



The Ruhr Valley is an industrialized region of northwest Germany.

ENVIRONMENT

# When the first defence fails

*Pollutants in the environment cause more harm to skin than once thought, with effects that can range from irritating to deadly.*

BY ELIZABETH SVOBODA

In the hazy streets of some of Asia's largest cities, people often wear face masks to help avoid inhaling airborne pollutants into their lungs. More than a decade ago, dermatologist Jean Krutmann began to wonder whether such pollutants also affected the body's largest organ, the skin. He and his colleagues began to study people from Europe and Asia who were exposed regularly to vehicle exhaust emissions such as the gas nitrogen dioxide or particulate matter, tracking changes in their health over time.

Krutmann's initial results were traffic-stopping. People who are exposed to common air pollutants have higher rates of chronic skin inflammation and more age spots than do those who live in cleaner areas<sup>1</sup>. "I was the one who bet nothing would come out of this," says Krutmann, director of the Leibniz Research Institute for Environmental Medicine in Düsseldorf, Germany. "We were all surprised to see that there was a strong association."

As the soft, flexible barrier that surrounds the body's tissues, skin is porous enough to soak up moisture, absorb medications from adhesive patches and release protective oils. But the same property also makes

skin vulnerable to assault by chemicals in the environment. And ultraviolet radiation in sunlight can cause premature skin ageing and skin cancer such as squamous cell carcinoma, a mechanism that has been known about for several decades. More recently, research has broadened dramatically to reveal the serious harm that can be inflicted on skin by air pollutants, pesticides and other common chemicals.

"Just in the last ten years, there's so much science about new environmental stressors," says Whitney Bowe, a dermatologist at Icahn School of Medicine at Mount Sinai in New York City. And although damage from such exposure is usually confined to skin, it can also go much further. Pollutants and chemicals that pass through skin can contribute to conditions such as asthma or breast cancer, so researchers are investigating fresh ways to keep dermal incursions at bay.

## MAKING AN ENTRANCE

Skin can be affected by the environment in a variety of ways. The most obvious is through direct exposure to chemicals: submerging an arm in a vat of acetone or benzene would enable the substance to enter the skin by diffusion.

Ultraviolet radiation does not penetrate skin in the same way, but can trigger a destructive

chemical reaction. When it strikes molecules on the skin's surface that contain oxygen, unstable compounds called free radicals are created. To stabilize themselves, free radicals steal electrons from nearby molecules — a process known as oxidation. This can damage the DNA of skin cells, which leads to tissue inflammation, accelerates skin ageing and promotes mutations that contribute to cancer.

But chemicals in the environment often enter skin in more insidious ways. "Skin exposures are stealthy," says physical scientist Frederick Frasch, a coordinator at the US National Institute for Occupational Health and Safety in Morgantown, West Virginia. "If a chemical is toxic through ingestion or inhalation, it will also be toxic through skin absorption." The smogs of Beijing, the pesticide hazes of the Central Valley in California and the smoke plumes that rise from wildfires in the western United States all contain an array of hazardous chemicals — many of which are still being identified.

Many airborne pollutants are so small that they enter pores in the skin like pebbles dropping into a cup, Bowe says. Others, including the polycyclic aromatic hydrocarbons found in vehicle exhaust emissions or wildfire smoke,

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Study participants are exposed to airborne phthalates through the skin.

are ‘fat-loving’ (lipophilic) and can easily pass through the fat-filled spaces between skin cells. They then enter the circulatory system, where they can cause widespread effects.

The most common problem associated with exposure to environmental pollutants is localized skin irritation, says Sean Semple, an occupational-health scientist at the University of Stirling, UK. But a number of pollutants can cause serious, long-term issues. High concentrations of air pollutants have been linked to infertility, asthma and even some cancers. Pesticides can impair brain and nerve function over time. And phthalates — chemicals that are used to make plastic more flexible and are released when it degrades — have been connected to hormonal imbalances in children and abnormal reproductive development in fetuses.

### MAPPING THE EXPOSURE LANDSCAPE

One of the main goals of environmental scientists is to document the scope and severity of air pollution’s effects on skin health. “Air pollution is not [only] in megacities in East Asia — it’s clearly in Western countries,” Krutmann says. “You cannot avoid it.” He has been following a cohort of older women in the Ruhr Valley, an urban region of Germany, who are exposed to road-traffic pollution at levels similar to those in countless other communities worldwide. After adjusting for socio-economic status, smoking habits and exposure to ultraviolet radiation, among other factors, Krutmann concluded that such pollution contributed to the accelerated skin ageing he saw in study participants<sup>1</sup>. He found similar results in a cohort of Han Chinese women from an urban area. And earlier this year, Krutmann and his colleagues built on that research to show that older women who are exposed to traffic pollution have increased rates of eczema, a skin condition characterized by inflammation and scaly red rashes<sup>2</sup>.

In the laboratory, researchers are working to understand exactly why air pollution has these

effects. A 2017 study that included scientists at Guangdong Environmental Monitoring Center in Guangzhou, China, confirmed that exposing immortalized human skin cells to particulate matter — a stew of microscopic dust, soot, exhaust and smoke particles usually suspended in air — leads to the formation of free radicals, DNA damage and cell death<sup>3</sup>.

Skin is also vulnerable to airborne phthalates. Researchers have long known that these hormone-disrupting compounds are dangerous when ingested. But Charles Weschler, who investigates pollutant exposure at Rutgers University in Piscataway, New Jersey, suspected that phthalates might also pose a danger when they leach from household goods into the home environment. To measure how efficiently airborne phthalates are absorbed by skin, Weschler confined a small group of people to rooms filled with air containing elevated levels of phthalates for six hours. In one trial, participants donned a breathing hood so that they inhaled filtered air; in another, they had no hood and were asked to breathe normally.

Weschler found that participants absorbed about the same amount of phthalates — and sometimes even more — through their skin as they did through their lungs<sup>4</sup>. And he thinks that the level of phthalate absorption by skin might be even more dramatic in real-world settings such as the home, where chemicals accumulate over long periods. “The modelling suggested that if we had kept those experiments going for two days, the uptake would have been five times greater,” he says.

Pesticides used by farmers and gardeners might pose a similar threat to skin. Earlier this year, researchers at Griffith University in Nathan, Australia, published a study in which they monitored farm workers who were applying the common pesticide chlorpyrifos to rice paddies in Ghana. The team measured how much pesticide residue passed through the workers’ clothing to contact their skin. From those data, they calculated that many of the

workers absorbed a dose of the pesticide that was several times higher than the dose known to increase risk of developing acute adverse health effects such as confusion and intestinal distress<sup>5</sup>. Pesticides have long been linked to a variety of skin conditions, including contact dermatitis, acne and even melanoma. The results from Ghana suggest that these disorders could be a direct result of pesticide absorption by skin.

But there is still much that researchers do not understand about the levels of skin exposure to pollutants throughout people’s lives. Laura Vandenberg, an environmental-health scientist at the University of Massachusetts Amherst, studies the effects of a common chemical called bisphenol A on skin. In one study, she investigated the exposure of skin to bisphenol A from thermal paper used in shop receipts<sup>6</sup>. On the basis of this and other experiments, Vandenberg thinks that some of the agencies responsible for chemical risk assessments, such as the European Food Safety Authority, probably underestimate people’s exposure through skin to various chemicals. But assessing precise levels of exposure, and predicting effects on health, can be exceedingly difficult. For example, two people who do different jobs at the same farm might receive dramatically different levels of pesticide exposure through skin. And genetic variation makes it even harder to predict the specific effects of pesticide exposure on the skin and general health of individuals.

The best way to assess the connection between skin absorption, levels of environmental exposure and genetic contributions, as well as their combined effects on health, is to conduct large-scale studies. But for now, the most prudent thing that people can do is to limit their exposure to pollutants. This includes taking common-sense precautions such as applying high-sun-protection-factor sunscreen to exposed skin and wearing protective clothing.

Another way to protect skin, particularly from free radicals, Krutmann says, is to use creams that are rich in antioxidant compounds. Such creams neutralize free radicals at the skin’s surface, helping to halt the cell-destroying cascade. Krutmann says that many of these products — especially those containing vitamin C or vitamin E — work well to limit damage in cells. Skin’s absorption of environmental pollutants is a complex problem. But the solution, Krutmann thinks, might be as simple as bolstering the protective barrier that the skin already provides. ■

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