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THE INVISIBLE HEALTH HAZARD: THE CRITICAL NEED FOR PFAS TESTING AND RESEARCH

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The global prevalence of per- and polyfluoroalkyl substances (PFAS), often termed "forever chemicals," presents a profound yet largely unaddressed public health challenge. Due to their exceptional resistance to grease, oil, water, and heat, these synthetic compounds have become universal environmental contaminants since the 1940s¹. Well-known PFAS, including perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) are found all over the world in air, water or soil and indoor areas and are routinely detected in human blood, breast milk, hair, placenta, and umbilical cord serum². This widespread contamination is caused by the production and use of these chemicals in many industries and products such as firefighting foams, alongside inadequate disposal methods such as industrial discharge and landfill leachates². Long-chain PFAS compounds are persistent organic pollutants that accumulate and last for extended periods in the human body and environment, with half-lives of years to decades⁷.

The health risks associated with PFAS affect nearly the entire human population¹. They act insidiously as endocrine disruptors, genotoxic agents, and immunotoxic compounds known to interfere with the normal functioning of essential bodily functions¹. Their exposure can cause a decline in growth parameters, neurodevelopmental problems such as ADHD, and lower visual motor skills, or suppressed antibody responses to common vaccinations in infants and children³. Adults experience a wide range of effects, including lipid disorders, hypertension, diabetes mellitus, kidney, and liver ailments¹. PFAS can be maternally transferred pre- and post-natally leading to long lasting health consequences.³

The biological consequences of PFAS exposure are extremely concerning. Because of PFOA's potential for environmental persistence, long half-life in humans, and possible toxicity, there is rising concern about whether it might be associated with human cancers⁴. In 2023, IARC identified PFOA as a Group 1 carcinogen and PFOS as Group 2B². Studies conducted on humans have revealed a correlation between PFOA-related elevated risk of kidney and testicular cancer¹. The RR for female genital cancers is 1.07, which suggests that there is a correlation between overall PFAS exposure and ovarian cancer⁵. PFAS might be potential risk factors for breast cancer, and the compounds in low exposure levels could have a more harmful impact on human

health⁶. Perfluorooctanoic acid (PFOA) and perfluorohexane sulfonic acid (PFHxS) were found to have a positive correlation with increased breast cancer risk in specific groups in some studies⁵. Studies have revealed a significant correlation between PFAS exposure and increasing thyroid cancer risk in children⁷, with linear PFOS (n-PFOS), branched PFOS (Sb-PFOS), PFNA, and linear PFHxS (n-PFHxS) all being notable markers of endocrine disruption and dysregulation of thyroid hormone levels⁸. Beyond cancer, PFAS exposure has been associated with developmental, metabolic, and immune disorders³. In addition, PFAS is connected to reproductive problems, such as elevated rates preeclampsia¹, pregnancy-induced hypertension², infertility³, and neurodevelopmental disorders like cerebral palsy², although some conclusions need to be further investigated.

Despite the strong evidence of existing risks, there are still significant gaps in research and monitoring. PFOA and PFOS are the primary focus of research, while many other PFAS compounds remain unstudied⁵. As regulations have restricted specific long-chain PFAS, manufacturers have frequently adapted by replacing prohibited compounds with newer, unregulated shorter-chain PFAS, such as PFBA; while these display less bioaccumulation, they may be just as toxic as their alternatives⁹. Research on alternative PFAS compounds and the combined effects of commonly used PFAS mixtures on humans is scarce¹. Moreover there is no routine requirement for new chemicals to undergo functional immunotoxicity testing, and developmental immunotoxic data are often overlooked¹. Regulatory bodies often overlook the significance of biochemical measures of immune system effects, such as reduced antibody responses after vaccinations. Consequently, there is a lack of accurate risk assessments and clinical guidance for tracking¹. Furthermore, the fact that around 40 million Americans rely on unsupervised well monitoring underscores the scarcity of information about PFAS contamination and low public awareness³. In developing and underdeveloped countries, there is a dearth of rigorous research and monitoring for PFAS regulations, which is particularly alarming. For instance, despite the detection of PFAS in various matrices, including hair, in countries such as India, the potential toxicity and exposure impacts of many PFAS, particularly short-chain ones, remain poorly understood.² In many cases, such as in Pakistan, there is a lack of detailed information and comprehensive health risk assessments for populations¹. Significant obstacles to adopting safeguards against PFAS include the prohibitive cost of traditional laboratory-based analysis (300–600 per sample), the need for highly trained personnel, and limited market demand for testing¹⁰. Environmental injustice further exacerbates this, as deprived communities often lack the financial or educational capacity to avoid exposure¹¹. Additional obstacles include a lack of detailed information on populations and limited international knowledge on female genital cancers outside North America and Europe⁵. These obstacles can be overcome by raising awareness to empower communities to advocate for exposure reduction¹¹.

The improvement of this situation necessitates a multifaceted approach, which includes mandatory functional and developmental immunotoxicity testing for all new chemicals, and the acknowledgement of all available data, such as considering biochemical measures of immune system effects as credible indicators of health risks¹. Health agencies must provide proactive communication about PFAS risks and enhance clinical guidance for vulnerable individuals by including immune system monitoring¹. There is a need to expand monitoring reach beyond public wells, into underserved areas³. The need for immediate attention and effective remediation strategies is necessary to address existing contamination through monitoring and other comprehensive measures in water, soils or other environmental media². The recent regulatory efforts undertaken by the EU and US EPA, which include setting limits on PFOA and PFOS and classifying them as hazardous substances, are critical steps, but they underscore the need for comprehensive approaches to safeguard public health worldwide¹². Regulatory efforts in the EU and Australia have begun setting limits on PFOA and PFOS but the limits are different in different countries which can cause confusion and make it harder for clear and consistent decision making⁹. In Australia, while manufacturing is not reported, the continued import of PFAS-containing products for industrial use contributes to local contamination⁹. These issues can be addressed by adopting a "one-substance one-assessment" (OS-OA) approach for better coordination¹² and by developing low-cost, portable sensors to provide real-time, actionable data¹⁰. Future research should focus on developing low-cost, energy-saving technologies for the removal of short chain PFAS². PFAS should be dealt with as a class of chemicals, eliminating all non-essential uses and replacing them with safe alternatives like silanes in textiles, ceramics, or cast iron for cookware and their use should be avoided in food packaging and personal care products². Lastly it is important to encourage collaboration among multiple stakeholders in creating comprehensive legislative and policy proposals that can accurately assess and mitigate the risks associated with PFAS.

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