PFAS: Insights from Past Actions to Inform Today's Decisions

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Sustainable decisions and actions are those that improve the well-being of individuals and communities today without compromising the health and welfare of future generations [1].

More than a decade ago, in response to environmental and health concerns related to the manufacture and release of long-chain poly- and perfluoroalkyl substances (PFASs), use of those substances was phased out in the United States and shorter-chain alternatives were developed. Despite this shift in chemistry, concerns continue about the impact of the persistent legacy contamination, as well as the potential environmental and human health implications of current production and newly discovered releases of an increasing number of continuously evolving PFASs. Impacted communities and concerned consumers are calling for action to understand the extent of the problem, clean up contaminated sites, address health effects, and set future policy [2]. Regulators and policy makers are seeking technical understanding necessary for informed and expedited decisions [3].

The past year, a subcommittee of the U.S. Senate Homeland Security and Governmental Affairs Committee held a hearing on “The Federal Role in the Toxic PFAS Chemical Crisis” (<https://www.hsgac.senate.gov/hearings/the-federal-role-in-the-toxic-pfas-chemical-crisis>). This meeting was organized to allow Senators to hear “what federal agencies are doing – what more they can do – and what Congress must do – to identify contamination, prevent exposure, reduce harm to human health, and to expedite clean-up and assistance for affected communities” [4].

To date, most of what is known about PFAS exposure and health effects is based on studies of the two chemicals that have been manufactured for the longest period of time:

perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). Recently, however, interest has been increasing in proactively regulating as a class the thousands of individual PFAS chemicals that have been created [5–7].

How do we use the information that we know now to make decisions today that minimize and mitigate the potential for future risk? How can exposure science be deployed to fill scientific gaps and inform health-protective decisions? This JESEE Special Topics Issue provides a glimpse of how exposure science is advancing understanding of the relationship between exposure to PFAS and human health impact, as well as enabling actions to address concerns related to PFAS.

Sunderland and coworkers review current understanding of the predominant exposure pathways for PFASs for different populations, highlight major health impacts associated with exposure, and identify some critical knowledge gaps. The authors conclude that “delayed action on legacy PFASs has resulted in widespread human exposures...and lessons should be learned from this example and not repeated for the newer PFASs entering the market.” Sunderland et al. also note that the phase-out of PFOS and its precursors between 2000 and 2002 rapidly reduced the exposure of humans and wildlife to these compounds, suggesting the power of coordinated action.

DeWitt et al. evaluate key and emerging epidemiological and toxicological data concerning the immunotoxicity of PFOA and PFOS to reconcile conflicting conclusions from two previously published reviews. The authors make the point that, although epidemiology studies cannot definitively identify causation and animal studies are not clear predictors of human effects, taken together, the body of evidence gleaned from combined data across multiple studies provides strong evidence that humans exposed to PFOA and PFOS are at risk for immunosuppression. The analysis presented by DeWitt and coworkers demonstrates how limitations of exposure characterization in epidemiology studies can be addressed by jointly considering the results of toxicology studies. Salihovic et al. applied a non-targeted metabolomic approach to elicit insights into the

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potential biochemical pathways and mechanisms for six PFASs measured in a large population-based study. As new technologies for characterizing internal exposures and proximate effects to larger sets of chemicals are developed and evaluated, these tools will further enhance the evidence available for evaluating risks.

Drinking water has been identified as a primary exposure pathway for many populations living near industrial and contaminated sites. Graber et al. compare the exposure levels in a cohort following known PFAS contamination of a community water supply with levels across the general population as measured in NHANES. Tasked with responding to contamination of drinking water and soil in residential areas, Scher et al. describe research to better understand the sources of contamination and to identify exposure pathways of concern.

Even less information is available on the important pathways associated with exposures to the general population. Borownow et al. examine the role of self-reported consumer product use in predicting the exposure levels of six PFAS chemicals in a cohort of middle-aged women, half of whom are African American. The results strengthen the evidence for exposure to PFASs from food packaging and personal-care products. The authors conclude that, while exposure to drinking water contamination by PFAS remains a major public health threat, removing PFASs from these products could reduce human exposure by from such pathways. The authors also note that individuals could lower their personal exposure to PFASs by avoiding the use of consumer products containing these chemicals.

Despite widespread drinking water contamination, ubiquitous population-level exposure, and toxicological and epidemiological evidence of adverse health effects, there are currently no enforceable federal PFAS drinking water standards. Schaidler et al. examine how several US states have developed their own risk-based water guideline levels for PFOA and PFOS to inform decisions about contaminated-site cleanup, and drinking water surveillance and treatment. The authors demonstrate how the resulting guidelines vary widely based on different interpretations of the science, combined with different policies as influenced by social, political, and economic considerations. In response to public health concerns regarding the impact of extensive PFASs ground-water contamination on sensitive populations in a major metropolitan area, Goeden et al. present and demonstrate the application of a toxicokinetic model to derive water guidance values for PFOA. The

model incorporates body burden at birth (placental transfer), ingestion of breastmilk, and age-specific water intake rates in order to derive health-based guidance values sufficiently protective during the sensitive early-life stages. Based on the results of this analysis, the Minnesota Department of Health became the first agency to develop PFOA water guidelines that directly incorporate early-life exposure via placental transfer and via breastfeeding.

Will we tell our children that we were uncertain about the exposures and potential for impacts, that we didn't have enough evidence to act? Or will we leverage the best information at hand, efficiently fill the most critical gaps, and make what we believe will be sustainable decisions?

Compliance with ethical standards

Conflict of interest The authors declare no competing interests.

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