

Eight ways chemical pollutants harm the body

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A new review of existing evidence proposes eight hallmarks of environmental exposures that chart the biological pathways through which pollutants contribute to disease: oxidative stress and inflammation, genomic alterations and mutations, epigenetic alterations, mitochondrial dysfunction, endocrine disruption, altered intercellular communication, altered microbiome communities, and impaired nervous system function.

The study by researchers at Columbia University Mailman School of Public Health, Ludwig Maximilian University, and Hasselt University is published in the journal *Cell*.

"Every day we learn more about how exposure to pollutants in air, water, soil, and food is harmful to [human health](#)," says senior author Andrea Baccarelli, MD, Ph.D., chair of Environmental Health Sciences at Columbia Mailman School.

"Less understood, however, are the specific biological pathways through which these chemicals inflict damage on our bodies. In this paper, we provide a framework to understand why complex mixtures of environmental exposures bring about

serious illness even at relatively modest concentrations."

We are continually exposed to a mixture of pollutants, which lead to changes in our bodies in multiple domains, from conception to old age. They govern [gene expression](#), train and shape our immune systems, trigger physiological responses, and determine wellbeing and disease.

The paper summarizes evidence for eight hallmarks of environmental insults:

1. Oxidative stress and inflammation: When antioxidant defenses are depleted, inflammation, cell death, and organ damage occur.
2. Genomic alterations and mutations: An accumulation of DNA errors can trigger cancer and other chronic diseases.
3. Epigenetic alterations: Epigenetic changes alter the synthesis of proteins responsible for childhood development and regular function of the body.
4. Mitochondrial dysfunction: A breakdown in the cellular powerplant may interfere with human development and contribute to chronic disease.
5. Endocrine disruption: Chemicals found in our environment, food, and consumer products disrupt the regulation of hormones and contribute to disease.
6. Altered intercellular communication: Signaling receptors and other means by which cells communicate with each other, including neurotransmission, are affected.
7. Altered microbiome communities: An imbalance in the population of bacteria and other microorganisms in our body can make us susceptible to allergies and infections.

8. Impaired nervous system function. Microscopic particles in air pollution reach the brain through the olfactory nerve, and can interfere with cognition.

Not all environmental exposures are harmful. The researchers note that exposure to nature has been reported to have beneficial impacts on mental health.

These eight hallmarks are by no means comprehensive and do not capture the full complexity of the chemical and physical properties of environmental exposures, including mixtures of exposures over the short and long-term. Further research is needed to understand the complex mechanisms by which exposures affect human biology, and how altered processes interact and contribute to disease or confer health benefits, across the life course.

"We need research to expand our knowledge of disease mechanisms going beyond genetics.

Advances in biomedical technologies and data science will allow us to delineate the complex interplay of environmental insults down to the single-cell level," says Baccarelli. "This knowledge will help us develop ways to prevent and treat illness. With the serious environmental challenges like air pollution and [climate change](#), most of all, we need strong local, national, and inter-governmental policies to ensure healthy environments."

More information: Annette Peters et al, Hallmarks of environmental insults, *Cell* (2021).
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