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Environmental pollution and the immune system

Moustafa Abdelnasser, PhD (Microbiol), MHPE, Diploma (TQM)
mostafa_online1@yahoo.com, mostafa.nasser@azhar.edu.eg

Abstract: Environmental pollution, particularly air pollution, is now a worldwide problem. Pollution represents a challenge not only to human health, but also to animals and plants. In turn, human health will also be affected. The immune system is also sensitive to any environmental changes. The immune system itself consists of multiple types of immune cells that act together to generate (or fail to generate) immune responses. Understanding the effects of ambient pollutants on the immune system is vital to understanding how pollution causes disease, and how that pathology could be abrogated. It is also aimed to know how to lessen or prevent their effects on human health.

Introduction

It is widely accepted that human health is a product of both genetics and environment; a premise that also holds true for the immune system. While our genetic makeup is essentially set at birth, the environment is constantly changing, presenting novel challenges in the development, regulation, and function of immunity **(Kreitinger*et al.*, 2016).** A well-functioning immune system is vital for a healthy body. Inadequate and excessive immune responses underlie diverse pathologies such as serious infections, metastatic malignancies and auto-immune conditions **(Glencross *et al.*, 2020).** Environmental pollution is one of the most serious challenges to health in the modern world**.** The major environmental pollutants that are attracting wide-ranging concern and the molecular basis underlying their effects on the immune system were extensively studied **(Suzuki *et al.*, 2020).**

What is an environment?: It is the air we breathe, the water we drink, the food we eat, and the places where we live, work, and play**(CDC, 2018). Pollution** is the introduction of substances (or energy) that cause adverse changes in the environment and living entities**.** Pollution need not always be caused by chemical substances such as particulates (like smoke and dust). Forms of energy such as sound, heat, or light can also cause pollution. These substances that cause pollution are called pollutants **(Kreitinger*et al.*, 2016)**. Numerous environmental factors can modulate human immunity early in life. These range from a biotic chemical exposures and nutritional status to biotic insults from infectious diseases and microbial or parasitic colonization. Early life represents windows of both vulnerability and opportunity that impact the developing immune system **(MacGillivray and Kollmann, 2014).**

Types of Pollution: There are different types of pollution, which are either caused by natural events (like forest fires) or by man-made activities (like cars, factories, nuclear wastes, etc.) These are further classified into https://byjus.com/ - AirPollutiontabair pollution, water pollution, soil pollution, and noise pollution. Besides, these 4 types of pollution, other types exist such as light pollution, thermal pollution, and radioactive pollution. The latter is much rarer than other types, but it is the deadliest **(Nathanson, 2022).**

Air pollution is a contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere**.** Household combustion devices, motor vehicles, industrial facilities, and forest fires are

common sources of air pollution **(WHO, 2022)**.These contaminants are quite detrimental and, in some cases, pose serious health issues. The effects of air pollution vary based on the kind of pollutant. Generally, the impact of air pollution ranges from increased risk of respiratory illness and cardiovascular problems to increased risk of skin diseases, which may increase the risk of cancer, global warming, and acid rain. ozone depletion and hazards to wildlife (**Manisalidis *et al.*, 2020)**.

Environmental air pollutants are heterogeneous mixture of particles suspended in a liquid and gaseous phase which trigger the disruption of redox homeostasis known under the term of cellular oxidative stress-in relation to the establishment of inflammation and cell death via necrosis, apoptosis, or autophagy. Activation or repression of the apoptotic process as an adaptative response to xenobiotics might lead to either acute or chronic toxicity (**Andreau *et al.*, 2012).** Environmental agents have been gaining more attention for their role in the pathogenesis of autoimmune diseases (ADs). Increasing evidence has linked environmental exposures, including trichloroethene (TCE), silica, mercury, pristane, pesticides, and smoking to a higher risk for ADs. However, the potential mechanisms by which these environmental agents contribute to the disease pathogenesis remain largely unknown **(Khan and Wang, 2020).**

Effects on immune cells: Exposure to environmental contaminants can produce profound effects on the immune system. Many different classes of xenobiotics can significantly suppress or enhance immune responsiveness depending on the levels (i.e. dose) and context (i.e. timing, route) of exposure **(Kreitinger *et al.*, 2016).**
Air pollutants can affect different immune cell types such as macrophages, neutrophils, dendritic cells that orchestrate adaptive immune responses, and lymphocytes that enact those responses. Common themes that emerge are the capacity of air pollutants to stimulate pro-inflammatory immune responses across multiple classes of immune cells. Air pollution can enhance T helper 2 (Th2) and T helper 17 (Th17) adaptive immune responses, as seen in allergy and asthma, and dysregulate anti-viral immune responses. Air pollutants can perturb *in vitro* anti-microbial and regulatory immune responses. Pollutants trigger inflammatory cytokine release from the epithelium and macrophages **(Glencrosse*t al.*, 2020).**

Pollutants alter immune responses and can provoke immunotoxicity **(Suzuki *et al.*, 2020).**Toxicants may access the human body through four points of entry (skin, blood, respiratory, and digestive tracts), and affect numerous organs including the immune system. Toxicants interact with the immune system as a result of deliberate or unintentional exposure, causing either immune activation or immune suppression. Depending on the disease context, this may be either beneficial or detrimental because undesirable immune activation or immune suppression may result in adverse health effects **(Kreitinger *et al,* 2016).**

Xenobiotic receptors, including the aryl hydrocarbon receptor (AHR), sense and respond to a subset of environmental pollutants by activating the expression of detoxification enzymes to protect the body. However, chronic activation of the AHR leads to immunotoxicity. KEAP1–NRF2 is another important system that protects the body against environmental pollutants. KEAP1 is a sensor protein that detects environmental pollutants, leading to the activation of the transcription factor NRF2. NRF2 protects the body from immunotoxicity by inducing the expression of genes involved in detoxification, and antioxidant and anti-inflammatory activities. Intervening in these sensor–response systems could protect the body from the devastating immunotoxicity that can be induced by environmental pollutants **(Suzuki *et al.*, 2020).** The consequences of pollution on the immune system are diverse, ranging from

autoimmune disorders to cancer. Vaccinations also have an important effect on immunity. Thus, it is likely that a crosstalk between vaccines and pollutants may have important consequences on human health. On the one hand, the interaction between vaccinations and pollution may protect against the consequences of the latter, yet it could also lead to further immune dysregulation. Another risk is the possible loss of efficacy of vaccinations for those living in a polluted environment, which could push further the no-vax movement (**Franza and Cianci, 2021)**.

The clinical effects of air pollution vary based on the kind of pollutant. Generally, the impact of air pollution ranges from increased risk of respiratory illness and cardiovascular problems to increased risk of skin diseases, which may increase the risk of cancer, global warming, and acid rain. ozone depletion and hazards to wildlife (**Manisalidis *et al.*, 2020)**.The known association between elevated ambient pollution and exacerbations of asthma and chronic obstructive pulmonary disease (COPD), is consistent with these identified immunological mechanisms. Air pollution also affects the wider immune system for example in the neonate and gastrointestinal tract (**Glencross *et al.*, 2020).** Early life exposures influence immune function over the lifespan—and maybe beyond. A conceptualization of how early life exposures may manifest in persistent alterations in immune function. Developmental exposures have the potential to change the responsive capacity of the immune system to challenge later in life, leading to detrimental consequences for the host at many life stages **(Boule and Lawrence, 2016).** Long-term exposure to air pollution was associated with a higher risk of developing autoimmune diseases, in particular rheumatoid arthritis, connective tissue diseases (CTDs) , and inflammatory bowel diseases (IBD). Chronic exposure to levels above the threshold for human protection was associated with a 10% higher risk of developing immune-mediated diseases (IMIDs) **(Adami *et al*., 2022).**

There are also things that suppress the immune system. These are lack of sleep, anxiety, low vitamin D. certain medications, and too few fruits and vegetables. Narcotics, a high-fat diet, and too little time outdoors are also involved. Consistent with immunology, pollution is clinically associated with respiratory exacerbations.

Some steps which might help to support a healthy immune system are suggested by **Harvard School of Public Health (2022).**These are: eat a balanced diet with whole fruits, vegetables, lean proteins, whole grains, and plenty of water, If a balanced diet is not readily accessible, taking a multivitamin (and minerals) , don't smoke (or stop smoking if you do), perform moderate regular exercise, aim for 7-9 hours of sleep nightly, aim to manage stress (exercise, meditation, a particular hobby, or talking to a trusted friend, practice regular walking or trip, conscious breathing throughout the day and when feelings of stress arise), and wash hands throughout the day: when coming in from outdoors, before and after preparing and eating food, after using the toilet, after coughing or blowing your nose.
In fact, strategies such as vitamin D supplementation, adequate sleep, a balanced and healthy diet ameliorate harmful immune effects.

In Conclusion: Environmental pollution, especially, air pollution has a divesting effect on humans, animals, and plants. Most of our body systems are exposed to air pollution. The immune system is more vulnerable. Avoiding air pollution is sometimes not possible. However, some food supplements or drugs may be given when needed. Healthy life by practicing sports in the open air, away from areas with heavy pollution is recommended.

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