 17). *Mental health of adolescents*. Retrieved from: Mental health of adolescents (who.int) (21 December 2023).

outcomes (Perera, 2022, p. 55). The NYC study in a sample of 7- to 9-year-old children showed significant correlations between their prenatal PAH exposure and decreased "white matter" of the brain that, in turn, correlated with various cognitive and behavioural problems in the children. A large cohort study in Barcelona, Spain, revealed that prenatal exposure to $PM_{2.5}$ during fetal life was linked to a thinner cortex in multiple brain regions when the children were imaged at ages 6 to10. These structural changes helped explain the connection between prenatal exposure to $PM_{2.5}$ and impaired ability to inhibit inappropriate impulses. Another study in Barcelona found that prenatal $PM_{2.5}$ exposure was associated with a decrease in the volume of a key connective structure in the brains of children who were imaged at 8-12 years: this specific structural change was linked with a higher hyperactivity score in the same children (Peterson, et al., 2015; Guxens, et al., 2018; Herting, et al., 2022; Bansal, et al., 2022)

3.2.6 Long-term Effects of Air Pollution on the Brain

At least a third of children with ADHD and half of those with autism continue to have poor outcomes as adults. Some of these early neurodevelopmental disorders can diminish or weaken as children pass through adolescence and into adulthood but the effects of toxic exposures on children's cognitive and behavioural functioning often persist into adulthood (Perera, 2022, p. 56). MRI-based research and epidemiology is now revealing that long-term exposure to airborne pollutant during early childhood years may set the stage for neurodegenerative diseases to develop, manifesting themselves in older age. Studies conducted on children residing in high air pollution areas in Mexico City have found distinct brain alterations like those seen in adults with Alzheimer's disease and mood disorders. Additionally, large-scale epidemiological research indicates that previous exposure to air pollution raises the likelihood of developing dementia, Alzheimer's and Parkinson's disease in older adults (Calderon-Garciduenas, et al., 2018).

Cumulatively, this evidence supports the conclusion that air pollution contributes to adverse neurodevelopmental outcomes, including when exposure occurs during the prenatal period, and it is clearly detrimental to children's cognitive and behavioural development and mental health, often with lifelong consequences for their ability to learn, earn, and contribute to society.

3.3 Asthma and Other Respiratory Conditions

The lung also shows remarkable speed of growth and complexity during prenatal and postnatal periods. Like the brain, the lung is not a finished organ at birth; it continues to develop after birth. At birth, the newborn requires a fully functional lung that can take in oxygen and remove CO_2 from the blood. The respiratory tract is highly vulnerable to toxic air pollutants in the first days, months, and years of life. Asthma is just one of the many health issues caused by pollution in children. A study published in *Lancet Planetary Health* revealed that traffic-related air pollution leads to the development of asthma in four million children each year. This study provides the first global analysis of the link between exposure to traffic-related air pollution and the onset of asthma in children (Anenberg, Achakulwisut, Brauer, & Hystad, 2019).

We now know that air pollution is not only able to trigger asthma attacks in children who have the disease but that it also can act to initiate the disease. Asthma often develops during childhood, though it can occur at any age. In cases of childhood asthma, the lungs and airways become highly sensitive and inflamed in response to triggers such as air pollutants, pollen, or a respiratory infection. If left untreated, asthma in children can lead to severe and potentially life-threatening attacks. Globally, the ratio of childhood asthma is high, about 13 percent, and the rate has increased significantly in recent decades. Particulate matter has been established as a trigger of severe symptoms and asthma attacks in children who have the disease, causing visits to emergency departments and hospitalisation. Nitrogen dioxide and ozone, environmental tobacco smoke, and pollen are known triggers as well. In 2019, approximately 1.85 million new cases of paediatric asthma worldwide were linked to nitrogen dioxide exposure (Milken Institute School of Public Health, 2022).

Other respiratory outcomes of serious concern associated with air pollution are impaired lung function and abnormal patterns of lung function growth. Multiple studies have linked exposure to air pollutants in childhood to both outcomes. A study conducted on nearly 2,000 school children in Southern California showed a significant decrease in lung function growth by age 18 among those exposed to higher levels of air pollution (Avol, Gauderman, Tan, London, & Peters, 2001). Acute respiratory infections are another consequence of air pollution exposure. Research involving over 140,000 children in Utah, primarily under the age of two,

revealed a link between short-term increase in $PM_{2.5}$ levels and the onset of acute lower respiratory infections in these children (Horne, et al., 2018). As with neurodevelopmental outcomes related to air pollution, these respiratory conditions frequently persist over the lifetime. Data from a study in Melbourne, Australia, showed that half of individuals who had had persistent asthma in childhood and 82 percent of those who had been classified as having had severe childhood asthma still had asthma symptoms at age 50 (Tai, et al., 2014).

3.4 Immune Effects

The immune system, which starts developing during the fetal stage and remains immature for years after birth, can be adversely affected by air pollution. For example, respiratory infections due to air pollution exposure can cause direct harm to the developing lung, and exposure to air pollutants can suppress the immune system's ability to guard against bacterial and viral infections like respiratory syncytial virus (RSV) and pneumonia. Usually, RSV causes mild, cold-like illnesses, but it can also cause severe illnesses such as bronchiolitis and pneumonia. Premature infants are at greater risk (Centers for Disease Control and Prevention, 2024). Stanford researchers found that children exposed to elevated levels of particulate matter and PAHs, experienced more severe symptoms compared to those living in areas with lower exposure levels. The researchers also collected blood samples from the children and measured the level of key immune cells – the T-regulatory (T-reg) cells – a subpopulation of white cells whose job is to suppress the harmful inflammatory responses that are the hallmark of asthma and other allergic diseases. They discovered that the children exposed to higher levels of air pollutants had reduced levels of T-reg cell function (Nadeau, et al., 2010).

4 The Impacts of Climate Change on Children's Health

The effects of climate change on infants and children are already severe and continue to worsen each year. Young children are particularly susceptible to both the direct and indirect impacts of climate change. Recent reports indicate that nearly every child worldwide is exposed to at least one climate-related hazard, shock, or stress, with one billion children residing in countries at extremely high risk from its effects (UNICEF, 2021). Children in low- and middle-income countries face the greatest burden of climate-sensitive diseases due to limited adaptation capacity. However,

climate change impacts are also growing in the US and Europe, particularly among low-income populations and communities of colour. In 2015, the UN International Children's Emergency Fund (UNICEF) emphasized that "there may be no greater, growing threat facing the world's children – and their children – than climate change" (UNICEF, 2015).

4.1 Floods and Severe Storms

Scientists overwhelmingly agree that human-induced global warming is intensifying and increasing the frequency of storms and major floods, even though no single event can be directly attributed directly to climate change. Of all the climate-induced severe weather disasters, floods are the most common, and the greatest damage to life and property is from secondary connected events such as storm surges, landslides, coastal and inland flooding, and tornados. Major floods and hurricanes, intensified by climate change, have led to drowning, physical injuries, and traumatic stress among children. By 2015, over half a billion children were living in regions with extremely high levels of flood risks (UNICEF, 2015).

Flood disasters, with drowning accounting for 75 percent of deaths, primarily affect children. The greatest risks are in low- and middle-income countries where people live in flood-prone areas and lack developed systems for warning, evacuation, and protection (WHO, 2024). Children worldwide feel the impacts of weather-related events, exacerbated by climate change. For example, Hurricane Katrina in 2005 killed over 1,800 people and left 370,000 children without schools, while Hurricane Sandy in 2012 caused severe damage in New Jersey and New York, closing schools for over 20,000 students. In 2017, Hurricane Harvey caused the deaths of 107 people in Texas, and affected up to 3 million children and their families. Hurricane Ida caused widespread flooding and dozens of deaths from drowning (Perera, 2022, p. 62).

Children are highly vulnerable to trauma and stress from extreme weather events, which can lead to mental health problems. Each year, around 100 million youths are exposed to disasters, with up to 72 percent showing posttraumatic stress symptoms within the first three months. Posttraumatic stress symptoms in children are linked to poorer mental and physical health, decreased academic performance, and future employment challenges. For example, children directly affected by Hurricane

Katrina later struggled with concentration in school, exhibited more behavioural problems, experienced greater anxiety, and faced persistent mental health issues (Lai, et al., 2021).

4.2 Heat

Climate change has intensified heatwaves, making them both hotter and longer across the US, Europe, and Asia. A recent analysis warns that, without rapid global action to reduce emissions, children born in 2020 will face up to seven times more extreme weather events than those born in the 1960s (Dunning, 2021). As the planet has become warmer, the incidence of heat-related illness in children is increasing. Almost half of heat-related illnesses are in infants and children. Pregnant women, fetuses, and young children are highly vulnerable to heat, which can lead to adverse birth outcomes through dehydration and impair fetal growth. Studies have shown that maternal exposure to heat is linked to increased risk of preterm birth and low birth weight. Additionally, heatwaves and $PM_{2.5}$ may combine to elevate the likelihood of preterm birth (Chersich, et al., 2020).

Direct effects of heatwaves are infant deaths, hyperthermia, heat stress, kidney disease, and impacts on mental health of children. Infant deaths have been increased during heat waves in Europe, China, Australia, and many other countries. Warmer temperatures act in other insidious ways to adversely affect children's health: they increase exposures to toxic air pollutants, chemicals, and infectious agents. Higher temperatures in dry areas can cause toxic chemicals and pesticides to become airborne, posing a particular risk to children's developing nervous systems. Higher temperatures cause migration of some pests and insects to more northern, cooler regions, resulting in more infectious disease (Sheffield & Landrigan, 2010).

4.3 Forest Fires and Smoke

Higher temperatures have increased the frequency of extreme forest fires which in turn have negatively impacted children's health. Climate change has led to increased $PM_{2.5}$ concentrations in some areas due to changes in temperature, precipitation, and air stagnation. It is not just children living close to the forest fires who suffer. Millions of children far from forest fires are also exposed to wildfire smoke, as pollutants can travel thousands of miles from their source.

The frequency and intensity of uncontrolled fires around the world are increasing each year. Forest fires inject vast quantities of particulate matter, PAHs, black carbon, hydrocarbons, and volatile organic chemicals into the atmosphere in the form of aerosols and gases, adding to and potentially interacting with the ambient load from fossil fuel burning. Because children inhale more air per unit of body weight compared to adults and their nasal passages are less effective at trapping particles, a higher proportion of particles reaches their lower lungs. Wildfire smoke contains higher levels of $PM2_{2.5}$, PAHs, volatile organic chemicals, and other ozone precursors, which means more potential to create harmful oxidative stress and inflammation in developing brains and lungs (Perera, 2022, p. 65).

Exposure to wildfire smoke during pregnancy is linked to lower birth weight and preterm birth in infants. Respiratory illnesses, including wheezing, pneumonia, and bronchitis, are increased by wildfires. Exposure of young lungs to intense episodes of wildfire pollution may trigger the development of asthma. Wildfire disasters can cause serious mental health effects in children. The combination of wildfire smoke exposure and the trauma of evacuation significantly impacts children's mental health. Research on youth from California and Australia have shown increased stress levels and prevalent posttraumatic stress disorder (PTSD) symptoms after experiencing fires (Abdo, et al., 2019).

4.4 Drought and Malnutrition

Droughts have become more frequent, prolonged, and intense in recent decades, a trend that is expected to intensify in many regions due to climate change. The result has been crop failure, livestock deaths, and food insecurity, affecting children in poor countries. Although drought is the most prominent and recognisable cause of malnutrition in children, other impacts of climate change - higher temperatures, water scarcity, floods, and changing patterns of agricultural pests and diseases - have also increased food insecurity around the world. In many regions, including Africa, Central and South America, and parts of Asia, food prices are climbing rapidly, leading to increased hunger. The crisis is especially severe in conflict zones, where war intensifies food shortages, raises costs, and heightens malnutrition. In 2015, around 160 million children lived in areas of extreme drought severity (UNICEF, 2019). Globally, the number of people affected by droughts is expected to grow by 9–17 percent in 2030 and up to 50–90 percent in 2080 (Andersson, et al., 2020).

As drought linked to climate change reduced food harvests, with such massive food insecurity has come a sharp increase in malnutrition in children. The greater nutritional needs of infants and children place them at the greatest risk of famine. Malnutrition leads to stunted growth and development, causing cognitive and behavioural issues. The result is that children are less able to learn. In 2020, 149 million children under five were stunted globally, with 14 million experiencing acute malnutrition. Malnutrition increases children's susceptibility to infection and infection contributes to malnutrition, setting up a vicious cycle (Perera, 2022, p. 66).

4.5 Infectious Diseases

Climate change is significantly increasing the risk of infectious disease in children worldwide. Variations in temperature, precipitation, and humidity influence disease transmission and rising temperatures are expanding the habitats of diseases like malaria and dengue and leading to the spread of infectious diseases. Diseases such as malaria, dengue fever, Zika, and Lyme disease disproportionately affect children due to their developing immune systems. The IPCC confidently warns that climate change amplifies global health threats, as the life cycles of many infectious diseases are inextricably linked to climate conditions (Van de Vuurst & Escobar, 2023).

Climate change is not the only factor causing these dramatic shifts in the pattern of infectious agents; it plays an important role. The toll on children's health from these infectious agents is huge and growing. For example, the geographic range of *Anopheles* mosquitoes that carry malaria has expanded in response to climate change. Malaria remains a major cause of illness and death among children in the world's most resource-limited regions, with those under five being particularly vulnerable. In 2018, an estimated 270,000 children under the age of five died from malaria globally (Donovan, et al., 2021). In 2022, the global malaria death toll reached an estimated 608,000, with the WHO African Region bearing the brunt, accounting for 95 percent (580,000) of these deaths. Children under five comprised about 80 percent of all malaria-related fatalities in the Region (World Health Organisation, 2023).

Dengue is the most important mosquito-borne viral disease globally - in this case, it is the *Aedes* mosquito that is the carrier. As global temperatures rise, mosquito-borne diseases are spreading to regions where they were previously uncommon, with

dengue cases recently being reported in parts of Europe and North America (Colon-Gonzalez, 2022, p. 143). Dengue primarily affects children under 15 years old, with the *Aedes* mosquito being the main vector. This mosquito also transmits the Zika virus, which poses a unique threat to developing fetuses, passing from a pregnant woman to her baby and evading the fetal immune system to reach the fetal brain, causing microcephaly, severe brain malformation, and other birth defects. The pattern of Lyme disease has also changed. Most children with Lyme disease recover fully if treated early, but some may develop post-infectious syndrome, experiencing symptoms such as fatigue, joint pain, headaches, sleep difficulties and trouble concentrating. Additionally, children are also more prone than adults to cholera and other diarrhoeal diseases caused by crop and water contamination from storms and floods. Repeated diarrhoeal infections in childhood can affect children's education and cognitive development (Perera, 2022, p. 68-69).

4.6 Allergy and Asthma

Due to climate change, children are experiencing more allergy and respiratory illness from increased pollen production from certain trees, grasses, and weeds at warmer temperatures. The increase in pollen levels is strongly coupled to observed warming and parallels the rise in pollen sensitisation in children. This trend also aligns with an increasing number of adolescents and adults with allergic asthma. Besides triggering symptoms of asthma, hay fever, and eczema in children with allergies, high-pollen periods are identified with greater susceptibility to respiratory illnesses by intensifying lung inflammation and weakening immune responses (Singh & Kumar, 2022).

Air pollutants like ozone, particulate matter, and sulfur dioxide can combine with pollen in many ways to exacerbate risk. Mold is another trigger of asthma attacks. Excess moisture from heavy rains and flooding due to tropical cyclones, hurricanes, and thunderstorms can lead to multiplication of mold in homes and other structures, thus leading to illness to those that inhabit them. Climate change, by raising temperatures, accelerates the formation of ground-level ozone, causing ozone levels to surge during heatwaves. This has led to higher ozone concentrations across vast areas of the US and Europe, particularly in the summer. This contributes to tens of millions of asthma-related emergency room visits by children annually. In addition

to being a short-term respiratory trigger, prolonged exposure to ozone is linked to reduced lung function and abnormal lung development in children.

4.7 Forced Migration and Displacement

Climate change affects mobility in various ways. It contributes to droughts, reduces the arability of land in large swathes of the world, raises sea levels that threaten coastal communities, and worsens natural disasters such as storms, floods, and wildfires. Climate change in combination with factors like armed conflict, political instability, overpopulation, poor resource management, and limited economic opportunities, can drive migration, particularly among poor and vulnerable populations. Additionally, it also affects the likelihood, frequency, and intensity of extreme climate-related events. These changes create stronger migration push factors (Arar & FitzGerald, 2022, p. 241).

The scale of these modifications is immense and is driving large-scale human displacement and forced migration, threatening people's habitats and livelihoods. Managing displacement caused by climate change could become the key environmental challenge of the 21st century. Every corner of the globe has the potential to be affected (Brock, 2021, p. 63). One certainty is that climate change disproportionately affects people in the Global South, who did much less to contribute to global warming via their consumption of fossil fuels than people in wealthy countries who, along with their ancestors, have been pumping GHGs into the air since the industrial revolution (Arar & FitzGerald 2022, p. 242).

A UNICEF report revealed that between 2016 and 2021, climate change-driven weather disasters displaced 43.1 million children across 44 countries. If current climate trends continue, over 100 million children and young people could be displaced by weather-related disasters in the next 30 years (UNICEF, 2023). Over 20 million people are displaced annually due to weather-related disasters. Projections for climate migrants by 2025 vary significantly, ranging from 25 million to 1 billion, with people relocating both domestically and internationally. Even the modest estimate of 200 million by 2050 is staggering (Perera 2022, p. 70, Arar & FitzGerald 2022, p. 242).

Children are most at risk from displacement physically and emotionally: they are prone to physical harm, chronic stress, and psychological trauma because of being forced to flee their homes. The mental health consequences include anxiety, depression, and posttraumatic stress. Children are also dependent on adult caregivers who themselves may be affected by injury or psychological trauma from forced migration. When families are displaced in developing countries, children are often separated from their parents, increasing their vulnerability to violence, exploitation, and abuse. Disasters and displacement have broken apart families and smashed social norms and supports, propelling an increase in violence against girls and women, rape, and sexual trafficking of children (Perera, 2022, p.71).

Migration driven by food shortages or extreme weather can spark conflicts. When these climate-related factors combine with social, economic, and political factors, they heighten the risk of wars and armed conflicts in vulnerable nations. The war in Syria and conflict in the Sahel region of Africa are examples of disasters attributable in part to climate change (McGuire, 2022, p. 113-116). In Syria, changing weather patterns caused a drought from 2006 to 2010, leading to massive food insecurity that helped fuel the Syrian war. Although not entirely caused by climate change, drought was a significant factor in fuelling this devasting war (Busby, 2022, p. 122).

4.8 Effects on Mental Health

Climate change is deeply connected to all aspects of human life, including food security, water access, economic stability and mental health. Its effects, along with air pollution, extend beyond immediate physical and developmental harm and contribute to rising mental health disorders among children and adolescents. Exposure to toxic air pollutants during pregnancy or childhood, as well as the broader impacts of climate change, can cause lifelong health issues. Research indicates that climate change will both initiate and intensify mental health challenges, disproportionately affecting young people and marginalised populations throughout their lives (Dober, 2024).

Common forms of mental health illness in children who have suffered many adverse childhood experiences include anxiety, depression, aggressive behaviour, PTSD, and substance use problems. Adverse experiences not only raise the risk for mental disorders in childhood but also confer a lasting vulnerability to anxiety, depression,

and mood disorders in adulthood. Almost one-third of all mental disorders worldwide have been attributed to exposure to adverse experiences in childhood (Scattolin & Resegue, 2022).

Even in the absence of direct exposure to the influence of climate change, stress due to the awareness of climate change and its impacts is having a significant effect of the mental health of children everywhere in the world. There is now a term, "climate change anxiety" for the conditions that many young people are experiencing. Many young people feel hopeless and incredibly frustrated when faced by the failure of governments to act, and determination of vested corporate interests to block the change. As children learn, either first-hand or through reports, of the climate threats to their very existence, this knowledge fosters a kind of PTSD. As with other climate disasters, the physical, emotional, and psychological scars left by wildfires can last a lifetime.

5 Disparities in Exposure to Air Pollution and Climate Change

Environmental challenges, such as air pollution and climate change, represent a form of slow violence, disproportionately impacting those in less wealthy nations of the global South. These problems do not discriminate based on status, ethnicity, or nationality, affecting people across socioeconomic, geographic, and racial or ethnic divides. However, the most immediate and severe consequences – whether from polluted air, rising sea levels, or failed crops – are felt most acutely by marginalised groups, especially those from lower socioeconomic backgrounds and communities often excluded on racial, ethnic, and religious grounds. While no one is entirely immune to these problems, children in low-income and communities of colour are particularly vulnerable (Darian-Smith, 2022, p. 2 and 97).

In recent years, the concept of environmental justice has gained traction among vulnerable communities in both rich and developing countries. This concept has become a unifying call for marginalised groups worldwide, who often bear an unequal share of the harm caused by environmental degradation. Studies highlight that poor and minority communities face greater risks from environmental hazards, such as polluted air and water, due to their proximity to high-polluting industries and waste sites. Focusing on environmental justice creates an opportunity to address how various groups are affected by decisions that impact the environment. Disputes

over environmental justice arises at international, national, and local levels (Pare, 2022, p. 152).

The environmental justice framework aims to uncover the relationship between environmental challenges and the unequal burden of air and climate pollution borne by populations of low socioeconomic status and communities of colour, who are often marginalised due to their ethnicity. It explores the health and environmental impacts of this disproportionate exposure, as well as the disparities in environmental protections and quality enforced through laws, regulation, and governmental programs. For these communities, the harm caused by air pollution and impacts of climate change is exacerbated by inadequate access to nutrition, healthcare, limited social support, and insufficient housing. Additionally, the psychological strain of poverty, violence, and racism further intensifies their vulnerability (Perera, 2022, p. 81).

Rooted in social justice theory, the environmental and climate justice movements emerged to tackle the stark socioeconomic and racial inequalities in environmental exposures and health impacts experienced by communities. These movements have become central to the development of environmental and climate policies. The glaring socioeconomic disadvantage and racial or ethnic disparities magnify the harm from air pollution and climate change (Perera, 2022, p. 104). Vulnerable groups often articulate their calls for environmental justice in terms of human rights, despite the absence of explicit environmental protections in most human rights treaties (Atapattu, Gonzalez & Seck, 2021, p. 9 & 12).

The climate crisis arises from a social and economic system dependent on the relentless extraction and consumption of the planet's resources. In the era of human-caused global warming, it is important to acknowledge that climate disasters intensify pre-existing vulnerabilities and disproportionately impact marginalised groups defined by race, ethnicity, politics, and economic status. Studies show notable systemic disparities in the occurrence and severity of diseases and developmental disorders caused by air pollution among children from different socioeconomic backgrounds and racial or ethnic groups. Injustice starts even before birth with fetal exposures.

5.1 Disparities in Fossil Fuel-generated Air Pollution Exposure and Health Impacts

Air pollution serves as a shocking example of environmental injustice. According to the WHO, 9 out of 10 people worldwide breathe polluted air. While air pollution affects everyone, it disproportionately impacts the poorest and most marginalised communities.[14] Although air pollution exposure is not limited to populations of colour or low-income groups, a study by the American Lung Association highlights stark disparities. Nearly 4 in 10 Americans – approximately 131.2 million people – live in areas with unhealthy levels of ozone or particulate pollution. A significant disparity exists in the distribution of air quality across countries with the worst conditions. Of the nearly 44 million residents in these areas, 63 percent are people of colour, while 37 percent are white. The report further highlights that people of colour are 2.3 times more likely than white individuals to live in these regions with the poorest air quality. This disparity is due to many interrelated factors: racism, class bias, land costs, unfair housing market and zoning practices, and imbalances in political power that perpetuate the siting of pollution sources such as power plants, industrial sources, major roadways in or near socially and economically disadvantaged communities.[15] In Europe, people with lower socioeconomic status are more likely to live, work, and study in areas with poorer air quality, reflecting global and US disparities. Apart from poverty, belonging to a certain racial or ethnic or Indigenous group in Europe correlates to more exposure to pollution.

Most of the 15 million babies born preterm are in low-income countries. Each year, about 20 million low-birth-weight babies are born worldwide, the majority in low- and middle-income countries. In the US alone, over 310,000 babies are born with low birth weight, highlighting a stark disparity: 13 percent of Black infants are low-birth-weight compared to 7 percent of White infants. Infant mortality shows the same glaring disparity. The US has the highest infant mortality rate among developed countries, with large variations between racial or ethnic groups. The rate is highest

[14] Nine out of 10 people worldwide are exposed to harmful air pollution, causing 7 million deaths annually, see: WHO. (2018, May 2). *9 out of 10 people worldwide breathe polluted air, but more countries are taking action*. Retrieved from: https://rb.gy/y0mdl4 (accessed: 15 September 2024).

[15] In the United States, 131.2 million people, or 39 percent of the population, live in areas with poor air quality due to unhealthy levels of ozone or particle pollution, see: American Lung Association (2024). Retrieved from: Key Findings | State of the Air | American Lung Association (assessed: 15 September 2024).

for Black infants (almost 11 per 1000 live births), more than twice that in Whites (Perera, 2022, p. 84-85).

Childhood asthma, the most common chronic illness among children, is likely to increase as particulate air pollution rises due to climate change. Long established as a trigger of asthma in children, air pollution is now considered to be a cause of the disease as well. Epidemiological studies found that over four million new paediatric asthma cases annually are associated with traffic-related air pollution (Anenberg, Achakulwisut, Brauer, & Hystad, 2019). Women with asthma and women of colour, particularly Black mothers, are at the highest risk from maternal exposure to air pollution. Asthma rates among children in the US show significant racial and ethnic disparities. While approximately 6.5 percent of all children under 18 are diagnosed with asthma, this average masks the reality that nearly 11.6 percent of Black children, compared to just 5.5 percent of White children, are affected by the condition (Centers for Disease Control and Prevention , 2023). A study by the Institute for Public Policy Research found that affluent white men from rural areas are the largest contributors to transport-related GHG emissions in the UK. The research, which examined transport emissions across income, gender, location, ethnicity and age, highlights the existing inequalities involved and calls for wealthier individuals to reduce their emissions (Taylor, 2024).

Air pollution affects children's immune defences, increasing their vulnerability to infectious agents. In the US, the incidence of pneumonia and other invasive pneumococcal diseases has traditionally been much higher in children of Alaska Native, Native American, and African American race or ethnicity compared to other groups. Air pollution is associated with mental health disorders such as ADHD, ASD, anxiety, and depression, with these disorders often showing disparities along racial or ethnic lines. For example, the percent of Black children diagnosed with ADHD or learning disability is higher than for White children in the US. A study of 290,000 mental health-related visits to paediatric emergency departments in the US concluded that Black children had a 52 percent higher rate of mental health visits compared with White children (Perera, 2022, p. 85-86).

5.2 Disparities in Fossil Fuel-generated Climate Change and Health Impacts

Children worldwide experience both physical and mental health impacts from climate change. Every harmful climate change impact disproportionately affects the health of marginalised and disempowered children. Systemic inequalities, such as wealth disparities, political power imbalances, and racial and ethnic segregation, drive fossil fuel-related GHG emissions contributing to climate change. These inequalities exist both within and between countries. The term climate gap highlights how disadvantaged groups disproportionately suffer from climate change's effects, while global climate policies fail to adequately protect the most vulnerable populations (Sritharan, 2023). The world's poorest communities, despite contributing minimally to global emissions, are the most affected by extreme weather events (Chomsky, 2022, p. 103 and 108).

Vulnerable children face the greatest harm to their health as the impacts of climate change intensify existing inequalities, including poverty, poor health, racism, and discrimination. Low-income and racially marginalised families and children face the highest risk of severe storms and floods, as they often reside in areas most vulnerable to such events and lack the resources to cope or recover. A child experiencing poverty, with inadequate access to housing, food, water, and sanitation, is not only more affected by an initial disaster but also faces increased vulnerability to future crises. In a downward spiral, each subsequent disaster is more damaging than the one before, as the ability to cope and recover is diminished. In the past two decades, more than 7000 major environmental disasters caused more than one million deaths worldwide and trillions of dollars in damage, mostly in developing countries. In low-income countries, the death toll per disaster was over three times higher than in high-income countries. Nearly all of the 67 million children affected annually by weather-related disasters over the past decade, as well as most child fatalities, resided in lower-income countries (Perera, 2022, p. 86-87).

Even within more affluent countries, the impacts of disasters are strikingly unequal. In the US, counties, cities, and neighbourhoods with large numbers of Black and Hispanic residents have suffered disproportionately from hurricanes because they are more often located in damage-prone areas and lack the resources to recover quickly from those disasters. Hurricanes Katrina, Harvey, Sandy, and Maria

disproportionately impacted low-income communities and people of colour, exposing them to greater risk of injury, death, and disaster-related mental health issues. The effects of hurricane Katrina in Louisiana vividly illustrate climate injustice. Mould in homes because of disasters also observes the general rule of inequality. Major storms cause flooding and excess moisture in homes and lead to the proliferation of mould, which is a notorious trigger of asthma attacks. African American children face higher risks of poor housing and mould sensitisation (Morello-Frosch & Obasogie, 2023).

In Europe, low-income families are the most exposed and vulnerable to climate change impacts. Apart from poverty, belonging to certain racial or ethnic or Indigenous groups means more exposure to disasters from climate change. Climate change is threatening the livelihoods, ways of life and culture of Indigenous peoples of Europe, such as the Saami. In a warming climate, the unique cultural livelihood and knowledge system of these ancient people is likely to fade away.

Communities of colour and low-income populations are particularly at risk due to factors such as uneven exposure to extreme temperatures in their neighbourhoods, poor working conditions, inadequate housing quality, limited access to air conditioning, higher rates of chronic health issues, and the broader consequences of structural racism and social inequality. For more than two decades, the world's poorest countries have faced a more significant rise in extreme temperatures compared to the highest-income countries. As climate change drives an increase in the frequency, intensity and duration of heatwaves, there has been growing concern about their health impacts (Gronlund, 2014).

Socially marginalised and low-income populations everywhere are more at risk because of their limited access to climate-controlled housing, and shelter from heat outdoors. In the US, exposure to extreme heat is unequal along both socioeconomic and ethnic or racial lines. Many of the same disadvantaged groups most affected by storms and flooding are also vulnerable to extreme temperatures: they live in urban "heat islands" created by extensive development using concrete and pavement and the lack of green spaces and trees to cool them. Indigenous groups face severe impacts from rising temperatures, with Alaskan and Pacific Northwest Native communities experiencing significant declines in food supplies due to damage to fish and wildlife.

A study of 53 developing countries found that the estimated impacts of hot days on infant mortality are 10-fold greater than estimates from rich countries. Heat-related impacts on birth outcomes and infant deaths are more severe in disadvantaged populations globally, like the effects of air pollution. In many cities in rich countries, people of colour and lower socioeconomic status have disproportionate exposure to heat, and consequently greater health risks (Perera, 2022, p. 90).

While climate change does not cause fires, it creates conditions that make them more intense and frequent. Wildfires, which can spread rapidly, may seem indiscriminate, unaffected by a person's status, ethnicity, or nationality. However, while everyone is at risk, some people and communities bear the brunt of their impact. The physical, emotional, and psychological damage caused by wildfires can endure a lifetime, similar to other disasters (Darian-Smith, 2022, p. 3). In addition to causing physical trauma, wildfire disasters have impaired children's mental health. High levels of stress and symptoms of posttraumatic stress disorder (hereinafter: PTSD) have been reported in youth affected by wildfires from California to Australia (Perera, 2022, p. 91).

With climate change driving a rise in wildfire frequency, the greatest burden falls on disadvantaged populations. Children in low-income and historically marginalised communities of colour face heightened risks from wildfire smoke, compounded by prior exposure to unhealthy air and high rates of chronic health issues. Those with asthma are particularly vulnerable to the respiratory harm. Wildfire smoke has been associated with low birth weight, preterm birth, asthma attacks, and other respiratory illnesses. Research by the University of Washington and the Nature Conservatory created an index to assess community resilience to wildfires, uncovering significant racial and ethnic disparities in vulnerability (Davies, Haugo, Robertson, & Levin, 2018).

Nothing highlights the complex and wide-ranging ramifications that climate change will inflict upon society more than the interrelationships between drought, food, famine, migration and conflict. In a hotter world, drought will impact severely on agriculture, which in turn will translate into food shortages and famine in the majority of the world and price hikes in developed countries. In the longer term, sustained drought conditions will drive mass migration and measures to protect

dwindling water supplies, bringing civil strife and cross-border conflict (McGuire, 2022, p. 77).

Drought is a threat multiplier for hungry and undernourished children in many ways: it affects not only the availability and affordability of food, but also its nutritional value. Children in developing countries have been especially affected by malnutrition and its dire consequences for their health and brain development. The burden of drought has disproportionately affected rural areas in developing countries, particularly in Africa, Central and South America, and Asia. Communities of colour, low-income, rural, tribal, and farming communities have been hit hardest. On top of experiencing greater food insecurity, these groups are most likely to lose access to clean water as droughts become more common and severe.

Although malnutrition is rare in the richer countries, undernutrition is not. Undernutrition, including wasting, stunting, underweight, and mineral deficiencies, significantly increases children's vulnerability to disease and death. In 2022, an estimated 149 million children under five were stunted, 45 million were wasted (14 million severely), and 37 million were overweight or obese globally (WHO, 2024). While stunting affects 3.4 percent of US children, 15 percent of households with children face food insecurity, putting them at risk of undernutrition. The rates of food insecurity differ sharply by race/ethnicity and socioeconomic status: Black households (almost 22 percent), Hispanic households (17 percent), and White households (8 percent). Households below the poverty threshold have the highest rate of all (28 percent).

Infectious vector-borne diseases, to which climate change is contributing, take a terrible toll on children in low-income countries. These vector-borne diseases are disproportionately linked to poverty and inequality. Numerous studies have examined the impact of climate change on malaria and dengue, two major global health threats. Infectious diarrhoeal diseases are also caused by water contamination from heavy rainfall and floods. Diarrhoeal disease is responsible for killing around 443,832 children every year and an additional 50,851 children aged five to nine years. Diarrhoeal diseases are the second leading cause of death for children under five, responsible for one in nine child deaths worldwide, with the highest mortality rates in South Asia and sub-Saharan Africa (UNICEF, 2024).

Climate change is becoming a major driver of migration, forcing more people in low-income countries to flee extreme weather events and violent conflicts caused by its effects. Countries most vulnerable to conflict and humanitarian crises due to climate change typically have: (1) weak state institutions, (2) exclusive political systems, and (3) foreign aid that is either restricted or unevenly distributed (Busby, 2022, p. 2). Around the world, the indications are clear that climate change is leading to food and water insecurity and risks escalating the number, length, and complexity of armed conflicts, accelerating and multiplying disasters, triggering and scaling migration, exacerbating inequalities and grievances, and weakening international law and governance. A few case studies have aimed to highlight the relationship between climate change and specific conflicts, with the civil war in Darfur, Sudan, and the Syrian war, standing out as examples. These conflicts are often cited as instances where climate processes have played a crucial role in intensifying or exacerbating the violence (Busby, 2022, p. 2-3).

Such conflicts have not only directly exposed children to violence and trauma, but also have torn families apart, interrupted schooling, cut off access to healthcare or food, and eliminated the jobs that families depended on for a living. Children caught in and fleeing zones of conflict have suffered physical injuries, psychological damage, developmental delays, malnutrition, and lost years of education. The effects often persist into adulthood and limit the person's ability to make a living; they may also affect the next generation. In addition to physical trauma, displacement and conflict have driven sexual violence and sexual trafficking, especially affecting poor and marginalised women and children (Perera, 2022, p. 93-94).

Forced migration places socioeconomically disadvantaged children and adolescents at high risk of chronic stress, anxiety, depression, and posttraumatic stress. The effects have been felt mainly in developing countries and among the least advantaged within them. Disparities result from a combination of social and environmental factors, including poverty, racism, unequal healthcare access, lack of education, pollution, and climate change impacts. These social and environmental exposures are concentrated in racial or ethnic minorities and those who live in socioeconomically disadvantaged circumstances. Although rich countries have not experienced major climate-related internal migrations, many millions of migrants fleeing war-torn countries that experienced a change in climatic and weather conditions have entered Europe and the US during the past two decades.

The Internal Displacement Monitoring Centre's 2023 Global Report revealed a record 75.9 million people living in internal displacements at the end of the year. Forced displacement due to conflict and violence totalled 20.5 million, while weather-related disasters caused 26.4 million internal displacements (Internal Displacement Monitoring Centre, 2024). Internally displaced persons (hereinafter: IDPs) and refugees are similar in many ways. The most fundamental distinction is that the refugee has crossed an international frontier while the IDP remains within their country of origin. IDPs and refugees often face the same practical problems, such as lack of documentation, adequate shelter, food, water, sanitation, healthcare, access to justice and financial resources (NiGhrainne, 2022, p. 182).

6 The International Law on Air Pollution and Climate Change

International environmental law continues to prioritise the issue of transboundary harm resulting from polluting activities occurring within or extending beyond boundaries. International environmental law imposes general obligations on states to address pollution and other environmental challenges. Some of these obligations are recognised as customary international law. A central obligation is the responsibility of states to prevent activities within their jurisdiction or control from causing harm to the environment of other states or areas beyond national boundaries. However, modern transboundary pollution challenges often transcend the traditional 'source state' and 'victim state' framework. Many such problems are now regional or global in nature, with climate change being the most prominent example. Addressing these widespread pollution challenges requires cooperation[16] and shared responsibilities among all contributing states (Bugge, 2015, p. 263-294).

The reliance on fossil fuels generates significant externalities, impacting climate, the environment, and human health. Air pollution caused by burning fossil fuels leads to numerous health issues, while climate change exacerbates existing threats, including diarrhoeal illness, vector-borne diseases, waterborne diseases, and cardio-respiratory diseases. Collaborations between the WHO and UNFCCC have become more prominent over the last several years. While recent conferences of parties (hereinafter: COPs) have brought renewed attention to the health effects of climate

[16] The duty of states to cooperate is recognised as a general principle of international environmental law. As such the duty to cooperate supplements and to some extent overlaps with the duty not to harm the environment of other states and areas outside national jurisdiction.

change, existing global public health frameworks often focus on other threats. Environmental degradation significantly amplifies health disparities both between nations and within communities. The scope of a regulatory action is influenced by factors such as the current scientific advancements of the issue or the practical realities of political feasibility (Dupuy & Vinuales 2018, p. 148).

6.1 Soft Law Instruments and Multilateral Conventions

The impacts of climate change are expected to be widespread but unevenly distributed. Currently, there is no global treaty specifically addressing air pollution, with little indication that states will adopt one soon (Okowa, 2021, p. 489). Many atmospheric concerns, including aspects of air pollution, are more effectively addressed at the local or regional level. The 1979 Geneva Convention on Long-Range Transboundary Air Pollution (LRTAP),[17] is the sole significant regional multilateral agreement focused on managing and mitigating transboundary air pollution. Its objective is to prevent, reduce, and control air pollution that crosses borders, originating from both new and existing sources (Boyle & Redgwell, 2021, p. 366). Despite the absence of a global framework, state practices have given rise to established principles of customary international law principles, supported by the interaction between treaties and customs. One widely recognised customary rule of international law, which is universally accepted as an established custom, obligates states to act with due diligence to prevent significant transboundary harm. This "no-harm principle" or "duty of prevention", is rooted in various been legal maxims and doctrines, prominent in both common and civil law traditions (McIntyre, 2017, p. 199).

In the 1941 *Trail Smelter* arbitration case[18], the tribunal ruled that "under the principles of international law…no State has the right to use or permit the use of its territory in such a manner as to cause injury by fumes in or to the territory of another or the property of persons therein, when the case is of serious consequence and the injury is established by clear and convincing evidence." The *Trail Smelter* case was one of the first inter-state claims addressing the harmful transboundary effects of airborne pollutants. The ruling was pivotal, as it marked the first time an

[17] Convention on Long-Range Transboundary Air Pollution (LRTAP), adopted 13 November 1979, 1302 UNTS 217 (entered into force 16 March 1983).
[18] *Trail Smelter Arbitration (United States of America, Canada)* (1938 and 1941) 3 RIAA 1905 (Trail Smelter).

international tribunal formally established the no-harm principle, requiring states to prevent, reduce, and manage transboundary environmental harm caused by activities within their jurisdiction (Rose, et al. 2022, p. 324).

Today, the older "no harm rule" (a duty not to cause significant transboundary harm) and the "harm prevention rule" (a duty to prevent significant transboundary harm) are considered two aspects of the same principle.[19] The difference in terminology mainly reflects the evolution of international environmental law (Brunnee, 2020, p. 53). The International Court of Justice (hereinafter: ICJ) first addressed states' responsibilities to safeguard the rights of other states within their territories in the *Corfu Channel* case.[20] In its Advisory Opinion on the *Legality of the Threat or Use of Nuclear Weapons*,[21] the ICJ reaffirmed that the harm prevention rule (obligation) is an established part of the international law, stating that "the general obligation of States to ensure that activities within their jurisdiction and control do not harm the environment of other States or of areas beyond national jurisdiction" (Brunnee, 2020, p. 52-119).

The Court reaffirmed this principle in its 1997 ruling in the *Gabcikovo-Nagymaros Project*,[22] its 2010 judgment in the *Pulp Mills* case,[23] and its 2015 inter-connected rulings in *Costa Rica v Nicaragua/Nicaragua v Costa Rica*.[24] These rulings make it clear that the harm prevention rule restricts a state's sovereign rights to engage in or permit harmful activities within its borders. The ICJ has consistently upheld that both the no-harm rule and associated procedural obligations apply not only to environmental damage within national territories but also to areas beyond national jurisdiction, including the global commons (Rose, et al., 2022, Brunnee, 2020; Harm Prevention, 2021, p. 271; Wewerinke-Singh, 2020, p. 56).

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[19] Some scholars make a distinction between two principles: the no-harm principle, which establishes a negative obligation for states to refrain from causing serious transboundary harm; and the preventive principle, a due diligence obligation to prevent activities that would cause serious transboundary harm from being carried out under their jurisdiction. See Benoit Mayer "Relevant Norms of General International Law," in The International Law on Climate Change (Cambridge: CUP, 2018).

[20] *The Corfu Channel Case (United Kingdom v Albania)* (1949) ICJ Rep 4. The ICJ confirmed the customary nature of this principle in 1949, in Corfu Channel case, referring to the existence of 'certain general and well-recognised principles, namely every State's obligation not to allow knowingly its territory to be used for acts contrary to the rights of other States', see Pierre-Marie Dupuy and Jorge E. Vinuales, *International Environmental Law* (Cambridge: CUP, 2018) 63.

[21] *Legality of the Threat or Use of Nuclear Weapons (Advisory Opinion)* (1996) ICJ Reports 226.

[22] *The Gabcikovo-Nagymaros Project (Hungary v Slovakia)* (1997) ICJ Rep 7.

[23] *Pulp Mills on the River Uruguay (Argentina v Uruguay)* (2010) ICJ Reports 14.

[24] *Certain Activities Carried Out by Nicaragua in the Border Area (Costa Rica/Nicaragua)* and *Construction of a Road in Costa Rica along the San Juan River (Nicaragua/Costa Rica)* (2015) ICJ Rep 665.

The harm prevention rule has evolved to cover situations where environmental harm affects areas of shared global interest. This framework is believed to apply to global commons, including the oceans, Antarctica, the atmosphere, and their interconnected ecosystems, all of which are facing unprecedented strain. While states have a responsibility to prevent harm to the global commons, the circumstances under which one state can hold another legally accountable for failing to take appropriate actions to protect these areas remain unclear (Brunnee, 2020, p. 134).

The rule was also reflected in several international documents, including Principle 21 of the 1972 Stockholm Declaration[25] and Principle 2 of the 1992 Rio Declaration.[26] Principle 21 asserts that while states have the "sovereign right to exploit their own natural resources pursuant to their own environmental policies," they also have the responsibility to ensure that activities within their jurisdiction do not cause harm to the environment of other states or of areas beyond their national control. The language of Principle 21 indicates that the harm prevention rule applies to the global commons such as high seas or Antarctica and by extension, the Earth's atmosphere (Bodansky, Brunnee & Rajamani, 2017, p. 40).

Principle 2 of the Rio Declaration restated the Stockholm Declaration's stance, while also stating that states have the right to utilise their resources according to their own environmental and "developmental" policies. At present, our economic development remains heavily reliant on fossil fuels. Climate science urges the need to decarbonise our entire economy to limit global temperature rise to 1.5°C. The Paris Agreement sets the goal of keeping the average global temperature increase "well below 2°C" and, ideally, below 1.5°C". Achieving net-zero emissions across the entire economy presents both technological and societal challenge (Bodansky, Brunnee, & Rajamani, 2017, p. p.40). Principle 2 does not impose an outright ban on environmental harm that crosses national boundaries, nor does it grant states unrestricted freedom to exploit natural resources or pursue economic development without considering environmental impacts (Boyle & Redgwell, 2021, p. 116).

[25] Declaration of the United Nations Conference on the Human Environment, Stockholm, 16 June 1972, UN Doc. A/CONF 48/14/Rev.1 (Stockholm Declaration).
[26] Rio Declaration on Environment and Development, 13 June 1992, UN Doc. A/CONF. 151/26. Rev. 1 (Rio Declaration).

The Rio instruments outline a framework that differentiates global environmental responsibilities from those that are regional or transboundary in nature, such as air pollution. These instruments use the term "common concern" to refer to issues that carry global responsibilities (Boyle & Redgwell, 2021, p. 142). Some have argued that common concerns align with *erga omnes* obligations, meaning duties owed to the international community at large, where all states have an interest in ensuring compliance. Both common concerns and erga omnes obligations address matters that impact individuals worldwide. The central principles of the climate regime are, therefore, of universal concern to all states (Soltau, 2016, p. 203-212).

In 1988, General Assembly resolution 43/53 declared that "climate change is the common concern of mankind," recognising that the climate is a fundamental condition for sustaining life on Earth.[27] This notion was incorporated into Principle 2 of the Rio Declaration, which was later reflected in the Preamble to the 1992 UNFCCC (Sands & Peel, et al. 2018, p. 209). The 1992 UNFCCC also asserts in its Preamble that "change in the Earth's climate and its adverse effects are a common concern of humankind" (Bodansky, Brunnee & Rajamani, 2017, p. 51). This distinction highlights that it is not the climate itself, but rather the change in climate and its negative impacts that are considered the common concern (Soltau, 2016, p. 209). Similarly, the Preamble of the 2015 Paris Agreement, adopted under the UNFCCC, reinforces that "climate change is a common concern of humankind." It further emphasises that, in taking action to address climate change, parties must respect and promote human rights, including the rights to health, the rights of indigenous peoples, local communities, migrants, children, persons with disabilities and people in vulnerable situations. The Agreement also underscores the importance of development, gender equality, empowerment of women and intergenerational equity in the context of climate action (Boyle & Redgwell, 2021, p. 394).

The UNFCCC establishes more extensive commitments than those contained in LRTAP or the Vienna Convention for the Protection of the Ozone Layer.[28] The UNFCCC sets out, in its Art. 3, certain fundamental principle of the climate change

[27] General Assembly Resolution 43/53 of 6 December 1988 (A/RES/43/53). The same resolution welcomed the establishment of the Intergovernmental Panel on Climate Change (IPCC) and outlined issues to be addressed by the Panel.

[28] Vienna Convention for the Protection of the Ozone Layer (adopted 22 March 1985, entered into force 22 September 1988) 1513 UNTS 293. The Vienna Convention established the framework of a regime "to protect human health and the environment against adverse effects resulting or likely to result from human activities which modify or are likely to modify the ozone layer."

regime, including the principle of common but differentiated responsibilities and respective capabilities (hereinafter: CBDRRC) (Art. 3(1)), the principle of intergenerational equity (Art. 3(1)), and the precautionary principle (Art. 3(3)) (Dupuy & Vinuales, 2018, p. 178). The UNFCCC recognises in Art. 3(4) that states have a right to promote sustainable development. However, Art. 3 is not an exhaustive list, and the principles guide the parties in their actions to achieve the objectives of the convention. The parties may consider other relevant principles in implementing the convention. States have accepted that their mitigation obligations depend on various differentiation principles. Climate change mitigation is a strong case for differentiation. A state's capacity to limit and reduce its GHG emissions depends on various national circumstances, including its financial and technological capacity, geographical situation, and economy. The CBDRRC principle has been recognised as a relevant principle in other aspects of global environmental protection, including the protection of the ozone layer and the regulation of mercury pollution (Mayer, 2022, p. 243).

The Preamble of the 2015 Paris Agreement acknowledges the principle of CBDRRC and includes references to key concepts such as equity, sustainable development, poverty reduction, and climate justice. Under the Paris Agreement, each party is required to submit nationally determined contributions (hereinafter: NDCs) that align with the principle of CBDRRC. The principle of CBDRRC originates from the broader application of equity in international law and emphasizes the importance of considering the specific needs of developing nations in creating, implementing, and interpreting environmental frameworks. The concept of responsibility within CBDRRC is grounded in the principle of cooperation, which calls for collaborative efforts among states to tackle transboundary pollution. Significantly, the widespread impacts of climate change are deemed a common concern for humanity, as addressing them effectively requires the active involvement of major GHG emitters, consistent with key principles of the climate regime, including the principle of CBDRRC (Soltau, 2016, p. 208-212).

Climate change has drawn increased attention to intergenerational responsibilities, raising critical questions about the obligations of the present generations to future ones. A significant driver of this attention has been the rise of child and youth climate activism, which underscores the vulnerability of children who are likely to face the brunt of a worsening climate crisis. As GHGs continue to accumulate in

the atmosphere, today's actions are not only intensifying the challenges of mitigating climate change but also imposing a heavier burden on future generations to adapt to its far-reaching consequences (Mayer, 2018, p. 30). Children are both part of the present generation and representatives of future generations, as they are excluded from current decision-making but bear the consequences of those decisions made by today's adults. A clear distinction can be made between individuals alive today and those yet to be born to differentiate between present and future generations. Arguing that children's rights are being violated in the present holds much potential. Children today may have legal standing to argue that they are already harmed, particularly in cases where their future interests are neglected or disregarded in current decision-making (Pare, 2022, p. 153).

The principle of intergenerational equity mandates that each generation utilise and enhance its natural and cultural heritage responsibly, ensuring it is preserved for future generations in a condition no worse than how it was inherited. The principle is deeply embedded within international law. Internationally, the rights and interests of future generations have been acknowledged in non-binding soft law declarations, in the preambles of several environmental treaties and, the provisions of the UNFCCC (Redgwell, 2016, pp. 195-196). Principle 3 of the Rio Declaration highlights intergenerational equity, asserting that the right to development must be pursued in a way that ensures developmental and environmental needs of present and future generations are met equitably (Boyle & Redgwell. 2021). The 1972 Stockholm Declaration stated that humanity has a profound responsibility to protect and improve the environment for both present and future generations. This concept was later expanded in 1987 by the Brundtland Commission's report, which defined the concept of sustainable development as fulfilling the needs of present generations without compromising the ability of future generations to meet their own needs (Dupuy & Vinuales, 2018, p. 88).

This principle is closely associated with concepts of fairness, and of distributive justice (Redgwell, 2016, p. 186). The increasing incorporation of an intergenerational perspective in international treaties and declarations emphasizes the growing recognition of the importance of protecting the environment for the benefit of future generations. This sentiment is echoed in Art. 3(1) of the UNFCCC, which stresses the need to consider intergenerational equity in the decisions made by its parties. Many global environmental treaties, including the 1985 Ozone Convention,

the 1992 Convention on Biological Diversity,[29] and UNFCCC aim to prevent irreversible harm to the environment. Additionally, there has been an increasing focus on generational rights in climate litigation by those over 18 years old, bringing cases that highlight the impact of climate inaction on future generations. In the domestic German case *Neubauer and others v Germany*,[30] for example, the plaintiffs argued that state's failure to mitigate the climate crisis placed an unfair burden on future generations. Although the principle has been acknowledged in both international and domestic court rulings, these cases do not establish that future generations have recognised legal rights under international law (Boyle & Redgwell, 2021, p. 121-122).

6.2 Human Rights-Based Approaches to Climate Change and Atmospheric Pollution

The impact of climate change on human rights is now well documented, highlighting the disproportionate harm experienced by marginalised groups and vulnerable communities. Environmental damage has been shown to interfere with the enjoyment of numerous recognised human rights, including the rights to life and health. Human rights are fundamental standards that belong to every individual, irrespective of nationality, place of residence, gender, ethnicity, disability, or socio-economic status. They provide the foundation for survival and development with dignity. The universal value of human dignity is affirmed by the international community's adoption of the UDHR. Art. 1 of the UDHR states: "All human beings are born free and equal in dignity and rights," emphasizing that human dignity is an inherent aspect of human existence. Building on this principle, it is understood that basic human rights are essential to preserving human dignity for all people, regardless of when and where they are born. These rights extend universally, both spatially and temporally, ensuring their relevance for future generations (Lawrence, 2019, p. 91).

International human rights law establishes states' fundamental obligations to treat all individuals with fairness, ensure non-discrimination, and guarantee the enjoyment of all human rights, including the right to health. The right to health is enshrined in

[29] Convention on Biological Diversity (CBD) (adopted 5 June 1992, entered into force 29 December 1993) 1760 UNTS 79.
[30] Bundesverfassungsgericht (BVerfG) (Federal Constitutional Court) BvR 2656/18/1, Mar. 24, 2021.

various legal frameworks and encompasses not only access to personal and public health services but also the fundamental determinants of health, such as clean water, adequate sanitation, sufficient nutrition, safe housing, and clean air. The importance of an adequate standard of living for health and well-being is explicitly affirmed in several key human rights instruments, including Art. 25(1) of the UDHR, in Art. 12(1) of the International Covenant on Economic, Social and Cultural Rights (hereinafter: ICESCR)[31], Art. 24(1) of the CRC, and other human rights treaties.

The CRC is built on four fundamental principles: 1) Non-discrimination: States must uphold children's rights without any form of discrimination, regardless of the child's or their parents' race, colour, gender, language, political or other opinion, national, ethnic or social origin, property, disability, birth or other status; 2) Best Interests of the Child: All laws, policies, and actions concerning children should prioritise their best interests; 3) Comprehensive Protection and Development: Governments are obligated to safeguard children's rights, ensuring their survival and promoting their physical, spiritual, moral, and social development; 4) Right to Participation: Children have the right to express their views and participate meaningfully in decisions that affect their lives (Butcher & Hallward, 2021, p. 112). The rights described in the UDHR have been incorporated into binding international human rights treaties and covenants that establish rights for individuals and responsibilities for governments, transnational corporations, organisations, and people. The right to health is intrinsically linked to living in an environment that is healthy, safe, clean, and sustainable. Yet, this fundamental right – to achieve the highest attainable standard of health (the right to health) - is under significant threat from the growing impacts of climate change (Wewerinke-Singh & Antonidis, 2022, p. 146-147).

Health is a universal right, equally applicable to all, including children. As individuals under the age of 18, children are entitled to additional protections under the CRC, due to their vulnerability and dependence on families and adults for their care, well-being, and the environments that support their growth and development. Children's physical and developmental needs make them particularly sensitive to the effects of climate change. The UN Committee on the Rights of the Child has identified climate change as one of the greatest threats to children's health. According to the former

[31] International Covenant on Economic, Social and Cultural Rights (ICESCR) (adopted 16 December 1966, entered into force 3 January 1976) 993 UNTS 3.

Special Rapporteur on human rights and the environment, children face the greatest vulnerability to environmental harm, with the long-term consequences of climate change and biodiversity loss likely to profoundly disrupt their lives for years to come (Narula, 2021, p. 148-149).

The principle of the best interests of the child, as outlined in Art. 3 of the CRC, offers a particularly promising approach. This principle shifts the focus in climate law and policy to prioritise children's needs over other competing interests. As a fundamental principle of the CRC, it provides a framework for interpreting all other rights within the Convention. Combined with complementary principles, such as the right of children to be heard, it ensures that their rights and interests are addressed comprehensively in legal and policy contexts.[32] The CRC Committee asserts that children's best interest should be a central consideration in all decision-making, including government policies related to climate and environmental issues. Since children are disproportionately impacted by climate change, their interests could be considered even more critical in environmental matters than in other policy areas (Daly, 2023).

The CRC identifies environmental pollution as a significant threat to children's access to nutritious food and clean drinking water, essential for achieving the highest attainable standard of health. Governments are obligated to take effective measures to mitigate these risks and uphold children's health rights. Children's extended life expectancy means they face longer exposure to worsening environmental conditions and a greater risk of developing diseases with long latency periods. Climate breakdown further affects children's access to education and other critical factors - recognised as human rights - that are fundamental to lifelong health and well-being. Since children's rights are inherently interconnected, fulfilling their right to health and development requires addressing related rights, including adequate living conditions, safe housing, protection from hazardous work and economic exploitation, and access to vital information that empowers them to protect themselves and make informed choices (Knox, 2016, p. 217). The UN human rights treaty bodies have repeatedly emphasised that environmental harm can undermine the realisation of human rights they protect. Climate change, as a specific form of

[32] Committee on the Rights of the Child, *General Comment No. 5: General Measures of Implementation of the Convention on the Rights of the Child* (27 November 2003) CRC/GC/2003/5. The other general principles are the right to be heard (Art. 12); the right to life, survival and development (Art. 6); and non-discrimination (Art. 2).

environmental harm, is no exception in this regard. Human rights bodies have consistently acknowledged that climate change poses a significant threat to the enjoyment of human rights (Knox, 2016, p. 218).

The climate crisis is a major threat to human rights but also offers opportunities to improve them. Climate change caused by human activity is expected to negatively impact well-being, affecting rights to life, health, and subsistence, particularly in poorer countries and marginalized communities. Groups at risk include children, women, the elderly, people with disabilities or chronic illnesses, Indigenous peoples, low-income populations, and those in jobs sensitive to climate or unsafe conditions. Children are especially vulnerable due to their development and physiology, making them more prone to health issues like heat and air pollution. Climate change is anticipated to worsen global child mortality and illness from diseases such as malaria, respiratory and diarrheal diseases, malnutrition, and other communicable diseases (Blaiklock, Williams & Jones, 2021, p. 397).

Unabated climate change affects various human rights, such as the rights to life, health, food, water, sanitation, housing, education, an adequate standard of living, and self-determination. Certain groups are more severely impacted than others, and those countries and communities that contribute least to climate change often suffer the most. They also lack the economic and infrastructural resources needed to adapt. A rights-based approach is crucial for guiding mitigation efforts to address these disparities. Human rights and dignity are essential for promoting intergenerational justice. Though there is no universally agreed-upon theory of intergenerational justice, it generally requires that current generations maintain an ecological system – including the climate system – that supports a minimum level of subsistence for future generations. This standard should protect fundamental human rights to life, health, and subsistence (Lawrence, 2019, p. 91).

States are bound by international human rights law to respect, protect, and fulfil the rights of all individuals. Since 2008, the UN Human Rights Council[33] has highlighted how climate change affects the enjoyment of human rights globally, both now and in the future. Given the broad nature of human rights treaties, climate change

[33] By General Assembly Resolution 60/251, the Assembly decided to establish, as a subsidiary organ, a Human Rights Council, to replace the Commission on Human Rights.

obligations under the UNFCCC must inform the interpretation of these human rights obligations. At the same time, states must ensure that their climate actions comply with human rights law. The 2015 Paris Agreement marked a significant milestone as the first multilateral environmental treaty to explicitly acknowledge human rights. Its preamble highlights the right to health and calls on Parties to respect, promote and consider their respective obligations on human rights while addressing climate action. It also emphasizes the importance of specific rights, including the right to health, the rights of indigenous peoples, local communities, migrants, children, persons with disabilities and vulnerable populations. Additionally, the Agreement stresses the right to development, gender equality, women's empowerment and intergenerational equity (Woerdman, Roggenkamp & Holwerda, 2021, p. 260; Wewerinke-Singh & Antonidis, 2022, p. 159).

International and regional human rights systems recognise states' duty to mitigate climate change as part of their human rights obligations. The Dutch Supreme Court's ruling in the *Urgenda Foundation v. State of Netherlands*[34] affirmed that protecting citizens from climate change align with the right to life and private life. This landmark case highlights how international human rights law can strengthen the obligations outlined in the UNFCCC and Paris Agreement. It also demonstrates how climate change law can inform the interpretation of states' human rights duties. These duties include establishing legal and institutional measures to protect against environmental harm, conducting environmental impact assessments, ensuring public awareness and participation in environmental decisions, providing remedies for harm, addressing the needs of vulnerable groups, and safeguarding the rights of individuals striving for a safe, healthy, and sustainable environment (Wewerinke-Singh & Antonidis, 2022, p. 159).

6.3 Sustainable Development

Sustainable development, introduced in the Brundtland Commission's 1987 report, emphasizes the integration of environmental, social, and economic goals. Principle 4 of the Rio Declaration highlights that environmental protection is essential to the development process and cannot be treated independently. Similarly, the 2002

[34] Supreme Court of the Netherlands, *State of the Netherlands v Urgenda,* Case19/00135, 20 December 2019.

Johannesburg Declaration on Sustainable Development[35] identifies economic development, social development and environmental protection as three pillars of sustainable development. Economic development cannot happen at the expense of the environment and of the well-being of humans. To achieve true sustainability, development must balance these pillars, ensuring economic progress does not compromise human well-being or environmental health (Dupuy & Vinuales 2018, p. 91).

Sustainable development's social pillar closely aligns with human rights, as fundamental human needs such as food, water, healthcare, shelter, and education, are framed in the language of rights (Atapattu, Gonzalez & Seck, 2021, p. 4). Similarly, the UNFCCC highlights the rights and responsibilities of its Parties in promoting sustainable development and expresses a collective commitment safeguarding the climate system for present and future generations. This emphasis is further reinforced in the Paris Agreement, where sustainable development is a central theme, mentioned at least twelve times (Mayer, 2018, p. 72).

Numerous treaties, international instruments, and court decisions affirm, directly or indirectly, the concept of sustainable development and states' responsibility to utilize natural resources in a sustainable fashion. These acknowledgements have solidified sustainable development as an integral component of international customary law (Sands, Peel, et al., 2018, p. 218-219). In the *Gabcikovo-Nagymaros Project* case, the ICJ highlighted the need to balance economic development with environmental protection, embodying the concept of sustainable development (Boyle & Redgwell 2021, p. 117). Judge Weeramantry, in his Separate Opinion, described sustainable development as more than just a concept, recognising it as a principle with normative value essential to resolving the case (Bosselmann, 2021, p. 40). Sustainable development is recognised as a broad framework comprising both substantive and procedural aspects. Substantive aspects principles like intergenerational equity, sustainable use, equitable use and integration. Procedural aspects focus on ensuring access to information, stakeholder participation in decision-making, environmental impact assessment, and access to remedies (Atapattu & Schapper, 2019, p. 20).

[35] The UN World Summit on Sustainable Development "Johannesburg Declaration on Sustainable Development", UN Doc. A/CONF.199/20 (2002).

The Agenda for Sustainable Development 2030 with its SDGs, adopted by 193 countries in September 2015, officially came into effect on January 1, 2016.[36] This Agenda encompasses 17 SDGs and 169 associated targets, addressing the three dimensions of sustainable development: economic, social, and environmental. The UN General Assembly recognised the urgency of addressing climate change and its impacts as a priority under Goal 13, which calls for states to implement the UNFCCC (Target 13.3) (Mayer, 2018, p. 263). Reducing air pollution is a key focus of the SDGs, particularly in targets 3.9 under SDG 3 (Health) and 11.6 under SDG 11 (Sustainable Cities) (Dupuy & Vinuales 2018, p. 149).

The Paris Agreement is closely connected to the SDGs, particularly with Goal 13, as both share the objective of addressing climate change. The SDGs are rooted in the promotion of human rights, aiming to enhance their enjoyment alongside environmental sustainability. Growing global awareness of climate change influenced the integration of climate-related targets within SDGs, paving the way for the Paris Conference later that year. Numerous parallels exist between the SDGs and the Paris Agreement, with Goals 13, 14 and 15 addressing climate change, while the Paris Agreement incorporates provisions on "sustainable lifestyles", "sustainable development", and "sustainable management of forests" (Giacomini, 2022, p. 114-115).

The right to development is recognized as a human right, as affirmed by Art. 1 of the 1986 UN Declaration on the Right to Development. The SDGs align closely with international human rights standards and are central to the work of the UN Human Rights Council, being referenced in universal periodic reviews and addressed by Special Procedure mandate holders. Each goal is overseen by a designated UN agency, which collaborates with States to conduct research, gather information, and promote activities to achieve the targets. Agenda 2030, which outlines the SDGs, serves as a strategic blueprint for achieving social equity, environmental protection, and economic prosperity. Its preamble underscores these three interconnected dimensions of sustainable development, presenting them as a vision for the future. The framework is built around themes that resonate with human rights values: prioritizing the inclusion of marginalized and vulnerable groups to ensure no one is

[36] UN General Assembly, '*Transforming Our World: the 2030 Agenda for Sustainable Development*' (21 October 2015) UN Doc A/RES/70/1.

left behind, holding governments and their partners accountable for development outcomes, and encouraging the active participation of all individuals in the process.

Facing an unprecedented planetary crisis, the United Nations has, for the first time, acknowledged the universal right to live in a clean, healthy and sustainable environment. Although not legally binding, resolutions adopted by the UN Human Rights Council and the UN General Assembly affirm this right and are expected to drive legal advancements globally, regionally, and locally while spurring efforts to uphold it. Recognising this right promotes better environmental outcomes, including cleaner air, improved access to safe drinking water and lower GHG emissions. It also aligns with the SDGs, under the 2030 Agenda, which address health, clean water, sanitation, and climate action. Achieving sustainable development depends on prioritising a healthy environment as the cornerstone of economic and social progress.

In recent years, climate litigation has surged as a significant development. As the climate emergency intensifies, rights-based climate cases are becoming an increasingly important tool for securing more ambitious climate action. Lawsuits are being filed against governments for not fulfilling their environmental and human rights duties, with the goal of compelling them to adopt more ambitious climate actions. Recent high-profile cases include those against the Netherlands, Germany, Australia, and the United States. Additionally, legal actions are being pursued against major corporate polluters such as large fossil fuel companies, to seek compensation for harm. One of the major litigation cases in 2023 was the *Held et al. v. State of Montana* (Cohen, 2023), in which a judge ruled in favour of young residents of Montana. The court determined that state officials had violated their right to a clean and healthy environment by supporting fossil fuels (Sritharan, 2023, p. 173). The CRC plays a crucial role by directly addressing environmental concerns. Art. 24, which focuses on the right to health, mandates that states take measures to combat disease and malnutrition, while also considering the dangers and risks posed by environmental pollution. Additionally, it ensures that parents and children receive education and are supported in areas such as child health, nutrition, hygiene and environmental sanitation (Pare, 2022, p. 161-162).

7 Conclusion

Environmental factors contribute significantly to the global burden of disease, with children, especially those in developing countries, being the most affected. Health impacts are distributed unequally, with the most vulnerable populations – those experiencing extreme poverty, social marginalisation, or existing health conditions – bearing disproportionate share of disease, disability, and mortality. Factors such as age, socio-economic status, and pre-existing conditions further exacerbate this inequality. Additionally, the changing climate poses an escalating threat to the health and well-being of children throughout the world. Their inherent vulnerabilities and limited agency make it particularly challenging for them to confront environmental injustices effectively.

The global focus on climate change has largely centred on GHG emissions, but it is equally important to recognise the health impacts of fossil fuel combustion. Sources of heat-trapping carbon emissions often release local pollutants such as fine particulate matter, ozone precursors, air toxins, and metals all of which can significantly degrade air quality and harm human health. Rising temperatures worsen air pollution, leading to increased risks of cardiovascular and respiratory illness. The health impacts of climate change are wide-ranging and severe, with the potential to affect every organ system in the human body. Children across the globe face the risk of at least one climate-related hazard, while vulnerable populations, including the very young, the elderly, those with limited mobility, socially marginalised groups, and economically disadvantaged communities, are disproportionately affected. Extreme heat contributes significantly to the global health burden worldwide, with heatwaves posing particular dangers to the very young and the elderly. Elevated temperatures can exacerbate cardio-respiratory conditions and central nervous system disorders. Moreover, climate change also amplifies existing environmental health challenges, including the spread of diarrhoeal illness and vector-borne diseases, while redistributing these threats by introducing diseases like malaria or dengue fever to previously unaffected regions.

Climate scientists warn that exposure to climate-related hazards and toxic air pollutants caused by burning of fossil fuels is expected to increase. Pregnant women and children are particularly at risk from overlapping exposures to factors such as air pollution, extreme heat, food insecurity, and severe storms. For infants and young

children, a combination of neurotoxic air pollutants and drought-induced malnutrition can impair cognitive development through synergistic effects. Air pollution weakens immune function, leaving children highly susceptible to infectious diseases that are spreading due to climate change. There is strong evidence of a combined impact of heat and air pollution to higher rates of cardiovascular and respiratory illnesses in both adults and children, with increased morbidity and mortality. Researchers also highlight the compounded risks of prenatal exposure to heat and air pollution which elevate the likelihood of preterm birth. Beyond immediate physical and developmental consequences, air pollution and climate change contribute to rising rates of mental health disorders among children and adolescents. Exposure to air pollution and elevated temperatures, starting in utero, raises the likelihood of preterm birth. Preterm babies are more prone to emotional and behavioral problems, including depression and anxiety. Stress and air pollution exposure experienced during childhood further amplify the risk of mental health problems during childhood and adolescence.

Climate change intensifies existing threats, amplifying their impact on communities. Climate change-fuelled extreme weather events such as wildfires, floods, tropical storms, tornadoes, hurricanes, and mudslides cause not only physical injuries and acute illnesses but also aggravate chronic health conditions. In the aftermath of these disasters, individuals face heightened exposure to infectious diseases and toxic chemicals, often through contact with contaminated floodwaters or unsanitary and unsafe living conditions. Additionally, the displacement and damage to infrastructure disrupt access to essential to medications and treatments, putting those with chronic diseases at greater risk.

A human rights approach focuses on how environmental impacts affect individual's rights to life, health, private life, and property. A rights-based approach to climate change emphasizes the obligations of states to respect, protect, and fulfil all human rights endangered by climate change. This perspective can drive the adoption of stricter environmental standards by requiring governments to mitigate pollution that endangers health and well-being. The Paris Agreement has become a foundation for legal challenges worldwide, allowing litigants to hold governments accountable for insufficient mitigation policies. Many rights outlined in international human rights law depend on a clean and healthy environment, yet such rights become difficult to

realise in polluted conditions. Despite these connections, the persistent lack of political determination remains a significant obstacle to meaningful progress.

The responsibilities of states and non-state actors to mitigate and adapt to climate change remain unclear despite the emergence of a complex web of regulatory framework. In recent years, children and young people have become prominent leaders in mass protests and civil society movements, amplifying political pressure and contributing to climate change-related litigation at both domestic and international levels. Rights-based climate lawsuits are increasingly used as a strategy to push for stronger climate action. Many of these cases rely on human rights arguments to hold governments accountable for inaction. Climate litigation has also become a regulatory tool to address the damage caused by human-induced GHG emissions, focusing on prevention, mitigation and compensation. In the context of human health impacts, such litigation examines whether domestic and international law, conventions, and climate change negotiations uphold the right to health and seek remedies for violation.

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Povzetek v slovenskem jeziku

Okoljski dejavniki, kot sta onesnaženost zraka in podnebne spremembe, močno prispevajo k globalnemu bremenu bolezni in so ključni za razumevanje razlik v zdravju med državami, pri čemer se države z nizkimi in srednjimi dohodki soočajo z največjim okoljskim zdravstvenim bremenom pri različnih boleznih in poškodbah. Čeprav je zdravje splošno priznano kot oboje, kot temeljna človekova potreba in temeljna človekova pravica, škodljivi učinki nezdravega okolja nesorazmerno slabše vplivajo na otroke. Raziskava kaže, da lahko izpostavljenost strupenim snovem iz okolja pred in po rojstvu zmoti razvoj možganov in pljuč ter poruši njihovo delovanje. Ti vplivi na zdravje so neenakomerno porazdeljeni, pri čemer marginalizirane skupine prebivalstva doživljajo večjo škodo. IPCC ali t. i. Medvladni forum za podnebne spremembe ugotavlja, da je izgorevanje fosilnih goriv glavno gonilo podnebnih sprememb. Epidemiološke študije nadalje poudarjajo obstoječe in prihodnje posledice podnebnih sprememb, vključno z njihovimi učinki na nalezljive bolezni, bolezni srca ter pljučne bolezni in duševno zdravje.