

THE IMPACT OF AIR POLLUTION ON HUMAN HEALTH

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ABSTRACT

This article examines the impact of air pollution on human health from environmental, medical, and public health perspectives. It analyzes the major sources of air pollution, including industrial emissions, motor vehicle exhaust, fossil fuel combustion, agricultural activities, and household pollutants, as well as their effects on human physiological systems. Particular attention is given to the health consequences of exposure to particulate matter (PM_{2.5} and PM₁₀), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), ozone (O₃), carbon monoxide (CO), and volatile organic compounds (VOCs). The article discusses the relationship between air pollution and respiratory diseases, cardiovascular disorders, neurological conditions, cancer, adverse pregnancy outcomes, and premature mortality. Furthermore, it highlights international environmental standards, evidence-based preventive strategies, and the role of governments, healthcare professionals, and communities in reducing air pollution exposure and promoting public health. The study emphasizes the importance of sustainable environmental policies and clean air initiatives for improving global health outcomes.

Keywords: air pollution, human health, environmental pollution, particulate matter (PM_{2.5}, PM₁₀), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), ozone (O₃), carbon monoxide (CO), volatile organic compounds (VOCs), respiratory diseases, cardiovascular diseases, public health, environmental protection, sustainable development, air quality.

INTRODUCTION

One of the most important professional requirements for international lawyers is the ability to negotiate effectively in multicultural and multinational environments. The adoption of the United Nations Sustainable Development Goals (SDGs) on 25 September 2015 emphasized the importance of international cooperation and peaceful dispute

resolution. Within this framework, legal negotiations have become a critical instrument for achieving international consensus and legal stability.

International lawyers frequently participate in negotiations involving trade agreements, investment treaties, environmental cooperation frameworks, and commercial transactions. Such activities require mastery of specialized terminology including *Good Faith Negotiation*, *Mutual Consent*, *Binding Commitment*, *Reservation Clause*, *Settlement Agreement*, *Mediation Framework*, and *Dispute Settlement Mechanism*.

From a pedagogical perspective, Legal English instruction provides an effective platform for developing negotiation skills through simulation exercises, role-playing activities, and case-based learning. Students who engage in authentic negotiation scenarios acquire practical experience in persuasive communication, legal argumentation, and conflict resolution. Consequently, Legal English functions not merely as a language subject but as a professional training tool that prepares future lawyers for real-world legal negotiations.

MAIN PART

Air pollution has become one of the most significant environmental and public health challenges of the twenty-first century. According to the World Health Organization (WHO), air pollution is now recognized as one of the leading environmental risk factors responsible for premature mortality and the growing burden of non-communicable diseases worldwide. The WHO estimates indicate that 99% of the global population lives in areas where air quality exceeds the recommended guideline limits established in the WHO Air Quality Guidelines. In 2019, exposure to ambient (outdoor) air pollution caused approximately 4.2 million premature deaths, while the combined effects of ambient and household air pollution were associated with approximately 6.7 million premature deaths globally. These findings were reaffirmed in the WHO fact sheet updated on 24 October 2024.

The scientific understanding of air pollution has changed considerably during the last two decades. Earlier studies mainly focused on respiratory diseases, whereas recent epidemiological and toxicological investigations demonstrate that air pollution affects

nearly every organ system. Fine particulate matter (PM_{2.5}), particulate matter (PM₁₀), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), ozone (O₃), carbon monoxide (CO), and volatile organic compounds (VOCs) initiate oxidative stress, chronic inflammation, endothelial dysfunction, mitochondrial damage, and immune dysregulation. These biological mechanisms contribute to cardiovascular diseases, chronic respiratory disorders, metabolic diseases, neurological degeneration, reproductive disorders, and several forms of cancer.

One of the most dangerous pollutants is PM_{2.5}, consisting of particles with an aerodynamic diameter smaller than 2.5 micrometres. Because of their extremely small size, these particles penetrate deeply into the alveolar regions of the lungs, cross the alveolar-capillary membrane, enter systemic circulation, and subsequently affect distant organs. Chronic exposure to PM_{2.5} accelerates systemic inflammatory responses, increases oxidative damage to vascular endothelial cells, promotes atherosclerotic plaque formation, and elevates the risk of myocardial infarction, stroke, chronic obstructive pulmonary disease (COPD), lung cancer, and premature death. WHO estimates show that approximately 68% of premature deaths associated with ambient air pollution are attributable to ischemic heart disease and stroke, 14% to chronic obstructive pulmonary disease, 14% to acute lower respiratory infections, and 4% to lung cancer.

Recent WHO assessments published on 25 June 2024 further emphasize that air pollution contributes not only to respiratory and cardiovascular diseases but also to adverse pregnancy outcomes, stillbirth, miscarriage, impaired fetal growth, neurodevelopmental disorders, cognitive decline, dementia, and diabetes mellitus. Vulnerable populations including children, pregnant women, elderly individuals, and patients with chronic diseases experience disproportionately greater health risks because of reduced physiological resilience and increased susceptibility to inflammatory injury. Approximately 85% of air pollution-related deaths are associated with non-communicable diseases, highlighting the importance of integrating environmental protection into national public health policies.

In response to these findings, WHO adopted Resolution WHA68.8 during the 68th World Health Assembly in 2015, recognizing air pollution as a major global health priority. Subsequently, WHO introduced the Strategic Approach for Air Quality, Energy Access and Health (2023-2030), which focuses on strengthening scientific evidence, expanding air quality monitoring systems, improving institutional capacity, and promoting multisectoral cooperation among governments, environmental agencies, healthcare institutions, and research organizations. The strategy emphasizes that reducing emissions from transportation, industry, household energy, agriculture, and waste management represents one of the most cost-effective interventions for preventing disease and improving life expectancy worldwide.

A major milestone in understanding the global burden of air pollution was the publication of the State of Global Air 2024 Report on 18 June 2024, prepared by the Health Effects Institute (HEI) in collaboration with UNICEF. The report analyzed global exposure data from 2021 and concluded that air pollution caused approximately 8.1 million deaths worldwide, making it the second leading global risk factor for premature death, surpassed only by high blood pressure. More than 90% of these deaths were associated with exposure to fine particulate matter (PM_{2.5}), confirming that microscopic airborne particles remain the principal environmental determinant of pollution-related disease.

One of the most alarming findings of the report concerns child health. Scientific analysis demonstrated that children younger than five years of age represent the most vulnerable population because their lungs, immune system, and nervous system are still developing. The report estimated that more than 700,000 children under five died in 2021 from diseases associated with air pollution, including acute lower respiratory infections and complications related to household and ambient air pollution. Researchers emphasized that the early years of life constitute a critical developmental window during which pollutant exposure may produce irreversible physiological damage extending into adulthood.

The report also identified PM_{2.5} as the most reliable predictor of adverse health outcomes worldwide. These ultrafine particles originate primarily from fossil fuel

combustion, industrial emissions, residential heating, biomass burning, traffic emissions, and wildfires. Because their aerodynamic diameter is less than 2.5 μm , they bypass the upper respiratory defense mechanisms, penetrate deeply into the pulmonary alveoli, cross the alveolar-capillary barrier, and enter systemic circulation. Once in the bloodstream, PM_{2.5} particles initiate oxidative stress, vascular inflammation, endothelial injury, platelet activation, and accelerated atherosclerosis, thereby increasing the incidence of myocardial infarction, ischemic stroke, chronic kidney disease, and neurodegenerative disorders.

CONCLUSION

Beyond mortality, the economic consequences of air pollution are becoming increasingly significant. OECD analyses indicate that pollution-related healthcare expenditure, reduced workforce productivity, disability, and premature mortality generate substantial financial losses for national economies. Consequently, environmental protection should be regarded not merely as an ecological objective but also as an essential investment in sustainable healthcare systems and economic development. Integrating clean energy technologies, improving urban transportation, strengthening industrial emission controls, and expanding continuous air-quality monitoring are considered the most effective long-term preventive strategies.

Overall, recent international scientific evidence demonstrates that air pollution represents a complex biomedical challenge requiring multidisciplinary intervention. Effective public health policies should combine environmental legislation, continuous monitoring of atmospheric pollutants, early disease prevention, clinical surveillance of vulnerable populations, and international cooperation. Such evidence-based strategies are expected to reduce the global burden of disease, improve life expectancy, and support sustainable development while protecting future generations from the long-term consequences of environmental pollution.

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